STOCKHOLM SCHOOL OF ECONOMICS
MASTER'S THESIS IN FINANCE

IDIOSYNCRATIC VOLATILITY

- EVIDENCE FROM THE NORDIC EQUITY MARKETS

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ABSTRACT

Using the disaggregated approach to study the volatility of common stocks at the market, industry, and firm levels, introduced by Campbell, Lettau, Malkiel, and Xu (2001), we present empirical evidence on the volatility composition of stocks traded on the Nordic equity markets. Our results reject the common notion of rising stock volatility with respect to all three components of volatility, but unveil recent periods of increased high-frequency noise. However, we find that all volatility components have returned to their long-run levels in the years following the speculative episodes during the late 1990s and early 2000s. Moreover, we find evidence that the components of volatility are sensitive to changes in the composition of securities used in the estimation

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We would like to express our gratitude to Andrei Simonov for his support and assistance in writing this thesis.

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1 Introduction

There is a widespread perception among the public that equity markets have become more volatile over time. This notion has been solidified by the strong equity appreciations in the 1980s and during the late 1990s and early 2000s, and the expression "in today's volatile markets" is used regularly in the media. However, this perception has generally had little support in academic literature. In an influential paper, Schwert (1990), documented a cyclical pattern of volatility but did not find any evidence of increased volatility in the aggregate market index of equities in a US sample. In a more recent paper published in The Journal of Finance, Campbell, Lettau, Malkiel, and Xu (2001), reaffirmed Schwert's results using US data for the period 1926 to 1997. In addition, they employed a novel disaggregated approach to measuring total stock volatility, which allows a decomposition of the volatility of a typical stock into a market, industry, and firm specific component. Their results show that market and industry-level volatility has remained on the same level over time but that firm specific, i.e. idiosyncratic, volatility exhibits a significant upward sloping trend over the sample.

The paper of Campbell, Lettau, Malkiel, and Xu (2001) has incited significant interest in idiosyncratic volatility and the topic is one of the more actively debated at the moment. Several hypotheses have been put forward to provide explanations, and other authors have tried to expand the empirical foundation by applying their disaggregated methodology to samples from other major equity markets.

This thesis uses the disaggregated approach of Campbell, Lettau, Malkiel, and Xu (2001) to investigate the market, industry, and firm-level volatility on the Nordic equity markets[1]. To our knowledge, this has only been performed on less comprehensive Swedish data previously, and at that time using a significantly smaller sample.

1.1 Background

Financial theory and standard asset pricing models stipulate that, in equilibrium, only systematic risk is priced and accordingly, most empirical studies have focused on the volatility of aggregate market indices. In addition, sophisticated econometric models such as GARCH have been developed to capture the time variation in volatility. The fact that stock market indices exhibit time varying volatility has been firmly established, and since idiosyncratic risk can be diversified away, this is the volatility experienced by an investor holding the market portfolio. However, deficient financial literacy or other exogenous factors may constrain investors from holding a fully diversified portfolio. For these investors, industry-level and idiosyncratic firm-level volatility are important factors affecting the risk-reward relationship.

[1] The Icelandic equity market has been excluded. For further discussion of our sample, we refer to the Data and Descriptive Statistics section.

In an influential paper by Campbell, Lettau, Malkiel, and Xu (2001) the authors propose a disaggregated approach to study the volatility of common stock returns at the market, industry, and firm levels. Their results, that idiosyncratic risk exhibits a strong positive trend over the period 1962 to 1997 in the US, has rekindled the interest of financial economists in the role of idiosyncratic risk as a component of total volatility and the implications of these results carry over to asset pricing and portfolio management. As an example of this, any rule of thumb concerning portfolio diversification ultimately depends on the level of idiosyncratic risk and thus the adequacy of any approximations may change over time. An increase in idiosyncratic volatility may also affect the informativeness and pricing efficiency of stock markets because of the increased risk faced by arbitrageurs who trade to exploit individual stock prices that deviate from their intrinsic value. Other important aspects of increased idiosyncratic volatility include implications for option pricing and for measuring the statistical significance of abnormal event-related returns in event studies.

The findings of Campbell, Lettau, Malkiel, and Xu (2001) have also incited significant interest in the intertemporal lead-lag relationship between the idiosyncratic volatility and stock market returns and also in how it affects aggregate output in macroeconomic models.

1.2 Purpose

The purpose of this thesis is to provide Nordic evidence of the historical movements in market, industry, and firm-level volatility as a contribution to the overall understanding of volatility dynamics in equity markets. Given that the behaviour and properties of idiosyncratic volatility on the Nordic stock markets have received little attention, our thesis aims at providing an independent assessment of the empirical findings reported in the recent literature on the topic (e.g. Campbell, Lettau, Malkiel, and Xu (2001), Guo and Savickas (2005), Frazzini and Marsh (2003), Chang and Dong (2005), Angelidis and Tessaromatis (2005), and Brandt, Brav, and Graham (2005)).

1.3 Delimitations

We limit the scale and scope of our thesis to include data on stock prices, market values, interest rates and real GDP growth for the Nordic countries Sweden, Denmark, Finland and Norway. The length of the time-series of stock prices and market values is limited by what is available through Datastream. Also, the methodological approach, developed by Campbell, Lettau, Malkiel, and Xu (2001), will be discussed but an exhaustive discussion on the statistical properties of their model does not lie within the scope of this thesis.

1.4 Outline

This paper is organized as follows. In the next section, we briefly describe the theoretical background that underpins the methodology and the relevance of adopting a disaggregated approach to measuring idiosyncratic volatility. In section 3 we provide a brief survey of the literature on the topic.

In section 4, the methodological framework of Campbell, Lettau, Malkiel, and Xu (2001) is presented in detail. In section 5, we describe the data used in the thesis. Section 6 contains an analysis of the decomposed volatility time series and section 7 examines lead-lag relationships and cyclical behavior. In section 8, we present the results of the thesis, followed by section 9 which presents concluding comments and suggestions for further research. The thesis ends with an index of references and an appendix.

2 Theoretical Background

This section provides a brief background on the financial theory underpinning the methodology employed by Campbell et al. (2001). Moreover, a discussion of the relevance of idiosyncratic volatility is presented.

2.1 Portfolio Theory

Modern portfolio theory is largely attributable to the work of Harry M. Markowitz and William F. Sharpe[2]. Markowitz (1952) studied the effects of asset risk, correlation and diversification on expected investment portfolio returns, and described how to combine assets into efficiently diversified portfolios. Specifically, a Markowitz Efficient Portfolio is one where no added diversification can lower the portfolio's risk for a given return expectation or, alternately, no additional expected return can be gained without increasing the risk of the portfolio. Furthermore, the Markowitz Efficient Frontier is the set of all portfolios that will provide the highest expected return for each given level of risk.

Based on the work of Markowitz, Sharpe (1964) introduced the famous Capital Asset Pricing Model which is used extensively in academia and by practitioners to determine the cost of capital of an asset. The formula takes into account the asset's sensitivity to non-diversifiable risk, i.e. systematic risk or market risk, as well as the expected return of the market as a whole and the expected return of a theoretical risk-free asset. The model is based on the rational assumption that investors should in equilibrium not be compensated for risk that they can avoid simply through diversification, i.e. at low or zero cost. The expected return, and equivalently the cost of capital, of any financial asset is according to the Capital Asset Pricing Model given by equation (1).

$$E(R_i) = R_f + \beta_i \left(E(R_m) - R_f\right) \tag{1}$$

[2] Harry M. Markowitz (born August 24, 1927) and William F. Sharpe (born June 16, 1934) won the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel in 1990 jointly with Merton Miller for their contributions to the field of financial economics.

Although fiercely disputed since its inception[3], the CAPM remains the most widely used asset pricing model. It has a strong logical appeal and it is an underlying assumption on which the methodology in this paper is developed.

2.2 Portfolio Mathematics

The mathematics governing the return and risk of portfolios is rather straight-forward. The return of a portfolio is simply the weighted sum of individual security returns as given by equation (2) below.

$$R_p = \sum_i w_i R_i \tag{2}$$

The variance of the return of a portfolio is given by the covariance matrix as detailed in equation (3).

$$\sigma_p^2 = \sum_i \sum_j w_i w_j \sigma_{ij} = \sum_i \sum_j w_i w_j \sigma_i \sigma_j \rho_{ij} \tag{3}$$

These portfolio formulas, in combination with the Capital Asset Pricing Model, make up the foundation on which the methodology employed in this paper is built.

2.3 Why Idiosyncratic Volatility Matters

Financial theory and standard asset pricing models stipulate that, in equilibrium, only systematic risk is priced. Therefore one may ask why it is relevant to devote a study to idiosyncratic risk. There are, however, several important reasons as to why idiosyncratic volatility matters:

- Investors may be restricted from holding well diversified portfolios. The fact that many investors have large holdings of individual stocks can be explained by transaction costs, incomplete information, the value of control, and institutional constraints such as taxes, liquidity needs, imperfect divisibility of securities, or other exogenous factors. Investors facing various restrictions to diversification may be concerned with not just market risk, but with the total risk of securities.
- A useful rule of thumb in finance is that most of the idiosyncratic risk of a portfolio can be eliminated by holding 20 to 30 individual stocks. However, Malkiel and Xu (2004) point out that this is only true if stocks are picked randomly. This is seldom the case, and therefore, the adequacy of the current rules of thumb concerning portfolio diversification ultimately depends on the level of idiosyncratic volatility of the stocks making up the portfolio.

[3] As put forward in a paper by Richard Roll in 1977, and what is generally referred to as Roll's Critique, the CAPM my not be empirically testable due to the inobservability of the true market portfolio. The market portfolio should in theory include every single asset that can be held as an investment, but in practice it is common to use a stock index as a proxy for the true market portfolio. This simplification can lead to false inferences as to the validity of the CAPM.

- The efficient market hypothesis (EMH) is based on the notion that mispricings in the market are corrected through the actions of arbitrageurs who take large long and short positions in individual stocks. They are thus exposed, not only to market risk, but also to idiosyncratic firm-specific risk. As an implication of this is, it is possible that increasing idiosyncratic risk will hamper market efficiency as the risk involved in holding an undiversified portfolio becomes more costly for the arbitrageur to bear.
- Idiosyncratic volatility affects the statistical significance of abnormal events in event studies, as the significance of abnormal events is determined by the volatility of individual stock returns relative to the market.
- Disaggregated measures of volatility are important, not only in finance, but also in economics. Models of sectoral reallocation imply that increases in industry volatility in productivity growth may reduce output as resources are diverted from production to costly reallocation across sectors.
- Options are priced on total risk of the underlying instrument, not just the market risk.

3 Previous Research

Idiosyncratic volatility is one of the most actively researched topics in financial economics at the moment. The focus of different authors has varied, but one can distinguish three major strands of literature on the topic. One strand of literature has focused on expanding the empirical foundation by employing the methodology of Campbell, Lettau, Malkiel and Xu (2001) on different data samples. Another strand tries to explain the increasing idiosyncratic risk in the US market as identified by Campbell, Lettau, Malkiel and Xu (2001). Finally, a third strand has focused on whether idiosyncratic risk matters and on studying its role in the intertemporal relation between risk and return. The following subsections provide a brief survey of the research in each respective strand.

3.1 Empirical Studies

Campbell, Lettau, Malkiel and Xu (2001) examined the volatility of the US equities market over the period 1962 to 1997 using a novel disaggregated approach and found strong evidence of a positive deterministic trend in idiosyncratic firm-level volatility, whereas the market and industry level volatility were fairly stable over the same period. Consistent with this, they find that correlations between individual stocks have declined over time and that the explanatory power of the market model has diminished. Furthermore, they find that firm-level volatility accounts for the largest share of total firm volatility and that market level volatility tends to lead industry level volatility and firm level volatility. All three volatility measures increase in economic downturns and tend to lead recessions. Also, the volatility measures help in forecasting economic activity and reduce the significance of other explanatory variables commonly used in forecasting. They also find evidence that the large number of small firms entering the market over the sample period may have caused the upward trend in firm level volatility.

Savickas and Guo (2005) analyze the aggregate idiosyncratic volatility of equities markets in the G7 countries using data up to 2003. Consistent with Campbell, Lettau, Malkiel and Xu (2001), they find a significant upward trend in some G7 countries when looking at equally-weighted average idiosyncratic volatility, including the US. They fail, however, to observe such a trend when looking at the value-weighted average idiosyncratic volatility or equally-weighted idiosyncratic volatility of the 500 largest companies in all seven countries, suggesting that there is a small-firm effect present in the data. In addition to the results in Campbell, Lettau, Malkiel and Xu (2001), they find a strong increase in idiosyncratic volatility in the late 1990s and early 2000s, where after it fell. These effects had no effect on the general upward trend however. Furthermore, they find that aggregate idiosyncratic volatility is highly correlated across the G7 countries.

Frazzini and Marsh (2003) investigated the relation between idiosyncratic volatilities and a set of firm specific observable variables to both US (-2002) and UK (1965-2003) stock return data and found that the clear upward trend in idiosyncratic volatility in the US, concentrating on small stocks, is not shared by the UK market which may have implications for the sources of the US trend. They also present evidence of a relation between idiosyncratic volatility and the degree of institutionalization of the US market.

Brandt, Brav and Graham (2005) present further evidence about the increase in idiosyncratic volatility in the US through the 1990s and early 2000s. According to their study, in the three years ending in 2004, idiosyncratic volatility fell to pre-1990s levels, thus reversing the time trend observed through the 1990s. Also, the period between 1926 and 1933 exhibited a temporary increase in idiosyncratic volatility closely resembling the increasing trend identified in recent years. Finally, the episode of high and increasing idiosyncratic volatility during the 1990s is concentrated primarily in firms with low stock prices and limited institutional ownership.

Sternbrink and Tengvall (2001) performed a volatility decomposition on data from the Stockholm stock exchange on a sample ranging from 1988 to 2001 and found that market and industry level volatility have increased over time, whereas firm level volatility was stable over time. However, the positive trend in the market volatility component proved not to be stable to the exclusion of large capitalization firms.

3.2 Possible Explanations for Changes in Idiosyncratic Volatility

Several hypotheses have been put forward as to why idiosyncratic risk may have increased. In theory, increased volatility can only result from three sources: an increase in the variance of the firm's expected cash flow, an increase in the variance of discount rates, or from an increase in the covariance between the cash flow shocks and discount rate shocks. (Campbell, Lettau, Malkiel, and Xu (2001))

Dennis and Strickland (2005) argue that increased idiosyncratic risk can be explained by two factors. First, they find that institutional ownership has increased monotonically over the past 20 years. Secondly, firm focus, measured by the number of business segments, has increased over the last 20 years. Also, the tendency in corporate governance to break up conglomerates and replacing them with more focused companies that specialize in a single industry has made it possible to measure each company's idiosyncratic risk separately, whereas it previously was part of an already diversified conglomerate. Hence, it is credible that the within conglomerate diversification has kept firms' idiosyncratic volatility artificially low. It is also possible that the increased volatility might have increased due to increased reliance on external funds rather than internal.

Another explanation brought forward by Brandt, Brav and Graham (2005), Gaspar and Massa (2003) and Irvine and Pontiff (2005) is that product markets have become more competitive. Lower search costs and better abilities of consumers to compare products have resulted in consumers being less loyal to a given firm's product. The implication is that competition induces increased firm level profit volatility.

Another possible explanation could be the increased use of options in management compensation packages. As the relative proportion of management's pay come from stock options, management have stronger incentives to maximize the value of the options by inducing more firm level volatility. It is not clear how management would induce greater volatility but Cohen, Hall, and Viceira (2000) detect a statistically significant effect, albeit small in magnitude.

Explanations specific to the Nordic setting seems to be the liberalization of the equity markets in the late 1980s and 1990s. Trading on the Stockholm Stock Exchange increased very rapidly when the remaining laws constraining foreign ownership and trading in the Swedish equity markets were lifted in 1992. Sellin (1996) documented an increase in volatility after 1992 and attributed this increase to increased noise trading that took place after the deregulation and the increased participation of foreign investors in the Swedish equity markets. He does not, however, relate his finding of this particular trading pattern to any measure of volatility. In a later study, Nilsson (2002) reaffirmed these results and showed that higher expected return, higher volatility and stronger links with international stock markets characterize the deregulated period for all Nordic stock markets. However, the increase in volatility has been coupled with an increase in expected returns and increased opportunities for Swedish investors to cross-border diversify. Hence, the risk-return characteristics have not changed adversely since the liberalization of the Nordic equity markets.

Wei and Zhang (2003) investigate why individual stocks in the US have become more volatile, focusing on the 1976-2000 period. They report that corporate earnings have deteriorated on average, that their volatility has increased over the sample period and that this is more evident for newly listed stocks than for existing stocks. They also find that stock return volatility is negatively related to the return-on-equity and positively related to the volatility of the return-on-equity in cross-sections. According to their study, the upward trend in average stock return volatility is fully accounted for by the downward trend in the return-on-equity and the upward trend in the volatility of the return on equity. Other variables that have cross-sectional explanatory power, such as firm equity size and firm age, are not found to contribute to the increase of stock return over time.

Chang and Dong (2005), in a similar study, use Japanese data from 1975 to 2003 to show that both institutional herding and firm earnings are positively related to idiosyncratic volatility. They reject the hypothesis that institutional investors herd toward stocks with high idiosyncratic volatility and systematic risk. The results suggest that there may be a behavioral explanation to the negative premium earned by high volatility stocks found by Ang, Dong, and Piazzesi (2004). They also find that the dispersion of change in institutional ownership and return-on-asset move together with the market aggregate idiosyncratic volatility over time. Their results suggest that investor behavior and stock fundamentals may both help explain the time-series pattern of market aggregate idiosyncratic volatility.

Hamao, Mei, and Xu (2002) examine the market-and firm-specific risks in the Japanese market over different market conditions. The price behavior of Japanese equities in the 1990s is found to resemble that of US equities during the Great Depression. Both show increasing market volatility and a prolonged large co-movement in equity prices. What is unique about the Japanese case is the surprising fall in firm-level volatility and turnover in Japanese stocks after its market crash in 1990. This large decrease in firm-level volatility may have impeded Japan's capital formation process as it has become more difficult over the past decade for both investors and managers to separate high quality from low quality firms. Using data on firm performance fundamentals and corporate bankruptcies, they show that the fall in firm-level volatility and turnover could be attributed to the sharp increase in earnings homogeneity among Japanese firms and the lack of corporate restructuring.

Bali, Cakici, Yan, and Zhang (2004) show that the significantly positive relation between the equal-weighted average stock volatility and the value-weighted portfolio returns found in Goyal and Santa-Clara (2003) is driven by small stocks traded on the NASDAQ, and is in part due to a liquidity premium and that their result does not hold for an extended sample up to 2001 and for portfolios of stocks traded on the NYSE/AMEX and NYSE. More importantly, they find no evidence of a significant link between the value-weighted portfolio returns and various measures of the median and value-weighted average stock volatility.

Fink, Fink, Grullon and Weston (2005) present empirical evidence that the recent rise in idiosyncratic risk is driven by the increasing propensity of firms to issue public equity at an earlier stage in their life cycle. They find that the age of the typical firm at its IPO date has fallen dramatically from nearly 40 years old in the early 1960s to less than 5 years old by the late 1990s. They argue that since younger firms tend to be riskier, this systematic decline in the average age of IPOs, combined with the increasing number of firms going public over the last 30 years, has caused a significant increase in idiosyncratic risk and that after controlling for the proportion of young firms in the market, there is no trend in the time series of idiosyncratic risk. Moreover, they find a negative trend in idiosyncratic risk after controlling for other measures of firm maturity. Brown and Kapadia (2005) extend their argument and claim that the increase in idiosyncratic volatility is due solely to new listings by riskier companies. This is a result of financial development that allows riskier companies to access capital markets more easily or cheaply. They also show that the previously documented decline in average R^2 of a market model is due to the new listing effect.

Bennet and Sias (2004) argue that the growth in firm-specific risk primarily reflects changes in the composition of securities used to estimate firm-specific risk, rather than systematic changes in firm-specific risk. Specifically, they propose that three key changes in the composition of the securities that are used to estimate firm-specific risk explain this rising trend: the growth of "riskier" industries, the increased role of small firms in the market, and the decrease in within-industry concentration.

3.3 Research on the Implications of Changes in Idiosyncratic Volatility

Goyal and Santa-Clara (2003) examine US market data up to 1999 and find a significant positive relation between average stock variance, which is largely idiosyncratic, and the return on the market. In contrast, they find that the variance of the market has no forecasting power for the market return.

Ang, Hodrickz, Xingx and Zhang (2004) examine the pricing of aggregate volatility risk in the cross-section of stock returns and find that stocks with high sensitivities to innovations in aggregate volatility have low average returns. In addition, they find that stocks with high idiosyncratic volatility relative to the Fama and French (1993) model have particularly low average returns.

Angelidis and Tessaromatis (2005) use data from the UK equities market between 1980 and 2003 to examine the predictive ability of various measures of idiosyncratic risk. They provide evidence which suggests that it is the idiosyncratic volatility of small capitalization stocks that matters for asset pricing and that small stocks' idiosyncratic volatility predicts the small capitalization premium component of market returns and is unrelated to pure market risk or the value premium.

Brown and Ferreira (2003) find that non-systematic volatilities of small firms are positively related with future returns on all age and size portfolios. They dominate systematic volatility, big-firm volatility and other volatilities. There is also strong evidence that idiosyncratic risk is priced in small-firm returns. Small-firm volatility as a predictor of big-firm returns is, in part, a proxy for systematic volatility and a consumption-wealth ratio. They rule out several hypotheses, including a liquidity premium, as potential explanations of the results, but not the idea that small-firm idiosyncratic volatility is correlated with the risk of the total investor portfolio, which includes non-equity assets.

4 Decomposition Methodology

The theoretical framework of Campbell, Lettau, Malkiel, and Xu (2001) for decomposing stock returns presented in this subsection aims at defining volatility measures that sum to the total return volatility without having to calculate covariances and without having to estimate firm or industry betas. These can be difficult to estimate correctly and may be unstable over time.

We follow Campbell, Lettau, Malkiel, and Xu (2001) and decompose the stock returns into three components: the market level return, an industry level residual, and a firm-specific residual, which we then use to construct time-series of volatility measures of the three return components for a stock.

Throughout the thesis industries are denoted by i, individual firms are indexed by j, and w_{jit} is the weight of firm j in industry i. The logarithmic excess return of firm j in industry i in period t is denoted as R_{jit}. The excess log-return is measured as an excess return over the one month interbank offered rate. The excess return of industry i in period t is given by $R_{it} = \sum_{j\in i} w_{jit} R_{jit}$. Similarly, the weight of industry i in the total market is denoted by w_{it}, and the excess return is $R_{mt} = \sum_i w_{it} R_{it}$.

Using CAPM we decompose firm and industry returns into the three components. As implied by CAPM we impose a zero-intercept restriction for industry excess returns:

$$R_{it} = \beta_{im} R_{mt} + \tilde{\varepsilon}_{it} \tag{4}$$

and

$$\begin{aligned} R_{jit} &= \beta_{ji} R_{it} + \tilde{\eta}_{jit} \\ &= \beta_{ji}\beta_{im} R_{mt} + \beta_{ji}\tilde{\varepsilon}_{it} + \tilde{\eta}_{jit} \end{aligned} \tag{5}$$

for individual firm returns. In equation (4) β_{im} denotes the beta for industry i with respect to the market return, and $\tilde{\varepsilon}_{it}$ is the industry-specific residual. Correspondingly, in equation (5) β_{ji} is the beta of firm j industry i with respect to its industry, and $\tilde{\eta}_{jit}$ is the firm-specific residual. The implicit assumption is that β_{jm} satisfies $\beta_{jm} = \beta_{ji}\beta_{im}$, i.e. $\tilde{\eta}_{jit}$ is orthogonal to the industry return R_{it}, market return R_{mt}, and the firm-specific residual. The weighted sums of the different betas equal unity:

$$\sum_i w_{it}\beta_{im} = 1, \sum_{j\in i} w_{jit}\beta_{ji} = 1 \tag{6}$$

The assumption that the different components of firm return are orthogonal permits a simple variance decomposition in which all covariance terms are zero:

$$\mathrm{Var}(R_{it}) = \beta_{im}^2 \mathrm{Var}(R_{mt}) + \mathrm{Var}(\tilde{\varepsilon}_{it}) \tag{7}$$

$$\mathrm{Var}(R_{jit}) = \beta_{jm}^2 \mathrm{Var}(R_{mt}) + \beta_{ji}^2 \mathrm{Var}(\tilde{\varepsilon}_{it}) + \mathrm{Var}(\tilde{\eta}_{jit}) \tag{8}$$

Equation (7) and (8), however, require the estimation of firm-specific betas that are difficult to estimate and may vary over time. To avoid this, Campbell, Lettau, Malkiel, and Xu (2001) propose a simplified model that does not require any information about betas.

Omitting β_{im} from equation (4) we get the following "market-adjusted-return model":

$$R_{it} = R_{mt} + \varepsilon_{it} \tag{9}$$

where ε_{it} is the difference between the industry return R_{it} and the market return R_{mt}. Comparing equations (4) and (9), we have

$$\varepsilon_{it} = \tilde{\varepsilon}_{it} + (\beta_{im} - 1)R_{mt} \tag{10}$$

Thus, for the market-adjusted residual ε_{it} to equal the CAPM residual in equation (7) it must hold that β_{im} =1 or that the market return R_{mt} =0. This decomposition, however, means that R_{mt} and ε_{it} are not orthogonal, and thus the covariance between them cannot be ignored. The variance of the industry return is

$$\begin{aligned} \mathrm{Var}(R_{it}) &= \mathrm{Var}(R_{mt}) + \mathrm{Var}(\varepsilon_{it}) + 2\mathrm{Cov}(R_{mt}, \varepsilon_{it}) \\ &= \mathrm{Var}(R_{mt}) + \mathrm{Var}(\varepsilon_{it}) + 2(\beta_{im} - 1)\mathrm{Var}(R_{mt}) \end{aligned} \tag{11}$$

Taking into account the covariance also means reintroducing the industry beta. However, when calculating the weighted average of variances across industries, the covariance terms, and therefore also the betas, cancel out:

$$\begin{aligned} \sum_i w_{it}\mathrm{Var}(R_{it}) &= \mathrm{Var}(R_{mt}) + \sum_i w_{it}\mathrm{Var}(\varepsilon_{it}) \\ &= \sigma_{mt}^2 + \sigma_{et}^2 \end{aligned} \tag{12}$$

where $\sigma_{mt}^2 \equiv \mathrm{Var}(R_{mt})$ and $\sigma_{\varepsilon t}^2 \equiv \sum_i w_{it}\mathrm{Var}(\varepsilon_{it})$. That betas cancel out was shown in equation (6) $\sum_i w_{it}\beta_{im} = 1$ and thus the residual ε_{it} in equation (9) can be used to construct a measure of average industry-level volatility without estimating any betas.

Correspondingly, for firm-level returns omitting β_{ij} from equation (5) gives:

$$R_{jit} = R_{it} + \eta_{jit} \tag{13}$$

where η_{jit} is defined as

$$\eta_{jit} = \tilde{\eta}_{jit} + (\beta - 1)R_{it} \tag{14}$$

The variance of the firm return is

$$\begin{aligned} \mathrm{Var}(R_{jit}) &= \mathrm{Var}(R_{it}) + \mathrm{Var}(\eta_{it}) + 2\mathrm{Cov}(R_{it}, \eta_{jit}) \\ &= \mathrm{Var}(R_{it}) + \mathrm{Var}(\eta_{jit}) + 2(\beta_{ji} - 1)\mathrm{Var}(R_{it}) \end{aligned} \tag{15}$$

The weighted average of firm variances in industry *i* is therefore

$$\sum_{j\in i} w_{jit}\operatorname{Var}(\mathrm{R}_{jit})\beta_{im} = \operatorname{Var}(\mathrm{R}_{it}) + \sigma^2_{\eta it}, \tag{16}$$

where $\sigma^2_{\eta it} \equiv \sum_{j\in i} w_{jit}\operatorname{Var}(\eta_{jit})$ is the weighted average of firm-level volatility in industry *i*. Using equation (12), the weighted average across industries cancel out any firm-specific betas

$$\begin{aligned}\sum_i w_{it}\sum_{j\in i} w_{jit}\operatorname{Var}(\mathrm{R}_{jit}) &= \sum_i w_{it}\operatorname{Var}(\mathrm{R}_{it}) + \sum_i w_{it}\sum_{j\in i} w_{jit}\operatorname{Var}(\eta_{jit}) \\ &= \operatorname{Var}(\mathrm{R}_{mt}) + \sum_i w_{it}\operatorname{Var}(\varepsilon_{it}) + \sum_i w_{it}\sigma^2_{\eta it} \\ &= \sigma^2_{mt} + \sigma^2_{\varepsilon t} + \sigma^2_{\eta t},\end{aligned} \tag{17}$$

where $\sigma^2_{\eta t} \equiv \sum_i w_{it}\sigma^2_{\eta it} = \sum_i w_{it}\sum_{j\in i} w_{jit}\operatorname{Var}(\eta_{\mathrm{jit}})$ is the weighted average of firm-level volatility across all firms.

As Campbell, Lettau, Malkiel, and Xu (2001) point out, a volatility decomposition using the "market-adjusted-return model" rather than a decomposition using the CAPM has some important theoretical implications. Aggregating equation (7) and (8) across industries and firms we find that

$$\sigma^2_{\varepsilon t} = \tilde{\sigma}^2_{\varepsilon t} + \mathrm{CSV_t}(\beta_{im})\sigma^2_{mt}, \tag{18}$$

where $\tilde{\sigma}^2_{\varepsilon t} \equiv \sum_i w_{it}\operatorname{Var}(\tilde{\varepsilon}_{it})$ is the average variance of the CAPM industry shock $\tilde{\varepsilon}_{it}$, and $\mathrm{CSV_t}(\beta_{\mathrm{im}}) \equiv \sum_i w_{it}(\beta_{im}-1)^2$ is the cross-sectional variance of industry betas across industries. Correspondingly, on the firm-level

$$\sigma^2_{\eta t} = \tilde{\sigma}^2_{\eta t} + \mathrm{CSV_t}(\beta_{jm})\sigma^2_{mt} + \mathrm{CSV_t}(\beta_{ji})\tilde{\sigma}^2_{\varepsilon t} \tag{19}$$

where $\tilde{\sigma}^2_{\eta t} \equiv \sum_i w_{it}\sum_{j\in i} w_{jit}\operatorname{Var}(\tilde{\eta}_{jit})$, $\mathrm{CSV_t}(\beta_{\mathrm{jm}}) \equiv \sum_i w_{it}\sum_j w_{jit}(\beta_{jm}-1)^2$ is the cross-sectional variance of firm betas on the market across all firms in all industries, and $\mathrm{CSV_t}(\beta_{\mathrm{ji}}) \equiv \sum_i w_{it}\sum_j w_{jit}(\beta_{ji}-1)^2$ is the cross-sectional variance of firm betas on industry shocks across all firms in all industries. What equation (18) and (19) show that cross-sectional variation in betas can produce common movements in the three variance components σ^2_{mt}, $\sigma^2_{\varepsilon t}$ and $\sigma^2_{\eta t}$ even if the CAPM variance components $\tilde{\sigma}^2_{\varepsilon t}$ and $\tilde{\sigma}^2_{\eta t}$ do not move at all with the market variance $\tilde{\sigma}^2_{mt}$. However, Campbell, Lettau, Malkiel, and Xu (2001) show that realistic cross-sectional variation in betas has only small effects on the time-series movements of our volatility components.

5 Data and Descriptive Statistics

We have collected daily stock prices and market values, in local currencies, for every stock ever listed on the Nordic stock exchanges, as far back as there is data available through Datastream. In total, our sample includes 2,400 tickers and approximately ten million datapoints. Iceland's stock exchange has been excluded from the study due to its limited size and low number of traded equities. A sufficient number of traded stocks is required for a meaningful industry classification and thus volatility decomposition; a criterion which Iceland does not meet.

One month interbank interest rates are obtained from IFS[4] for all countries, which are used as a proxy for the risk-free asset.

Table I.

Descriptive statistics, Raw data

The table presents descriptive statistics for each of the four datasets used in the study.

	Sweden	Denmark	Finland	Norway
Period	Jan 1982 - Sep 2005	Feb 1980 - Sep 2005	Jun 1987 - Sep 2005	Feb 1980 - Sep 2005
Datapoints(1)	3,903,868	2,541,324	1,202,090	2,010,624
Total number of tickers	1,149	413	298	547
Number of industries used	21	14	11	16
Total Mkt Cap, Sep '05	MSEK 3,060,914	MDKK 1,055,477	MEUR 175,140	MNOK 1,346,323

(1) Half of which are returns and half of which are market caps

Unfortunately, the industry classification scheme suggested by Datastream proved to be erroneous and inaccurate. The required industry classification has thus been based on the rather time consuming process of manually researching every single firm's operations. A positive side effect of this approach is that it has made possible an industry classification tailored specifically to the spectrum of firms in each country. The choice of industry classification is based on a trade-off between precision on one hand and the need for enough breadth to avoid dominance by one or a few firms on the other hand. The number of industries per country are presented in table I, and detailed information about firms and industry classification can be found in the appendix.

To get daily excess returns, we subtract the daily logarithmic returns by the daily logged return on the risk-free asset. A handful of erroneous returns due to faulty data in Datastream have been manually removed from each of the four datasets.

We follow the procedure presented in Campbell, Lettau, Malkiel, and Xu (2001) to estimate the three volatility components in equation (17). Using daily returns the sample volatility of the market return in period t (MKT_t) is

$$\mathrm{MKT_t} = \hat{\sigma}^2_{mt} = \sum_{s \in t} \left(\mathrm{R}_{ms} - \mu_m \right)^2 \tag{20}$$

[4] International Financial Statistics, IMF

where μ_m is defined as the mean of the market return R_{ms} over the sample. The market returns are computed as the weighted average using all firms in the sample, with weights based on market capitalization. For weights in period *t* we use the market capitalization of a firm in period *t*-1 and hold them constant within period *t*. As expected, the calculated market index differs slightly from a comparable firm-wide value-weighted index. However, correlations amount to 95% or above in each market.

To estimate volatility in industry *i*, we sum the squares of the industry-specific residual in equation (9) within a period *t*:

$$\hat{\sigma}^2_{mt} = \sum_{s \in t} \varepsilon^2_{is} \tag{21}$$

As mentioned, to ensure that the covariances of individual industries cancel out we have to average over industries. The average industry volatility, denoted as IND_t, is thus:

$$\text{IND}_{\text{t}} = \sum_i w_{it} \hat{\sigma}^2_{\varepsilon it} \tag{22}$$

Similarly, to estimate firm-specific volatility we sum the squares of the firm-specific residual in equation (13) for each firm:

$$\hat{\sigma}^2_{\eta jit} = \sum_{s \in t} \eta^2_{jis} \tag{23}$$

Then the weighted average of the firm-specific volatilities with an industry is calculated as follows:

$$\hat{\sigma}^2_{\eta it} = \sum_{j \in i} w^2_{jit} \hat{\sigma}^2_{\eta jit} \tag{24}$$

To obtain a measure of average firm-level volatility, denoted as FIRM_t, and also to ensure that firm-specific covariances cancel out we average over industries:

$$\text{FIRM}_{\text{t}} = \sum_i w_{it} \hat{\sigma}^2_{\eta it} \tag{25}$$

In addition, we will elaborate on one of the possible explanations for changes in idiosyncratic volatility that has been presented in the literature, namely that of changes in market and industry concentration. It was evident during the process of performing the disaggregated analysis on Nordic data, that the sensitivity of the results to industry classification is high. Hence, we find it reasonable to believe that results are sensitive in a similar way to concentration within industries and the market. To shed some light on this possibility, we will match observed changes in the three volatility components with changes in the total number of stocks listed in a market, the average market capitalization of stocks and the median capitalization of stocks. In addition, we will calculate, and analyze changes in, a measure of concentration based on the Herfindahl-Hirschman Index[5]. It is commonly used in economics to measure of the degree of competition in a market and is calculated as the sum of squares of the market shares of all firms in accordance with equation 26.

$$H = \sum_{i}^{n} \left(s_i^2 \right) \tag{26}$$

As it is constructed, it can range from 0 to 1 which indicates a move from a very large amount of very small firms to a single firm completely dominating the market. Although the index is normally used in applications which are of a different nature than ours, we are of the opinion that the concept is applicable in this context as well. We calculate three indices per country using individual firms' share of the whole market, individual industries' share of the whole market and finally as a market capitalization weighted average of within-industry concentration across all industries.

6 Analysis

Univariate statistics for all twelve time series, three per country, are presented in table II below. It is evident that the firm level volatility component is the largest on average in all countries except in the case of Finland, where, somewhat unintuitively, the market component dominates by a small margin. In Denmark and Norway, the industry level volatility component is larger than the market level component, whereas the opposite is true for Sweden and Finland. The sum of averages for the three components was 0.128 in Sweden, 0.099 in Denmark, 0.170 in Norway and 0.178 in Finland. This corresponds to a weighted average total annual standard deviation of 35.8%, 31.5%, 41.2% and 42.2% respectively for stocks in the four countries. Turning to extreme values, Norway stands out with a maximum market level volatility component of 0.770 and a maximum volatility component of 1.379. The time series will be further investigated on a country-by-country basis in the following subsections.

Table II.

Descriptive statistics, volatility time series

	Sweden			**Denmark**			**Norway**			**Finland**		
	MKT	IND	FIRM	MKT	IND	FIRM	MKT	IND	FIRM	MKT	IND	FIRM
Mean	0.034	0.028	0.068	0.017	0.027	0.055	0.030	0.038	0.104	0.071	0.043	0.084
Stdev	0.043	0.026	0.050	0.019	0.022	0.038	0.053	0.027	0.141	0.097	0.039	0.066
Min	0.002	0.002	0.004	0.000	0.004	0.006	0.003	0.009	0.011	0.003	0.007	0.017
Max	0.334	0.168	0.282	0.143	0.134	0.247	0.770	0.172	1.379	0.478	0.239	0.485

[5] The Herfindahl-Hirschman Index (HHI) is attributable to the work of Orris Herfindahl, an environmental economist, and Albert O. Hirschman, a member of the Institute for Advanced Study at Princeton University.

6.1 Sweden

Figure 1 plots the market level volatility time series both as actual values and as a twelve month moving average. Visual inspection reveals no discernable trend, but periods of increased volatility as well as individual events causing spikes in the volatility series are evident. Large spikes can be observed during the devaluation in 1982, in October 1987 when the world experienced a major stock market crash, and in fall 1998 during the Russian debt crisis. We also observe a spike in fall 1992, when speculative pressures on the Swedish Krona forced the central bank to abandon the fixed currency regime. During the years 1989 through 1992 several spikes are present in the data. Possible explanations could be the fall of the Soviet satellite regimes in Eastern Europe, the collapse of the Soviet Union, the Iraqi invasion of Kuwait and the subsequent intervention by the allied forces in Iraq. A period of increased volatility can also be observed during the first years of the new millennium, in the aftermath of the speculative bubble.

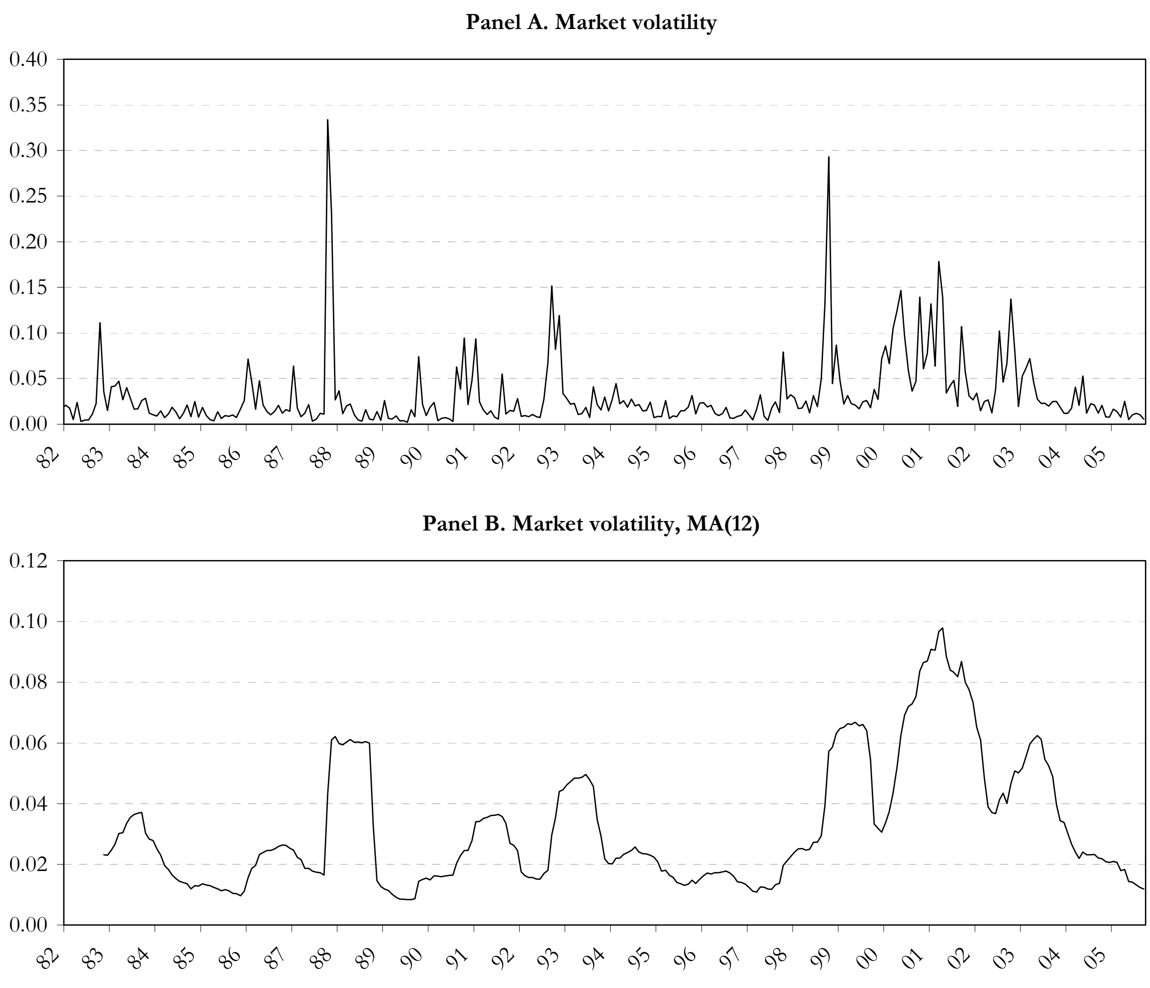


Figure 1. Market volatility, Sweden. Panel A shows the annualised variance of each month from Jan 1982 to Sep 2005 calculated as $MKT_t = \hat{\sigma}^2_{mt} = \sum_{s \in t} \left(R_{ms} - \mu_m\right)^2$. A twelve month moving average is shown in panel B.

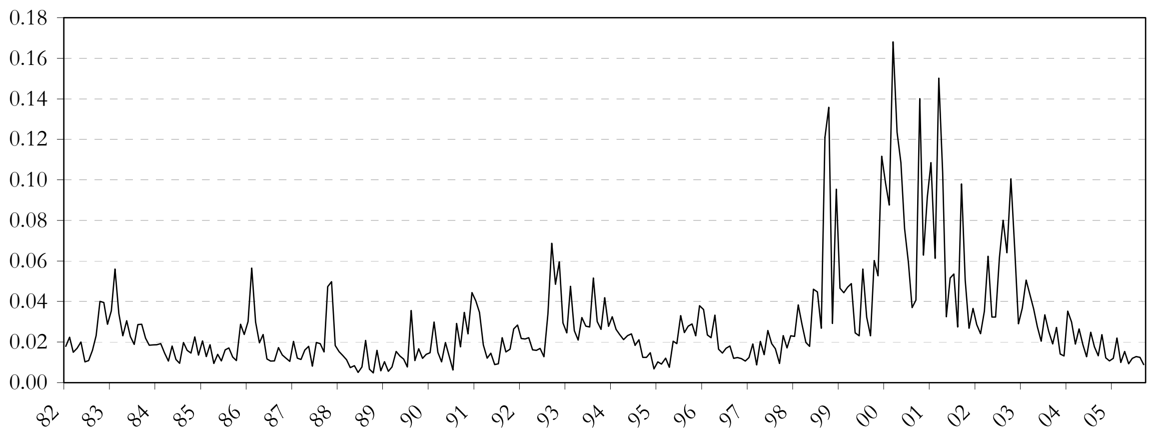
The linear trend estimation presented in table III below shows that there is no statistical evidence of a linear trend in market volatility over the whole sample period. The analysis has also been performed on the time series pre and post December 1997, in which cases statistically significant negative trends are revealed. However, these are likely influenced by the market crashes of 1987 and 1998, and are not confirmed by the visual inspection.

Table III.

Linear trend estimation, MKT volatility time series Sweden

	Jan 82 - Sep 05	Jan 82 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	0.399	-1.118**	-5.591***
t-value	(1.292)	(-2.180)	(-3.292)

Panel A. Industry volatility



Panel B. Industry volatility, MA(12)

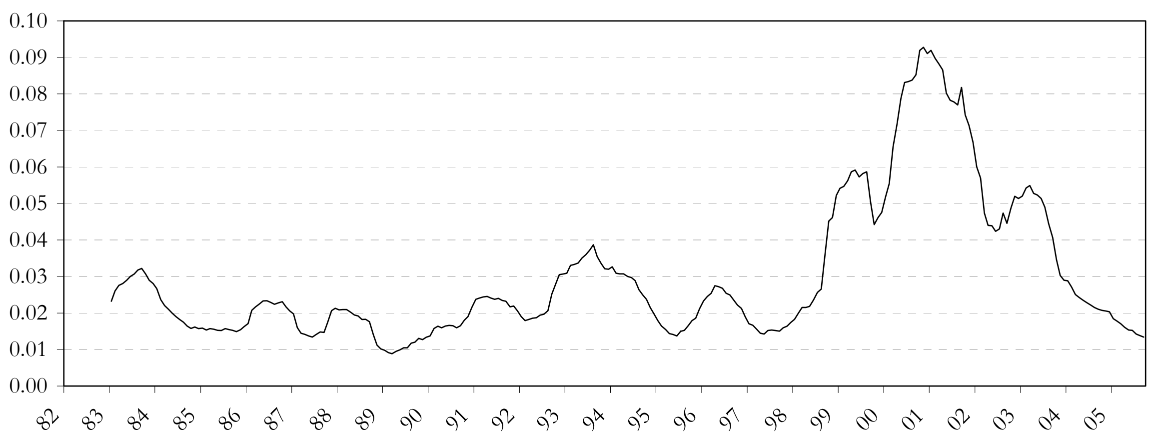


Figure 2. Industry volatility, Sweden. Panel A shows the annualised variance of each month from Jan 1982 to Sep 2005 calculated as $\text{IND}_t = \sum_i w_{it} \hat{\sigma}^2_{\varepsilon it}$. A backwards twelve month moving average is shown in panel B.

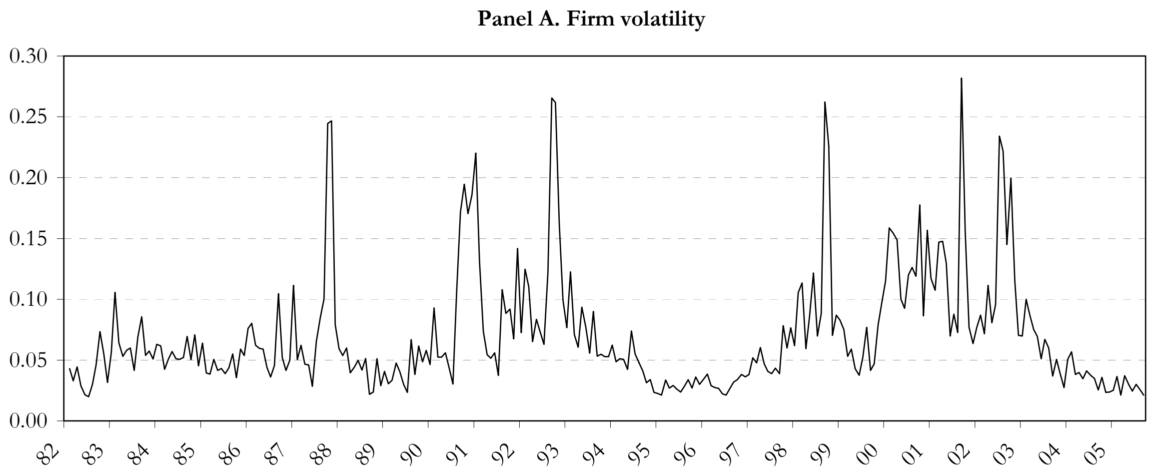
Turning to industry level volatility, shown in figure 2, there is again no strong visual evidence of a trend in the time series. A spike in fall 1998, coinciding with the Russian debt crisis, is followed by spikes in March 2000 as the IT bubble burst and a few others ending with October 2002. It appears as if there is a period of generally increased volatility from the late 90's to the end of year 2002.

Table IV reveals a statistically significant positive trend in industry level volatility over the whole sample period. However, the trend is positive over the pre December 1997 time series and then strongly negative over the remainder of the sample when studied in isolation. Hence, we conclude that any positive trend has been reversed by the end of the sample.

Table IV.

Linear trend estimation, IND volatility time series Sweden

	Jan 82 - Sep 05	Jan 82 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	1.242***	0.460***	-5.905***
t-value	(7.147)	(3.274)	(-4.700)



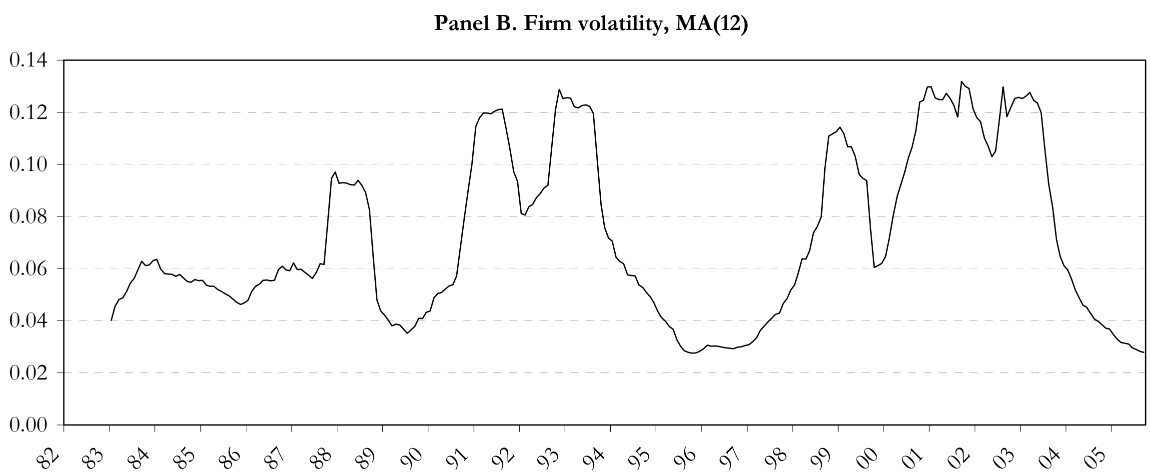


Figure 3. Firm volatility, Sweden. Panel A shows the annualised variance of each month from Jan 1982 to Sep 2005 calculated as $\text{FIRM}_t = \sum_i w_{it}\hat{\sigma}^2_{\eta it}$. A backwards twelve month moving average is shown in panel B.

By visual inspection of figure 3, and disregarding a handful of spikes, the firm level component of volatility seems to have moved in cycles. It is comparatively low from 1982 to 1985, during the mid 90's and in the end of the sample period, and comparably somewhat higher in-between. If one disregards the return to low volatility in the firm level component in recent years, a visual inspection would have given some support for an increasing trend over the period in line with the findings of Sternbrink and Tengvall (2001).

According to the analysis in table V below, there is a statistically significant positive trend when testing over the entire sample. However, as in the case of industry volatility, there is a strong reversion in the time series when studying the post December 1997 period in isolation.

Table V.

Linear trend estimation, FIRM volatility time series Sweden

	Jan 82 - Sep 05	Jan 82 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	1.178***	0.724	-8.599***
t-value	(3.299)	(1.232)	(-4.366)

Turning to figure 21 in the appendix, we see that the number of listed stocks has shown a steady increase over the Swedish sample. There is a particularly steep increase of listed firms during the late 1980's, followed by a return to the long-term trend after the financial crisis in the early 1990's, forming a major hump in the curve. One can also observe a slight decline in the number of listed firms during the early years of the new millennium. The average and median market capitalization of stocks in the Swedish market, shown in figure 25 in the appendix, increases steadily from the years after the financial crisis until around the turn of the millennium and the burst of the speculative bubble. From year 2003 on, the average and median market capitalization has continued to increase. The Herfindahl-Hirschman indices in figure 31 are relatively constant over the sample, except around the turn of the millennium when all three indices increased temporarily. An educated guess would be that this is a manifestation of the fact that Ericsson came to constitute a large fraction of the market during this period.

Figure 4. shows the development of all three volatility components over time, added together. The top panel shows the absolute sum of the three measures whereas the bottom panel shows their relative contribution to the total weighted average volatility of Swedish common stocks. Again, there is no visual evidence of a trend in the aggregated measure but periods of increased volatility can be observed. The relative contribution of the three components appears to be relatively constant.

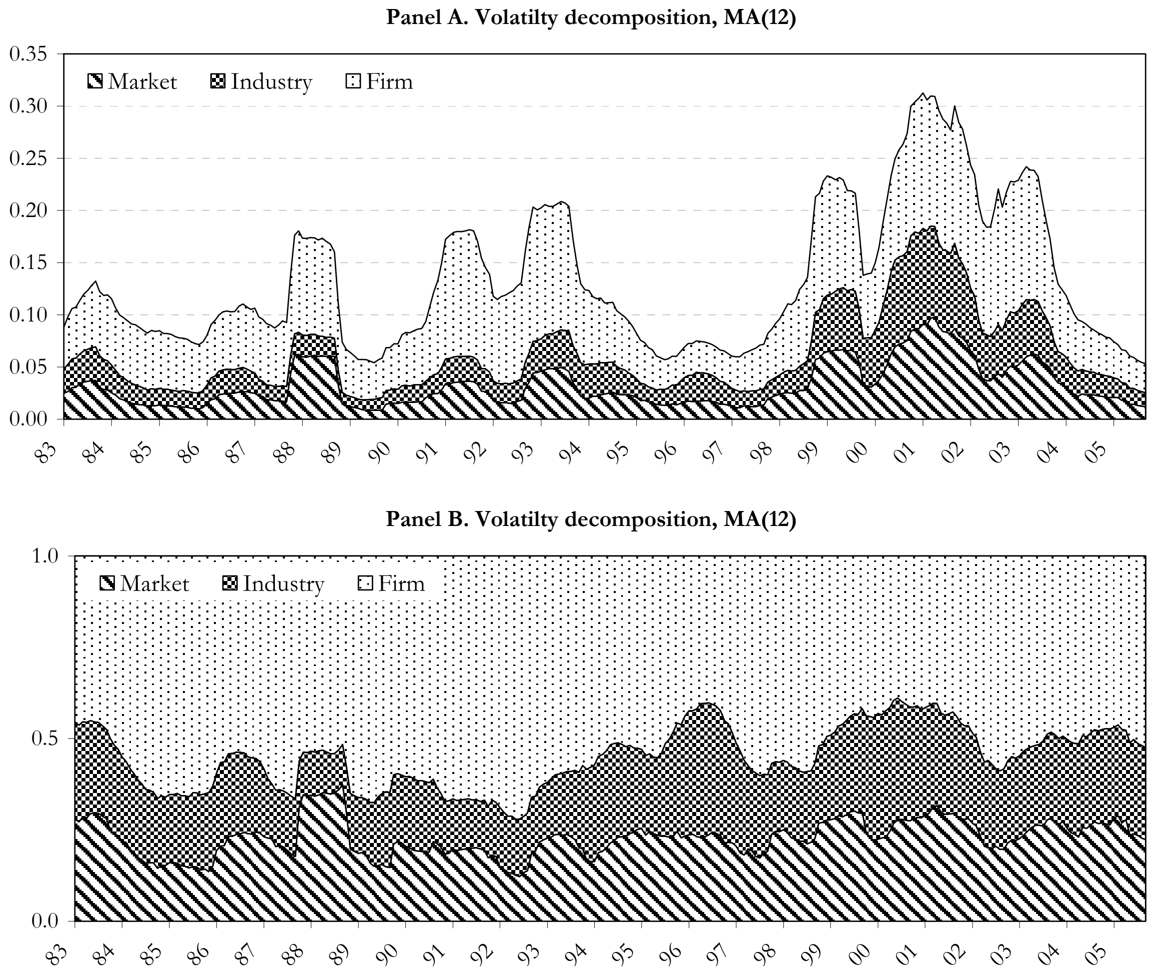


Figure 4. Volatility decomposition, Sweden. The absolute (A.) and relative (B.) sum of twelve-month moving averages of the components of weighted average firm volatility $\sum_i w_{it} \sum_{j \in i} w_{jit} \operatorname{Var}\left(R_{jit}\right) = \sigma_{mt}^2 + \sigma_{\varepsilon t}^2 + \sigma_{\eta t}^2$.

From table VII, we can determine that all three volatility series exhibit high autocorrelation which may be an indication that they contain unit roots. Hence, Augmented Dickey Fuller (ADF) tests are conducted on the time series and reported in table VIII. The tests are performed with and without a trend component and on the whole sample as well as a sample that ends in December 1997 to make it comparable with Campbell et al. (2001). The hypothesis of a unit root can be rejected at the five percent significance level on all instances, thus indicating stationarity.

Table VI.

Correlation structure, Sweden

The table shows the correlation between the three monthly volatility time series over the Swedish sample.

MKT	IND	FIRM
1.000	0.650	0.615
	1.000	0.681
		1.000

Table VII.

Autocorrelation structure, Sweden

The table shows the autocorrelation (ACF) and partial autocorrelation (PACF) function of the three monthly volatility time series; MKT, IND and FIRM in Sweden from Jan 1982 to Sep 2005.

	Autocorrelation			**Partial Autocorrelation**		
	MKT	IND	FIRM	MKT	IND	FIRM
ϱ_1	0.516	0.686	0.717	0.516	0.686	0.717
ϱ_2	0.277	0.615	0.508	0.015	0.272	-0.012
ϱ_3	0.226	0.635	0.431	0.105	0.289	0.148
ϱ_4	0.144	0.460	0.367	-0.019	-0.187	0.017
ϱ_6	0.110	0.463	0.271	0.015	0.086	0.118
ϱ_{12}	0.100	0.443	0.201	0.071	0.070	-0.026

Table VIII.

Unit Root Tests, Sweden

This table reports the test statistics of the Augmented Dickey Fuller (ADF) test applied to the three monthly volatility time series. The left panel shows the test statistics for the whole sample whereas the right panel is cut of at December 1997 to enhance comparability with Campbell et al. (2001). The lag order is determined using the Akaike information criterion, and is reported for each test. The test is performed with and without the trend component (t), and the test specification is $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-1} + \varepsilon_t$

	Jan 1982 - Sep 2005			Jan 1982 - Dec 1997		
	MKT	IND	FIRM	MKT	IND	FIRM
Constant						
t-test	-6.52	-3.65	-5.11	-6.04	-4.83	-5.29
p-value	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000
Lag order	2	4	2	2	3	1
Constant & trend						
t-test	-6.56	-3.92	-5.14	-6.12	-4.97	-5.28
p-value	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
Lag order	2	4	2	2	3	1

6.2 Denmark

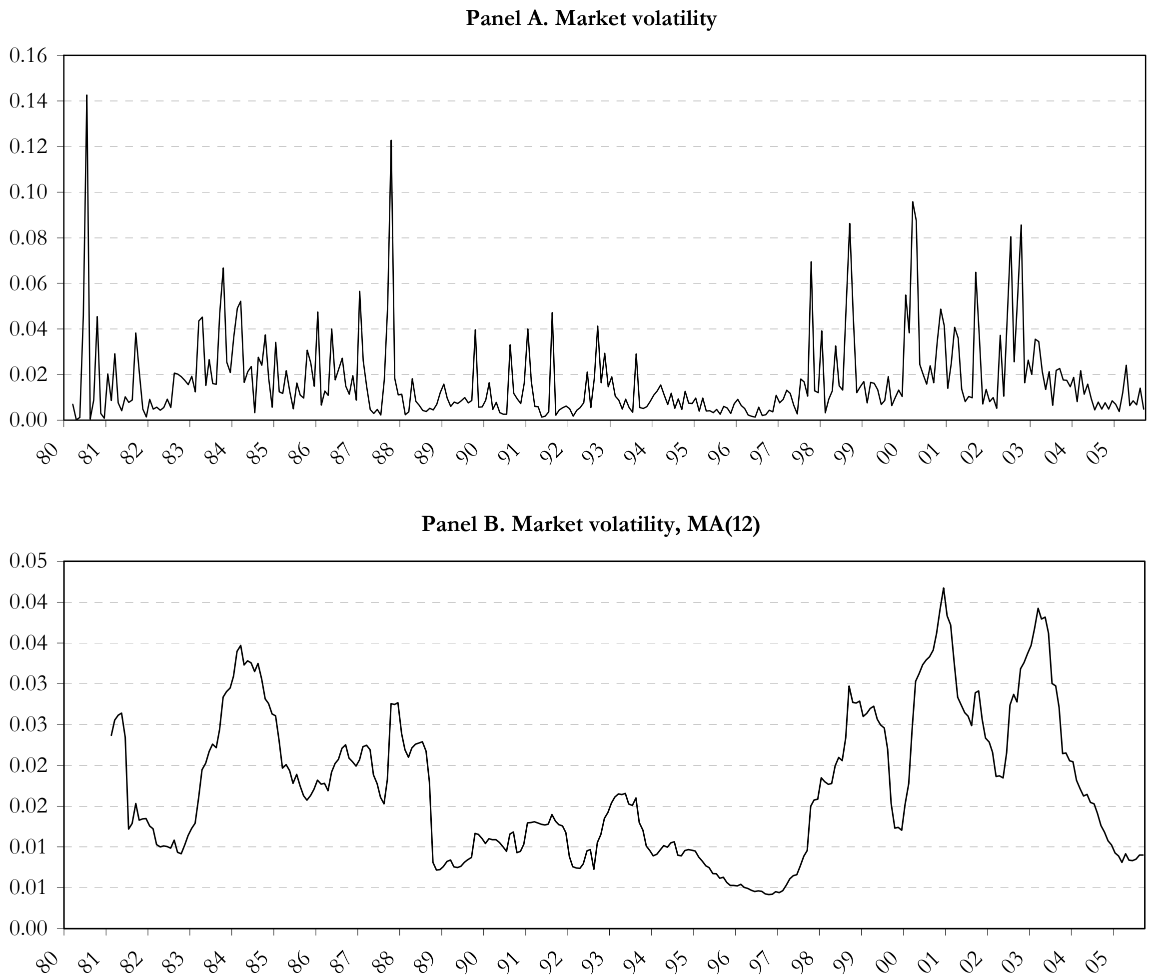


Figure 5. Market volatility, Denmark. Panel A shows the annualised variance of each month from Jan 1980 to Sep 2005 calculated as $\text{MKT}_t = \hat{\sigma}^2_{mt} = \sum_{s \in t} \left(\text{R}_{ms} - \mu_m \right)^2$. Panel B shows the twelve month moving average.

From a visual inspection of figure 5 above, the market level volatility component in Denmark appears to lack any trend just as in the case of Sweden. Also, a spike at the time of the global stock market crash in October 1987 is evident, as well as heightened volatility in the late 90's and the first few years of the new millennium. Moreover, as in the case of Sweden, it is also evident that market volatility has returned to a low level in recent years. As a general observation, market level volatility seems to have behaved very similarly in Denmark and Sweden over the sample period.

Table IX.

Linear trend estimation, MKT volatility time series Denmark

	Feb 80 - Sep 05	Feb 80 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	0.031	-0.724***	-1.774**
t-value	(0.258)	(-3.889)	(-2.295)

Table IX shows that, when tested in isolation, both the pre and post December 1997 time series exhibit statistically significant negative trends. However, there is no statistically significant trend in market volatility when testing over the entire sample

Industry level volatility in Denmark over the sample period, shown in figure 6, exhibits a steadily declining pattern from the early 1980's to around 1997, where after it increases sharply and peaks in spring 2000. It then returns gradually to what appears to be a long term average level by the end of the sample period.

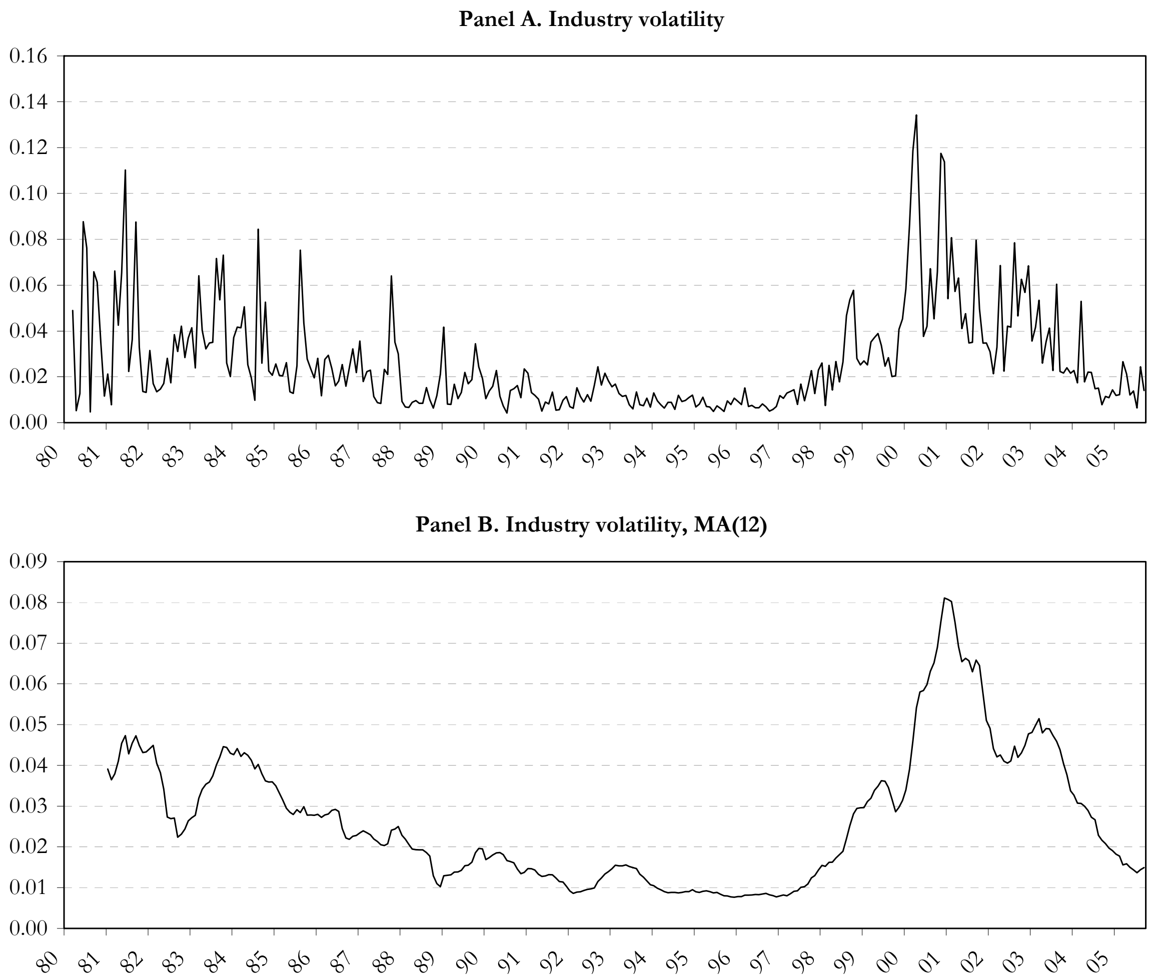


Figure 6. Industry volatility, Denmark. Panel A shows the annualised variance of each month from Jan 1980 to Sep 2005 calculated as $\mathrm{IND}_t = \sum_i w_{it}\hat{\sigma}^2_{\varepsilon it}$. The twelve month moving average is shown in panel B.

Statistically, as shown in table X below, there is no linear trend when testing over the entire industry volatility time series. The pre and post December 1997 time series both exhibit significant negative trends, in line with the visual evidence. However, in conclusion, there does not seem to be any overall trend present in the data.

Table X.

Linear trend estimation, IND volatility time series Denmark

	Feb 80 - Sep 05	Feb 80 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	0.101	-1.710***	-2.749***
t-value	(0.702)	(-10.499)	(-2.845)

Turning to the firm level component of volatility, a cyclical pattern can be discerned in figure 7. From the beginning of the sample period until the beginning of the new millennium, there appears to be a positive trend in the time series. However, as has been the case with all the time series studied so far, the volatility returns to a relatively lower level by the end of the sample period, which contradicts the notion of a positive trend in the firm level component of volatility.

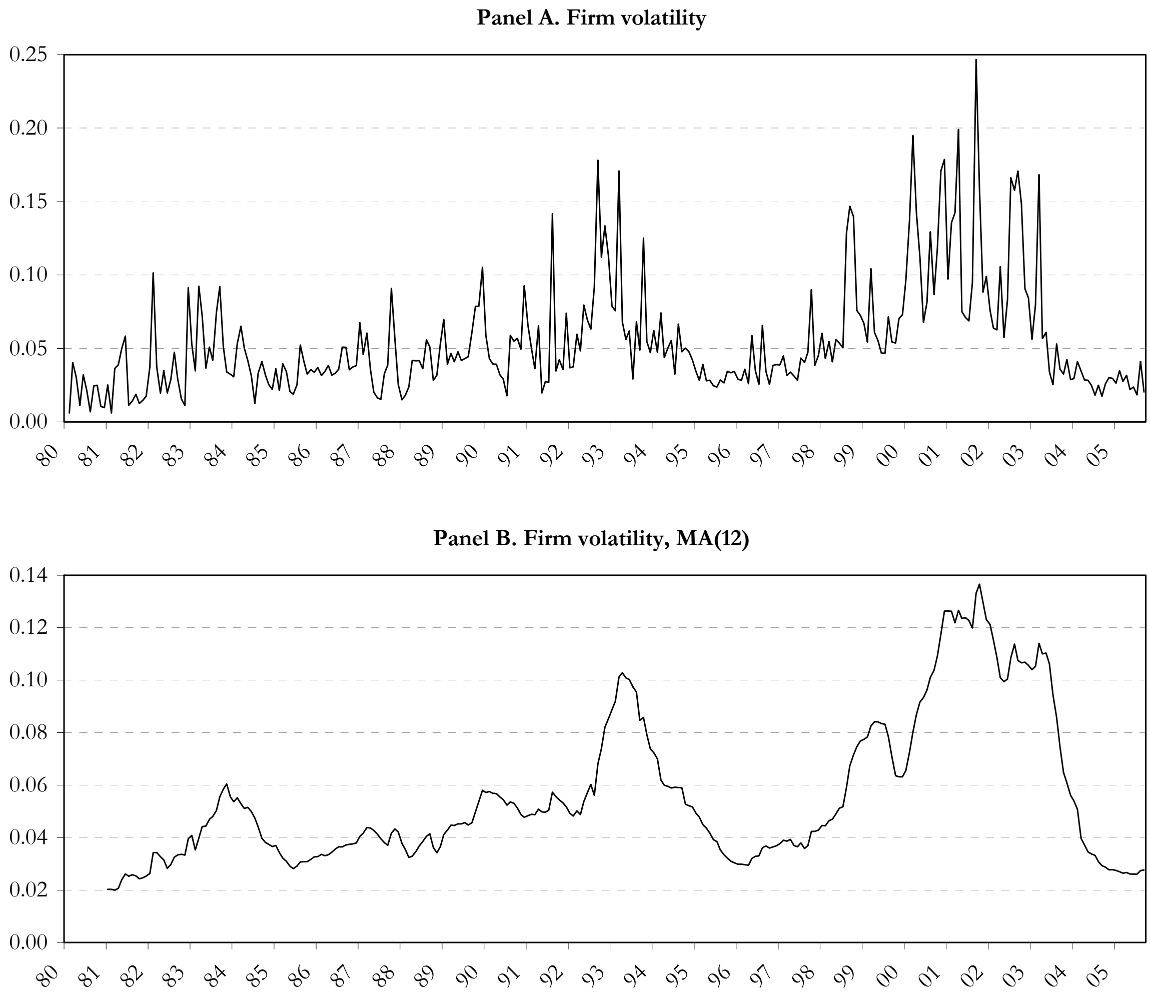


Figure 7. Firm volatility, Denmark. Panel A shows the annualised variance of each month from Jan 1980 to Sep 2005 calculated as $\text{FIRM}_t = \sum_i w_{it}\hat{\sigma}^2_{\eta it}$. The backwards twelve month moving average is shown in panel B.

Table XI confirms the impression from the visual inspection, of a positive trend over the sample, which however is reversed by the end of the time series.

Table XI.

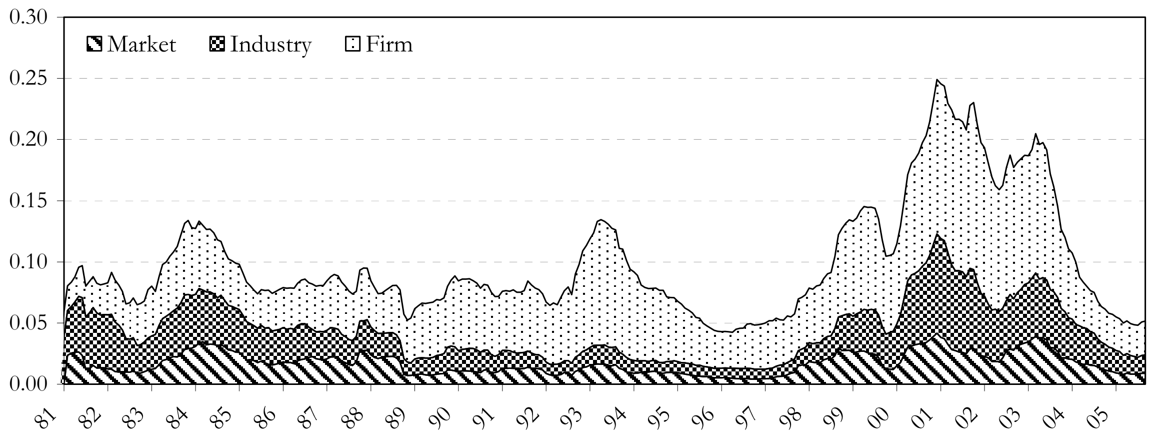
Linear trend estimation, FIRM volatility time series Denmark

	Feb 80 - Sep 05	Feb 80 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	1.485***	1.005***	-6.905***
t-value	(6.423)	(3.562)	(-3.811)

Figure 22 in the appendix reveals that the number of listed firms in Denmark has fallen since the early 1990's and the Hirfendahl-Hirchman indices in figure 29 show that the concentration of firms in the market is U-shaped over the sample, the concentration of individual industries as a share of the market has decreased steadily and that the concentration of firms within industries exhibits peaks that coincide with the shape of the industry volatility component.

The volatility decomposition in figure 8 reveals that the total weighted average volatility of Danish stocks has been relatively constant except during the mid 1980's, the financial crisis in the early 1990's and, especially, around the turn of the millennium. The bottom panel shows that the relative size of the market component has been fairly stable over time, whereas the firm component increased up until the mid 1990's after which it is pushed back by the industry component.

Panel A. Volatilty decomposition, MA(12)



Panel B. Volatilty decomposition, MA(12)

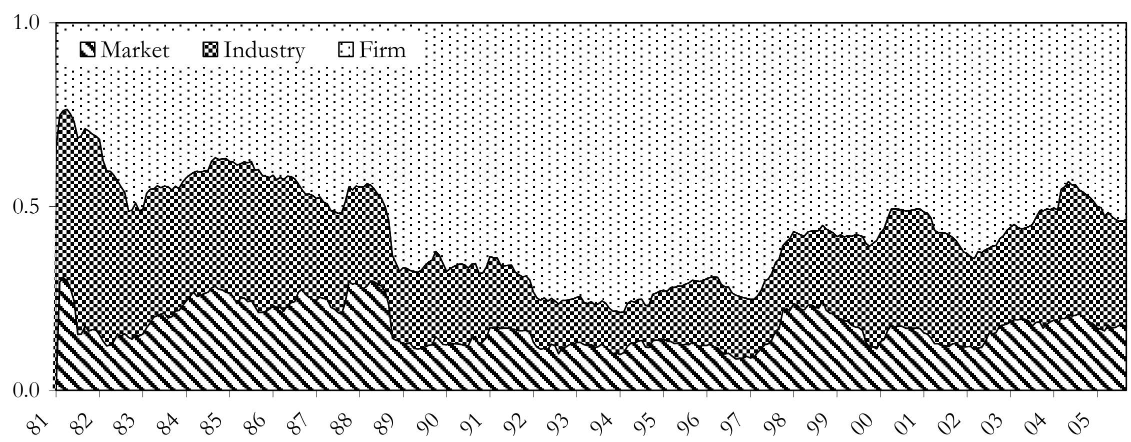


Figure 8. Volatility decomposition, Denmark. The absolute (A.) and relative (B.) sum of twelve-month moving averages of the components of weighted average firm volatility $\sum_i w_{it} \sum_{j \in i} w_{jit} \mathrm{Var}(R_{jit}) = \sigma^2_{mt} + \sigma^2_{\varepsilon t} + \sigma^2_{\eta t}$.

Table XIII reveals that autocorrelation again is strong in all three time series, inducing us to perform a test for unit root. The results from the augmented dickey fuller test presented in table XIV show that the null hypothesis of a unit root can be rejected for all time series, performing the test with and without a trend component, and regardless of whether the time series is cut off at December 1997.

Table XII.

Correlation structure, Denmark

The table shows the correlation between the three monthly volatility time series over the Danish sample.

MKT	IND	FIRM
1.000	0.628	0.512
	1.000	0.542
		1.000

Table XIII.

Autocorrelation structure, Denmark

The table shows the autocorrelation (ACF) and partial autocorrelation (PACF) function of the three monthly volatility time series; MKT, IND and FIRM in Sweden from Jan 1980 to Sep 2005.

	Autocorrelation			**Partial Autocorrelation**		
	MKT	IND	FIRM	MKT	IND	FIRM
ϱ_1	0.359	0.636	0.669	0.359	0.636	0.669
ϱ_2	0.130	0.524	0.528	0.001	0.200	0.146
ϱ_3	0.184	0.513	0.466	0.158	0.208	0.123
ϱ_4	0.061	0.455	0.432	-0.065	0.062	0.098
ϱ_6	0.108	0.408	0.443	0.055	0.122	0.083
ϱ_{12}	0.106	0.440	0.383	0.050	0.110	0.026

Table XIV.

Unit Root Tests, Denmark

This table reports the test statistics of the Augmented Dickey Fuller (ADF) test applied to the three monthly volatility time series. The left panel shows the test statistics for the whole sample whereas the right panel is cut of at December 1997 to enhance comparability with Campbell et al. (2001). The lag order is determined using the Akaike information criterion, and is reported for each test. The test is performed with and without the trend component (t), and the test specification is $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-1} + \varepsilon_t$

	Jan 1980 - Sep 2005			Jan 1980 - Dec 1997		
	MKT	IND	FIRM	MKT	IND	FIRM
Constant						
t-test	-5.48	-4.21	-3.25	-4.66	-3.16	-4.95
p-value	0.0000	0.0000	0.0013	0.0000	0.0018	0.0000
Lag order	5	3	5	5	5	2
Constant & trend						
t-test	-5.49	-4.22	-3.78	-5.10	-5.37	-5.15
p-value	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000
Lag order	5	3	4	5	5	2

6.3 Finland

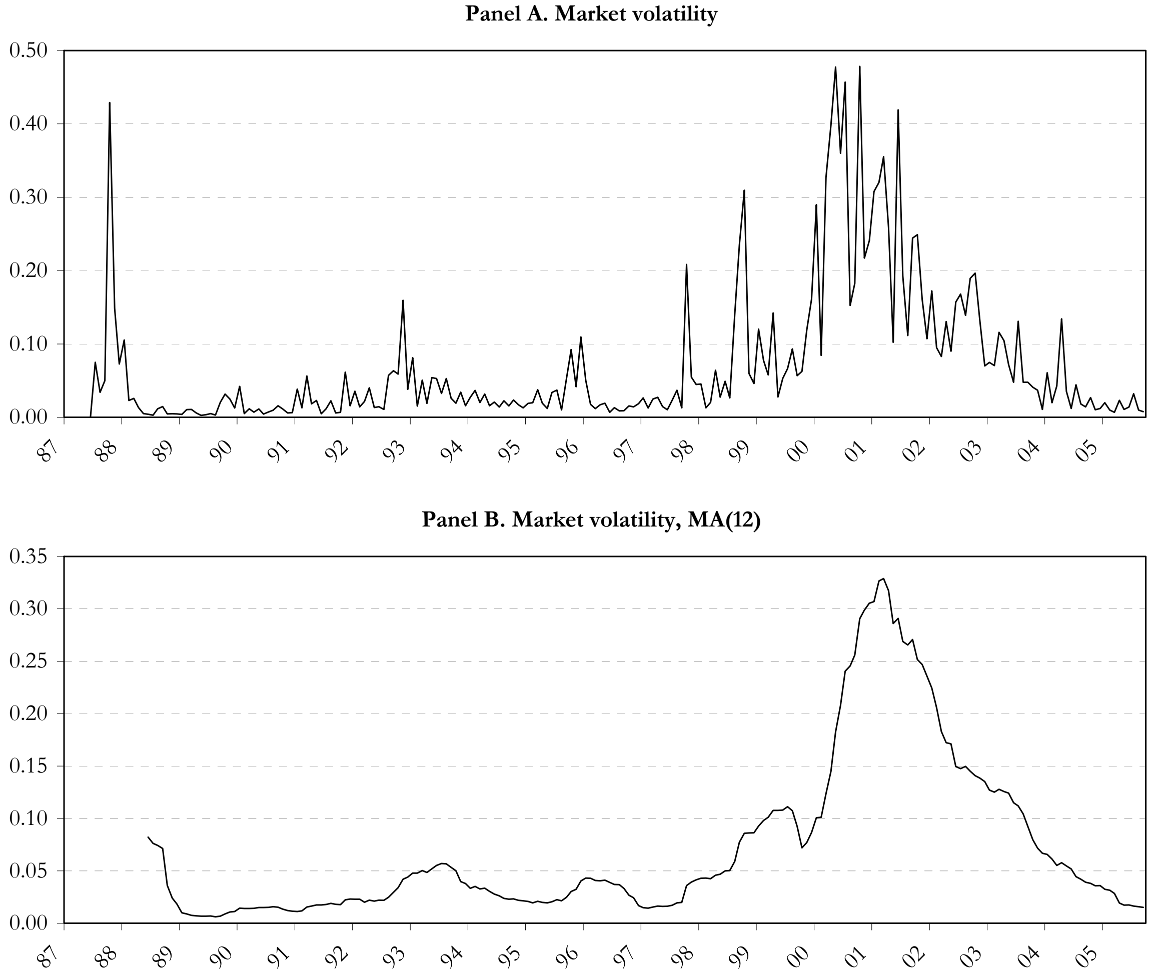


Figure 9. Market volatility, Finland. Panel A shows the annualised variance of each month from Jun 1987 to Sep 2005 calculated as $\mathrm{MKT}_t = \hat{\sigma}^2_{mt} = \sum_{s \in t} \left(R_{ms} - \mu_m\right)^2$. Panel B shows the twelve month moving average.

The Finnish market level component time series, which starts in June 1987 and is presented in figure 9, begins with a major spike corresponding to the global stock market crash in October 1987. The volatility is then more or less constant until around 1998 when it increases significantly, to peak in year 2000 when the IT bubble burst and the gradually return to normal levels by the end of the sample. Hence, no general trend can be distinguished over the sample.

Table XV.
Linear trend estimation, MKT volatility time series Finland

	Jun 87 - Sep 05	Jun 87 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	4.939***	-0.600	-14.838***
t-value	(5.046)	(-0.517)	(-3.420)

Again, the trend estimation, presented in table XV, shows the tendency of an overall positive trend, which is reversed by a strongly negative trend in the post December 1997 period.

The industry level component shown in figure 10 also does not appear to exhibit any trend. A number of spikes can be observed as well as a general increase in the volatility level around the turn of the millennium.

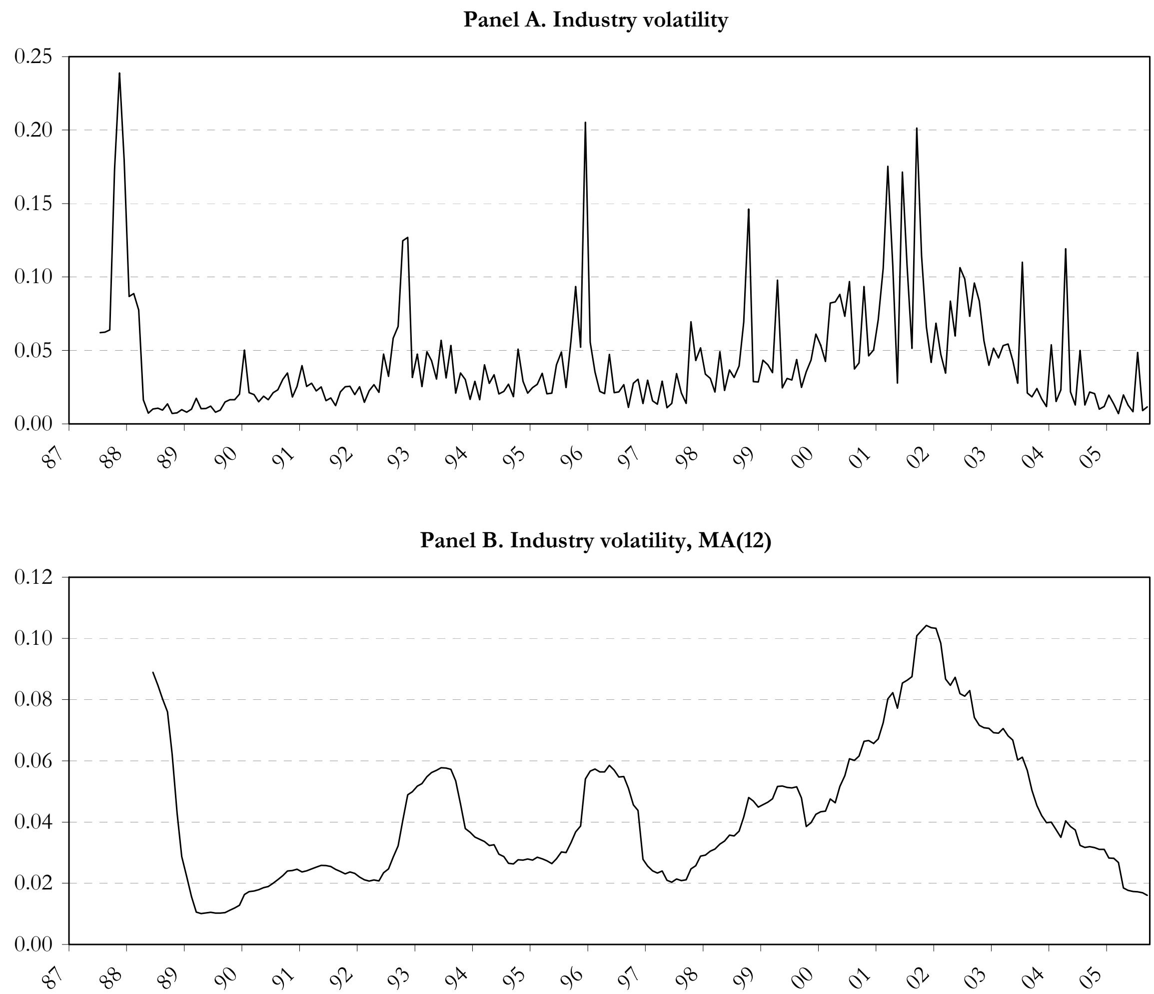


Figure 10. Industry volatility, Finland. Panel A shows the annualised variance of each month from Jun 1987to Sep 2005 calculated as $\mathrm{IND}_t = \sum_i w_{it}\hat{\sigma}^2_{\varepsilon it}$. The twelve month moving average is shown in panel B.

As was the case for market volatility, the trend estimation for industry volatility shows a positive trend over the sample, but is reversed by a strongly negative trend in the post December 1997 period.

Table XVI.

Linear trend estimation, IND volatility time series Finland

	Jun 87 - Sep 05	Jun 87 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	0.699*	-0.917	-3.306**
t-value	(1.695)	(-1.013)	(-2.228)

Firm level volatility show in figure 11 is generally increased, and exhibits spikes, during the early years of the 1990's in conjunction with the financial crisis. Besides this, it appears to maintain a relatively steady level.

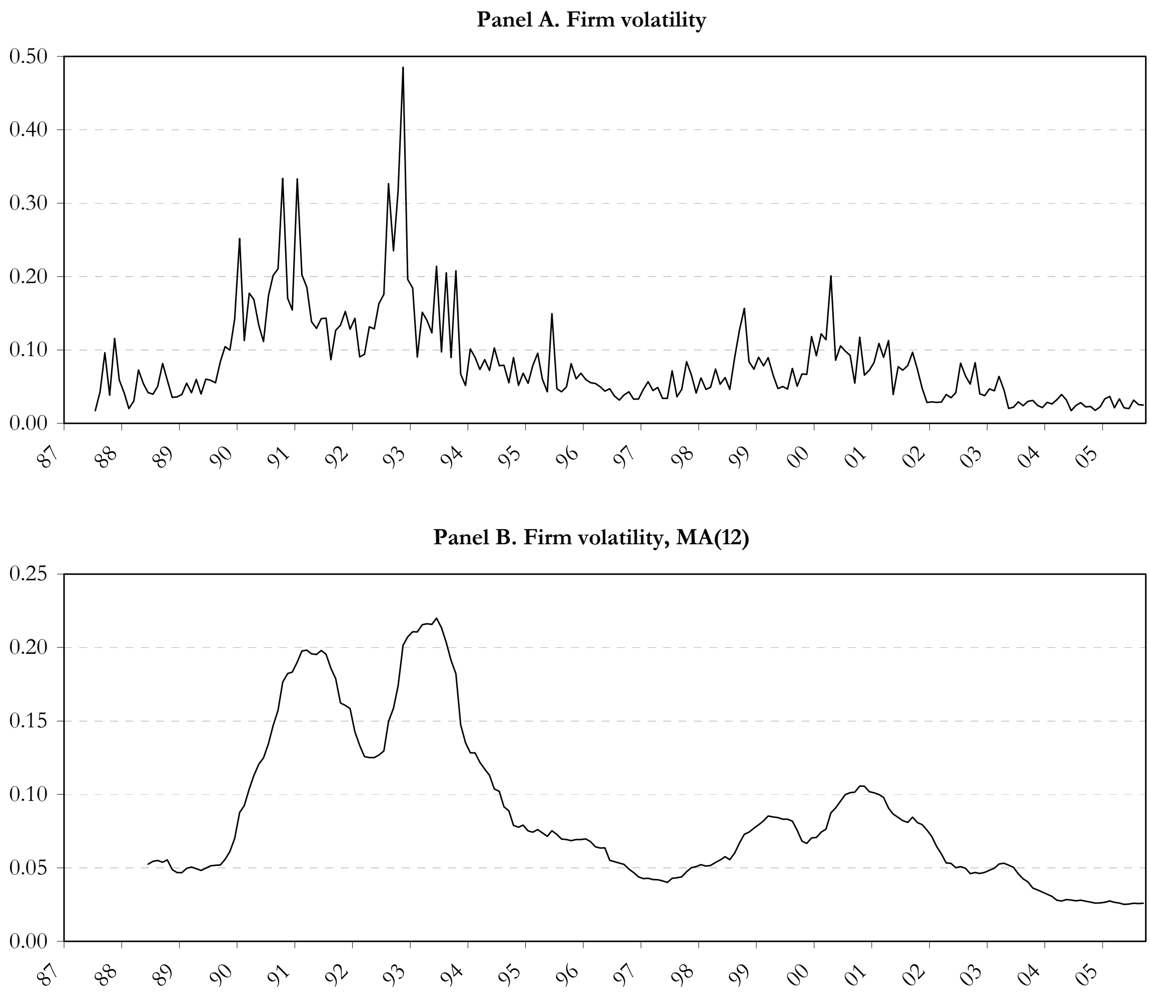


Figure 11. Firm volatility, Finland. Panel A shows the annualised variance of each month from Jun 1987 to Sep 2005 calculated as $\text{FIRM}_t = \sum_i w_{it} \hat{\sigma}^2_{\eta it}$. The backwards twelve month moving average is shown in panel B.

Uniquely, the trend estimation for firm level volatility in Finland turns out significantly negative over all three time intervals as presented in table XVII below.

Table XVII.

Linear trend estimation, FIRM volatility time series Finland

	Jun 87 - Sep 05	Jun 87 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	-4.206***	-3.374*	-8.070***
t-value	(-6.560)	(-1.829)	(-7.751)

Figure 23 in the appendix, displaying the development of the number of individual stocks in the Finnish sample, tells us that the total count available through Datastream was very low until in 1988, indicating that the industry classification and volatility decomposition may not be very accurate prior to that. Subsequently, the number gradually increased and peaked in 2000/2001, after which it has declined slowly. Figure 26 showing average and median market capitalization, reveals a large peak in average market capitalization in year 2000 but not in the median market capitalization. We assume that this is due to the fact that Nokia constituted a very substantial share of the total Finnish market at that time, and see this as an explanation for the peculiar patterns of volatility in Finland.

The sum of volatility components, shown in figure 12, displays no trend, but increased levels during the early 1990's as well as over the turn of the millennium. However, it is interesting to note that the relative size of the three components changed dramatically over the sample period. The market and industry components dominate at the beginning of the sample, only to be taken over by the firm component in the early 1990's. Interestingly, the firm component is then gradually pushed back by the market component, culminating in the early 2000's. The firm level component then increases in relative size at the end of the sample period. Again, we suspect that this is related to Nokia gradually starting to dominate the Finnish equity market over the course of the 1990's.

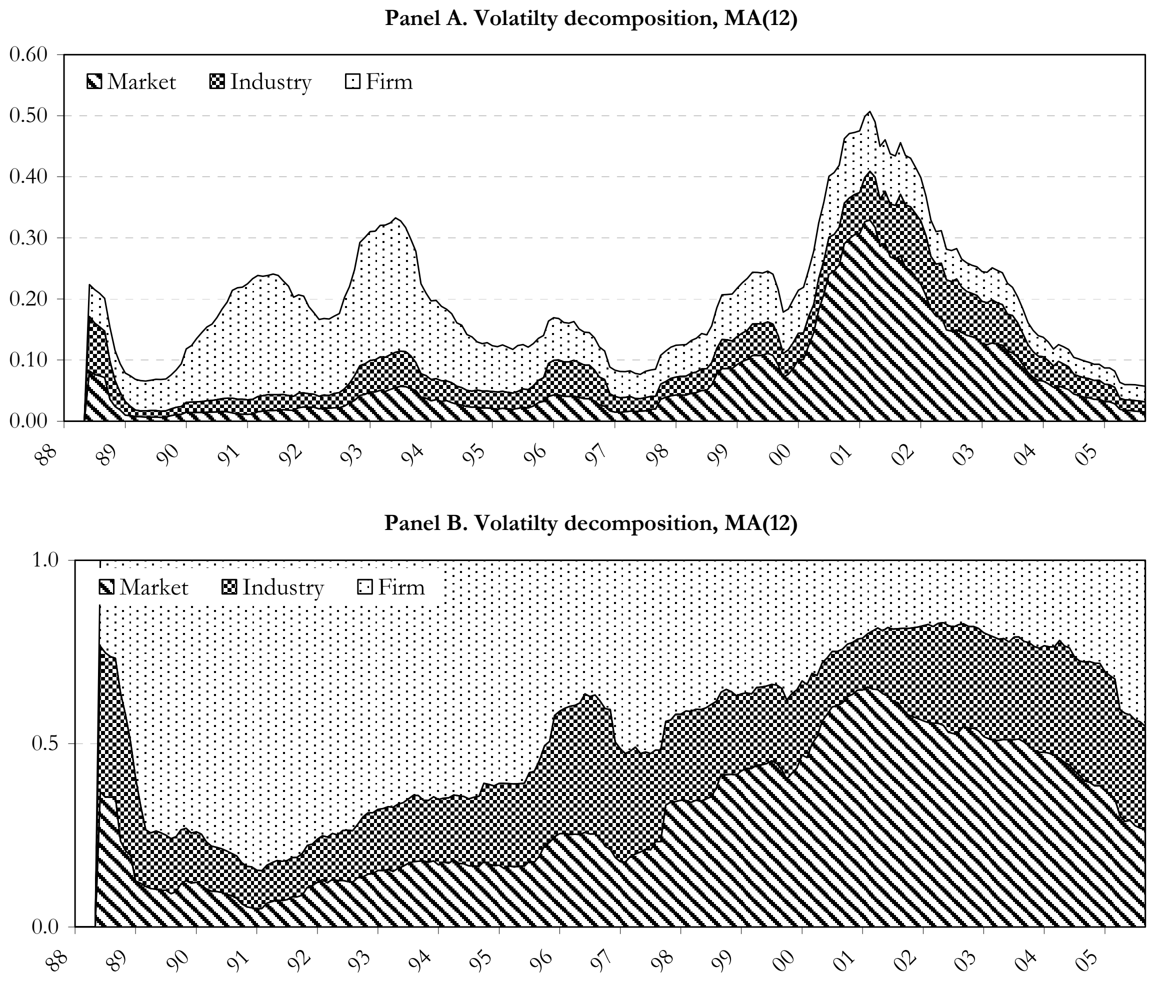


Figure 12. Volatility decomposition, Finland. The absolute (A.) and relative (B.) sum of twelve-month moving averages of the components of weighted average firm volatility $\sum_i w_{it} \sum_{j \in i} w_{jit} \mathrm{Var}(\mathrm{R}_{jit}) = \sigma^2_{mt} + \sigma^2_{\varepsilon t} + \sigma^2_{\eta t}$.

Turning to figure 32 in the appendix, we make some interesting observations in the Herfindahl-Hirschman indices. Sepcifically, the concentration with respect to all three indices is extremely high until late 1987 due to the low number of stocks reported in Datastream. This explains the very large relative size of the market and industry components in figure 12 in the beginning of the sample. Subsequently, the concentration is relatively constant until 1997/1998 when it starts to increase gradually. Peaking in 2000, the concentration measures reach very high levels, again explaining the peculiar patterns resulting from the volatility decomposition.

Similar to the case of Sweden and Denmark, there is strong autocorrelation in all three time series, as indicated by the statistics in table XIX. Thus, the Augmented Dickey Fuller test for unit root is performed and reported in table XX. However, the hypothesis of a unit root is rejected at all instances.

Table XVIII.

Correlation structure, Finland

The table shows the correlation between the three monthly volatility time series over the Finnish sample.

MKT	IND	FIRM
1.000	0.687	0.080
	1.000	0.164
		1.000

Table XIX.

Autocorrelation structure, Finland

The table shows the autocorrelation (ACF) and partial autocorrelation (PACF) function of the three monthly volatility time series; MKT, IND and FIRM in Sweden from Jun 1987 to Sep 2005.

	Autocorrelation			**Partial Autocorrelation**		
	MKT	IND	FIRM	MKT	IND	FIRM
ϱ_1	0.702	0.551	0.716	0.702	0.551	0.716
ϱ_2	0.643	0.421	0.694	0.296	0.169	0.372
ϱ_3	0.675	0.440	0.644	0.324	0.228	0.158
ϱ_4	0.602	0.268	0.564	0.044	-0.109	-0.023
ϱ_6	0.559	0.202	0.477	0.063	0.029	0.020
ϱ_{12}	0.429	0.144	0.402	-0.032	0.042	0.020

Table XX.

Unit Root Tests, Finland

This table reports the test statistics of the Augmented Dickey Fuller (ADF) test applied to the three monthly volatility time series. The left panel shows the test statistics for the whole sample whereas the right panel is cut of at December 1997 to enhance comparability with Campbell et al. (2001). The lag order is determined using the Akaike information criterion, and is reported for each test. The test is performed with and without the trend component (t), and the test specification is $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-1} + \varepsilon_t$

	Jun 1987 - Sep 2005			Jun 1987 - Dec 1997		
	MKT	IND	FIRM	MKT	IND	FIRM
Constant						
t-test	-2.78	-5.23	-2.95	-4.96	-6.64	-2.38
p-value	0.0059	0.0000	0.0035	0.0000	0.0000	0.0190
Lag order	3	5	2	5	5	2
Constant & trend						
t-test	-3.23	-5.74	-3.52	-5.23	-6.69	-2.51
p-value	0.0015	0.0000	0.0005	0.0000	0.0000	0.0135
Lag order	3	5	2	5	5	2

6.4 Norway

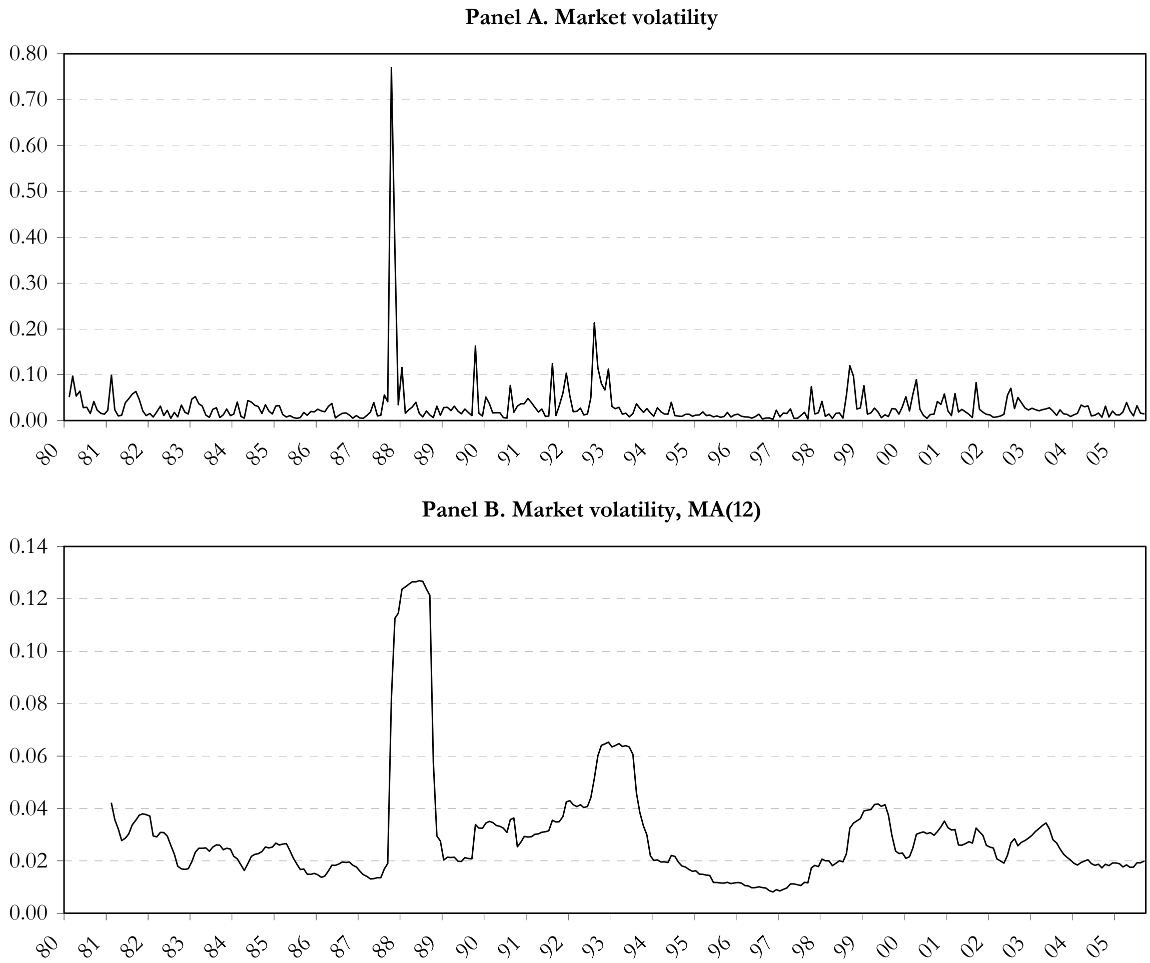


Figure 13. Market volatility, Norway. Panel A shows the annualised variance of each month from Feb 1980 to Sep 2005 calculated as $\mathrm{MKT}_t = \hat{\sigma}^2_{mt} = \sum_{s \in t} \left(R_{ms} - \mu_m\right)^2$. Panel B shows the twelve month moving average.

The Norwegian market volatility time series, shown in figure 13 above, does not appear to have any trend by visual inspection. Except for the spike in October 1987, observed in every studied country, and some smaller spikes in the early 1990's and around the turn of the millennium, there are not many observations to be made in the data.

There are no statistically significant trends over the whole sample or the pre December 1997 sample, as shown in table XXI below. However, there is evidence of a negative trend in the post December 1997 period.

Table XXI.

Linear trend estimation, MKT volatility time series Norway

	Feb 80 - Sep 05	Feb 80 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	-0.462	-0.601	-1.701**
t-value	(-1.360)	(-0.883)	(-2.093)

The industry component of volatility shown in figure 14 below also lacks any distinguishable trend. Several spikes can be observed, as well as an exceptionally "quiet" period during the mid 1990's.

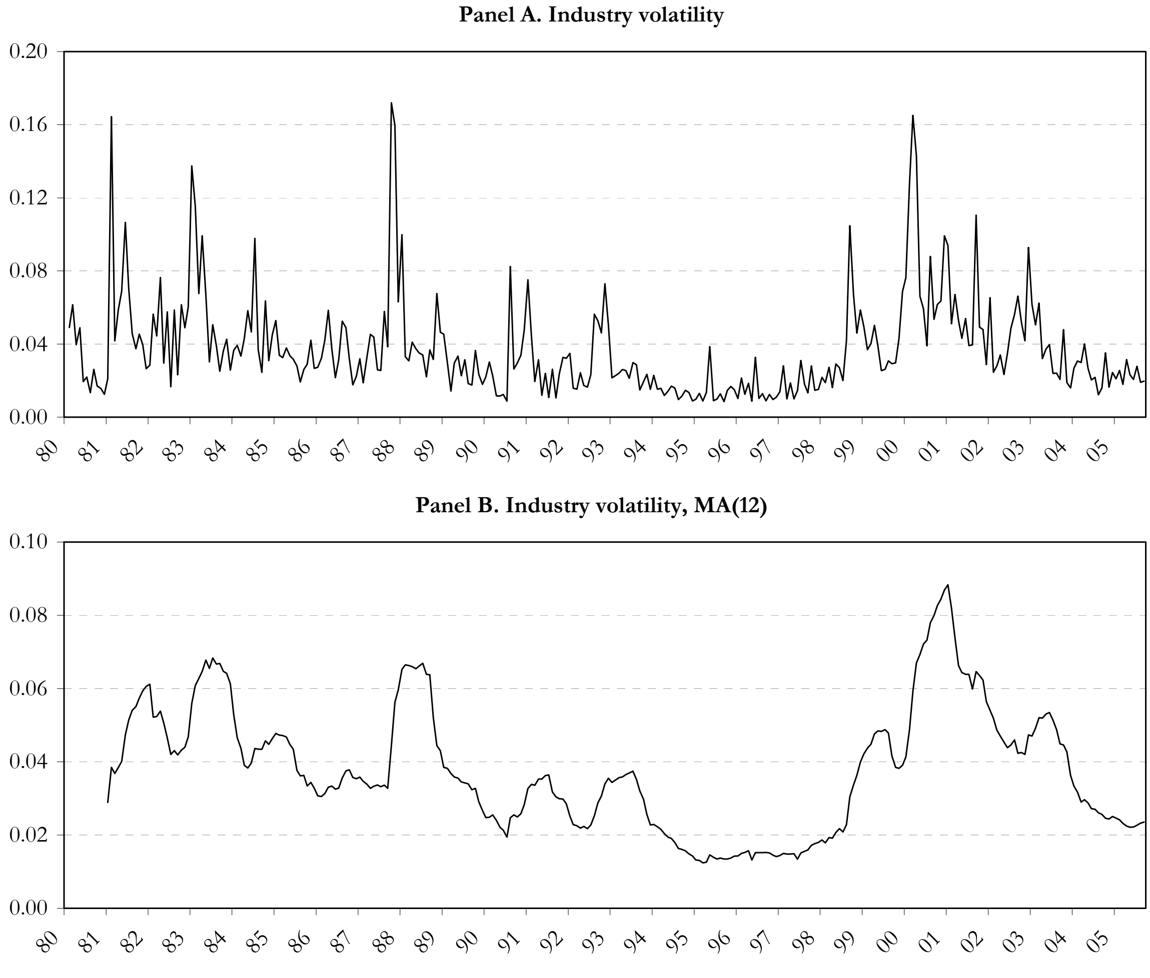


Figure 14. Industry volatility, Norway. Panel A shows the annualised variance of each month from Feb 1980 to Sep 2005 calculated as $IND_t = \sum_i w_{it}\hat{\sigma}^2_{\varepsilon it}$. The twelve month moving average is shown in panel B.

Negative trends are evident over all time periods in table XXII below, although the trend over the entire sample is only significant on the ten percent level. The visual inspection, however, revealed a return to a normal level by the end of the sample rather than any discernable trend.

Table XXII.

Linear trend estimation, IND volatility time series Norway

	Feb 80 - Sep 05	Feb 80 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	-0.308*	-1.909***	-3.373***
t-value	(-1.767)	(-7.442)	(-3.224)

The firm level volatility reported in figure 15 below is generally flat, but is dominated by a number of very large spikes around year 2003. However, volatility returns to normal levels by the end of the sample period.

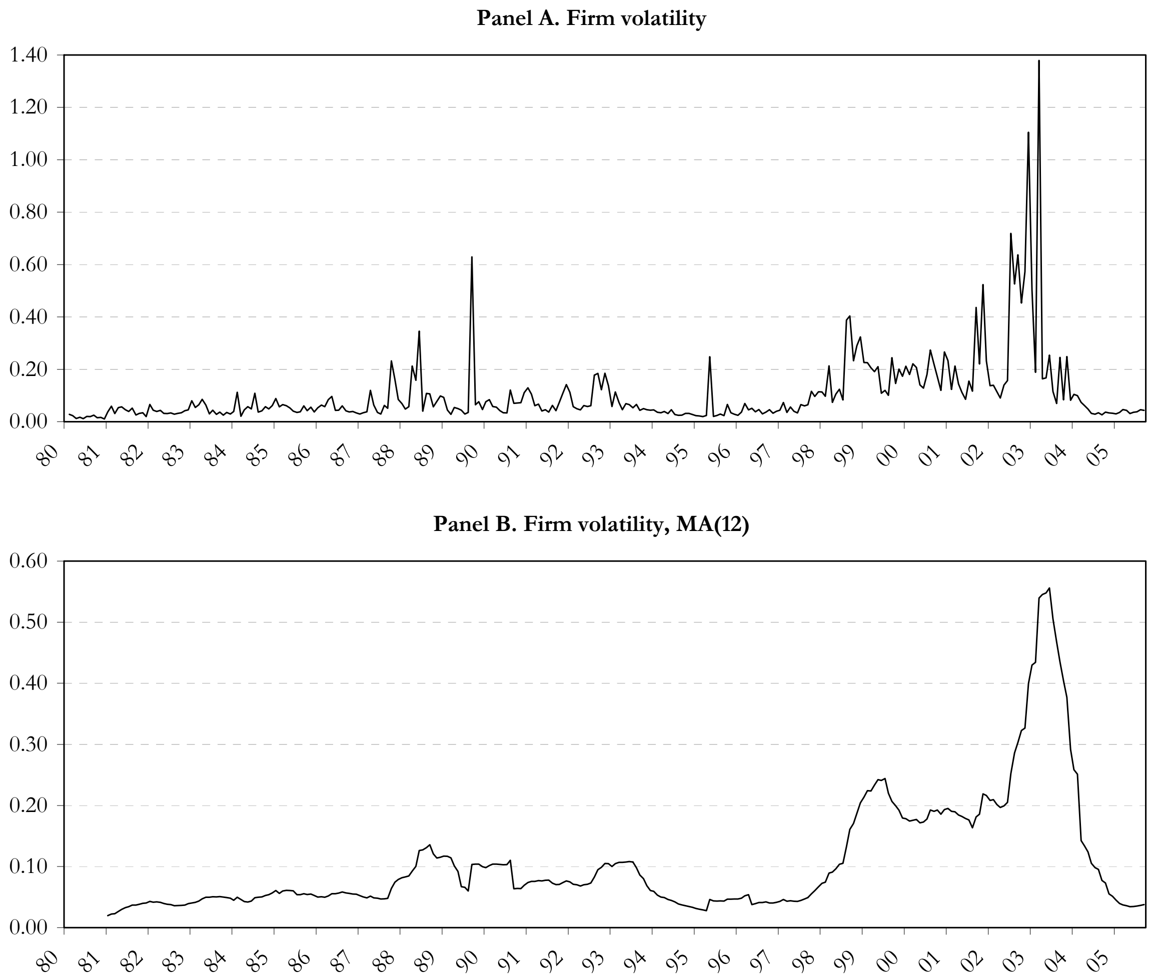


Figure 15. Firm volatility, Norway. Panel A shows the annualised variance of each month from Feb 1980 to Sep 2005 calculated as $\text{FIRM}_t = \sum_i w_{it}\hat{\sigma}^2_{\eta it}$. The backwards twelve month moving average is shown in panel B.

The spikes around 2003 contribute to generating a statistically significant trend when testing the entire sample. However, this is evidently reversed by the end of the sample.

Table XXIII.

Linear trend estimation, FIRM volatility time series Norway

	Feb 80 - Sep 05	Feb 80 - Dec 97	Jan 98 - Sep 05
Linear trend * 10^4	5.860***	1.049*	-9.508
t-value	(6.977)	(1.659)	(-1.169)

The number of firms in the sample, presented in figure 24 in the appendix, shows a steady increase from the beginning of the sample up until 1998 after which it started to decline. However, the increased IPO activity in Norway since 2004 has reversed that trend. The average and median market capitalization has increased steadily, disregarding a few kinks in the curve, and the Herfindahl-Hirchmann indices in figure 30 show that all concentration measures are decreasing from the beginning of the sample.

Studying the sum of the three volatility components in figure 16 below, one observes that there is no trend in the series. However, there are periods of increased total volatility. Notably in late 1980 and the early 1990's, and especially from 1998 to mid 2004. The relative size of the firm component increased from the beginning of the sample period until the mid 1990's, where after it has been pushed back somewhat by the market and industry components.

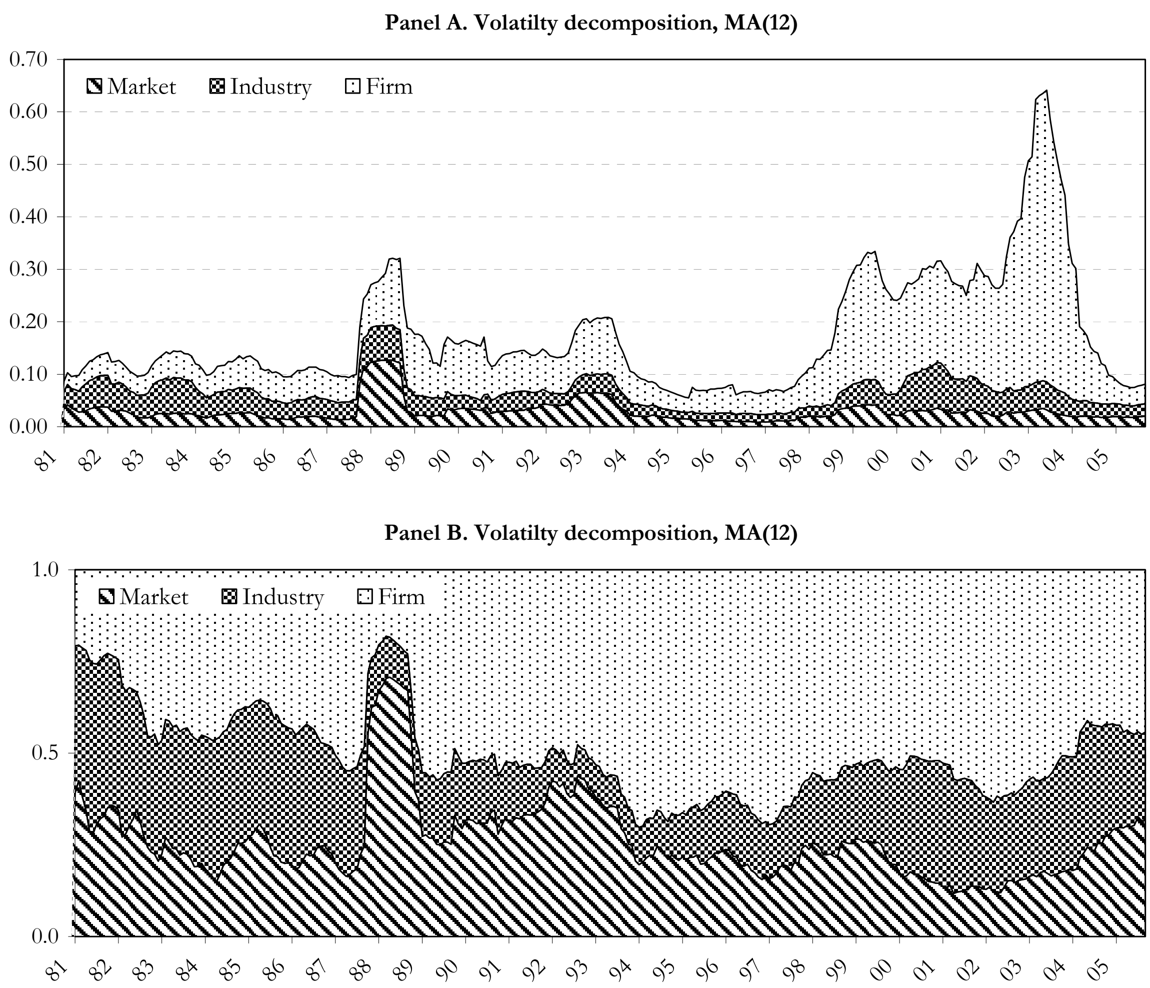


Figure 16. Volatility decomposition, Norway. The absolute (A.) and relative (B.) sum of twelve-month moving averages of the components of weighted average firm volatility $\sum_i w_{it} \sum_{j \in i} w_{jit} \mathrm{Var}\left(\mathrm{R}_{jit}\right) = \sigma_{mt}^2 + \sigma_{\varepsilon t}^2 + \sigma_{\eta t}^2$.

Table XXIV.

Correlation structure, Norway

The table shows the correlation between the three monthly volatility time series over the Norwegian sample.

MKT	IND	FIRM
1.000	0.525	0.136
	1.000	0.335
		1.000

Table XXV.

Autocorrelation structure, Norway

The table shows the autocorrelation (ACF) and partial autocorrelation (PACF) function of the three monthly volatility time series; MKT, IND and FIRM in Sweden from Feb 1980 to Sep 2005.

	Autocorrelation			**Partial Autocorrelation**		
	MKT	IND	FIRM	MKT	IND	FIRM
ϱ_1	0.384	0.584	0.590	0.384	0.584	0.590
ϱ_2	0.103	0.461	0.602	-0.052	0.183	0.389
ϱ_3	0.110	0.382	0.456	0.103	0.087	0.017
ϱ_4	0.002	0.279	0.415	-0.086	-0.021	0.025
ϱ_6	-0.005	0.183	0.344	-0.026	0.020	0.082
ϱ_{12}	0.012	0.214	0.368	0.035	0.072	-0.003

Table XXVI.

Unit Root Tests, Norway

This table reports the test statistics of the Augmented Dickey Fuller (ADF) test applied to the three monthly volatility time series. The left panel shows the test statistics for the whole sample whereas the right panel is cut of at December 1997 to enhance comparability with Campbell et al. (2001). The lag order is determined using the Akaike information criterion, and is reported for each test. The test is performed with and without the trend component (t), and the test specification is $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-1} + \varepsilon_t$

	Feb 1980 - Sep 2005			Feb 1980 - Dec 1997		
	MKT	IND	FIRM	MKT	IND	FIRM
Constant						
t-test	-7.92	-6.59	-3.85	-8.48	-5.78	-7.88
p-value	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
Lag order	2	1	2	1	1	1
Constant & trend						
t-test	-7.94	-6.59	-3.85	-8.48	-6.92	-7.95
p-value	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
Lag order	2	1	2	1	1	1

6.5 Common Observations

Our analysis so far has shown that, disregarding the peculiar but explained patterns observed in Finland, there is no discernable long-term trend over any of the volatility time series in our Nordic sample, unlike the findings of Campbell et al (2001) who used US data and found a positive trend in the firm specific volatility component. There are several events during the sample period which cause spikes in the volatility series across all four countries. Notably, the stock market crash in October 1987, the Russian debt crisis in fall 1998 and spikes related to the financial crises in the early 1990's. Also, the increased volatility level in the years after the speculative episode at the turn of the millennium is evident in all four samples. The latter is especially pronounced in the industry volatility component, except in the case of Finland for reasons discussed earlier.

Table XXVII.

Correlation structure, MKT

The table shows the correlation of the MKT time series between the four countries

Sweden	Denmark	Norway	Finland
1.000	0.589	0.629	-0.152
	1.000	0.426	-0.324
		1.000	-0.324
			1.000

Table XXVIII.

Correlation structure, IND

The table shows the correlation of the IND time series between the four countries

Sweden	Denmark	Norway	Finland
1.000	0.516	0.205	-0.119
	1.000	0.426	-0.072
		1.000	-0.001
			1.000

Table XXIX.

Correlation structure, FIRM

The table shows the correlation of the FIRM time series between the four countries

Sweden	Denmark	Norway	Finland
1.000	0.432	0.488	-0.242
	1.000	0.553	-0.080
		1.000	-0.242
			1.000

Cross country correlations range from 0.205, between industry volatility in Sweden and Norway, to 0.629 between market volatility in the same two countries. However, the volatility time series in Finland turn out to be negatively correlated with corresponding series in the other countries. Again, this is explained by the peculiar shape of the volatility curves induced by the steep increase in the Herfindahl-Hirschmann concentration measures over the Finnish sample.

7 Lead-Lag Relationships and Cyclical Behaviour

We now follow the example of Campell et al (2001) and investigate whether each of the different volatility time series in a country are useful in predicting the other two time series, using trivariate Granger causality tests. The p-values for each time series and country are presented in table XXX-XXXIII below. In the case of Sweden, we observe that MKT and IND both have significant predictive power on each other on the five percent level. In addition, FIRM has predictive power on MKT at the five percent level and on IND at the one percent level.

Table XXX.

Granger Causality, Sweden

This table reports the p-values of Granger causality VAR tests on the three volatility time series for Swedish data. The lag length, 5 in this case, has been determined based on the Akaike information criterion.

Trivariate VAR

	MKT_t	IND_t	$FIRM_t$
MKT_t	–	0.0446	0.3189
IND_t	0.0013	–	0.2630
$FIRM_t$	0.0109	0.0020	–

Turning to Norway in table XIX, one can observe that only MKT has any predictive power, on IND in this case and at the one percent level.

Table XXXI.

Granger Causality, Norway

This table reports the p-values of Granger causality VAR tests on the three volatility time series for Norwegian data. The lag length, 4 in this case, has been determined based on the Akaike information criterion.

Trivariate VAR

	MKT_t	IND_t	$FIRM_t$
MKT_t	–	0.0032	0.6570
IND_t	0.6261	–	0.7384
$FIRM_t$	0.7399	0.7687	–

In the case of Finland, MKT has predictive power on IND and vice versa on the one percent level. Moreover, IND significantly Granger causes FIRM on the ten percent level.

Table XXXII.

Granger Causality, Finland

This table reports the p-values of Granger causality VAR tests on the three volatility time series for Norwegian data. The lag length, 5 in this case, has been determined based on the Akaike information criterion.

Trivariate VAR

	MKT_t	IND_t	$FIRM_t$
MKT_t	–	0.0089	0.2992
IND_t	0.0090	–	0.0624
$FIRM_t$	0.6890	0.9769	–

Finally, studying the results of the Granger causality test on Danish data, we observe that IND and FIRM both significantly Granger cause MKT on the five percent level.

Table XXXIII.

Granger Causality, Denmark

This table reports the p-values of Granger causality VAR tests on the three volatility time series for Norwegian data. The lag length, 5 in this case, has been determined based on the Akaike information criterion.

Trivariate VAR

	MKT_t	IND_t	$FIRM_t$
MKT_t	–	0.3286	0.6601
IND_t	0.0272	–	0.9167
$FIRM_t$	0.0425	0.1281	–

Overall, we find that MKT Granger causes IND and the other way around in three out of the four markets. Also, none of the other variables Granger cause FIRM on the five percent significance level, but FIRM Granger causes MKT on two instances and IND in one. This is not in line with the results presented in Campbell et al. (2001), where market volatility is found to lead the other time series and industry volatility is found to lag, and where FIRM and IND are found to have predictive power on each other.

Next, we turn to studying the relation between the volatility measures and the business cycle. Specifically, we follow the example of Campbell et al. (2001) and regress quarterly GDP growth in each country on the following five variables, which are all of quarterly frequency and lagged by one period; GDP growth (in the preceding period), return on the market portfolio, MKT volatility, IND volatility and FIRM volatility. As pointed out by Ghysels, Santa-Clara, and Valkanov (2003), realized volatility is a function of long distributed lags of daily returns. Hence, volatility should, all else equal, have stronger forecasting power in quarterly than monthly data. The results are presented in table XXXIV-XXXVII below.

In the Swedish sample, we find that quarterly GDP growth is significantly affected by the return on the market index in during the previous quarter. However, out of the three volatility series, only IND displays any significance in the regressions, and only on one occasion. Hence, we draw the conclusion that volatility generally does not affect economic output in the case of Sweden.

Table XXXIV.

Cyclical Behavior: GDP Growth, Sweden

This table reports the results of a regression of GDP growth on lagged GDP growth, lagged stock market return, lagged market volatility, lagged industry volatility and lagged firm volatility. All variables are measured are on a quarterly basis and all lags amount to one quarter. T-statistics are provided in parentheses. * denotes significance at the 10 percent level, ** denotes significance at the 5 percent level, *** denotes significance at the 1 percent level. $GDP_t = \alpha + \beta_1 GDP_{t-1} + \beta_2 RET_{t-1} + \beta_3 MKT_{t-1} + \beta_4 IND_{t-1} + \beta_4 FIRM_{t-1}$

GDP_{t-1}	RET_{t-1}	MKT_{t-1}	IND_{t-1}	$FIRM_{t-1}$	R^2 (p-value)
0.867	0.023**				0.483
(23.009)	(2.576)				(0.000)
0.845***	0.024**	0.024			0.479
(16.052)	(2.438)	(0.705)			(0.000)
0.809***	0.024**		0.076		0.489
(14.075)	(2.596)		(1.562)		(0.000)
0.823***	0.025***			0.029	0.486
(13.381)	(2.669)			(1.099)	(0.000)
0.812***	0.023**	-0.043	0.123*		0.486
(14.117)	(2.505)	(-0.832)	(1.890)		(0.000)
0.827***	0.025***	-0.023		0.039	0.481
(13.165)	(2.701)	(-0.559)		(1.201)	(0.000)
0.809***	0.024**		0.070	0.003	0.483
(13.607)	(2.421)		(1.005)	(0.081)	(0.000)
0.811***	0.023**	-0.048	0.104	0.013	0.481
(13.606)	(2.420)	(-0.975)	(1.264)	(0.321)	(0.000)

Table XXXV.

Cyclical Behavior: GDP Growth, Denmark

This table reports the results of a regression of GDP growth on lagged GDP growth, lagged stock market return, lagged market volatility, lagged industry volatility and lagged firm volatility. All variables are measured are on a quarterly basis and all lags amount to one quarter. T-statistics are provided in parentheses. * denotes significance at the 10 percent level, ** 5 percent level, *** 1 percent level. $GDP_t = \alpha + \beta_1 GDP_{t-1} + \beta_2 RET_{t-1} + \beta_3 MKT_{t-1} + \beta_4 IND_{t-1} + \beta_4 FIRM_{t-1}$

GDP_{t-1}	RET_{t-1}	MKT_{t-1}	IND_{t-1}	$FIRM_{t-1}$	R^2 (p-value)
0.773***	0.039*				0.281
(11.419)	(1.770)				(0.000)
0.658***	0.033	0.288**			0.330
(6.936)	(1.537)	(2.402)			(0.000)
0.691***	0.029		0.149*		0.311
(7.814)	(1.187)		(1.959)		(0.000)
0.693***	0.033			0.068**	0.304
(8.646)	(1.473)			(2.240)	(0.000)
0.658***	0.036	0.361*	-0.053		0.324
(6.906)	(1.617)	(1.750)	(-0.475)		(0.000)
0.662***	0.034	0.356		-0.027	0.325
(7.208)	(1.660)	(1.556)		(-0.456)	(0.000)
0.687***	0.029		0.120	0.017	0.304
(8.213)	(1.165)		(0.850)	(0.293)	(0.000)
0.662***	0.036	0.386	-0.033	-0.021	0.318
(7.230)	(1.604)	(1.634)	(-0.251)	(-0.309)	(0.000)

Table XXXVI.

Cyclical Behavior: GDP Growth, Finland

This table reports the results of a regression of GDP growth on lagged GDP growth, lagged stock market return, lagged market volatility, lagged industry volatility and lagged firm volatility. All variables are measured are on a quarterly basis and all lags amount to one quarter. T-statistics are provided in parentheses. * denotes significance at the 10 percent level, ** denotes significance at the 5 percent level, *** denotes significance at the 1 percent level. $GDP_t = \alpha + \beta_1 GDP_{t-1} + \beta_2 RET_{t-1} + \beta_3 MKT_{t-1} + \beta_4 IND_{t-1} + \beta_4 FIRM_{t-1}$

GDP_{t-1}	RET_{t-1}	MKT_{t-1}	IND_{t-1}	$FIRM_{t-1}$	R^2 (p-value)
0.896***	0.029**				0.811
(31.654)	(2.370)				(0.000)
0.883***	0.029**	0.010			0.809
(23.919)	(2.294)	(0.645)			(0.000)
0.874***	0.030**		0.034		0.810
(22.196)	(2.370)		(0.995)		(0.000)
0.897***	0.029**			-0.004	0.808
(29.194)	(2.362)			(-0.183)	(0.000)
0.876***	0.030**	-0.008	0.047		0.808
(21.836)	(2.367)	(-0.414)	(0.924)		(0.000)
0.880***	0.030**	0.017		-0.013	0.807
(23.860)	(2.285)	(0.781)		(-0.476)	(0.000)
0.858***	0.030**		0.078	-0.030	0.812
(22.546)	(2.459)		(1.587)	(-1.035)	(0.000)
0.860***	0.030**	-0.011	0.097*	-0.030	0.809
(22.014)	(2.477)	(-0.580)	(1.795)	(-1.053)	(0.000)

Table XXXVII.

Cyclical Behavior: GDP Growth, Norway

This table reports the results of a regression of GDP growth on lagged GDP growth, lagged stock market return, lagged market volatility, lagged industry volatility and lagged firm volatility. All variables are measured are on a quarterly basis and all lags amount to one quarter. T-statistics are provided in parentheses. * denotes significance at the 10 percent level, ** denotes significance at the 5 percent level, *** denotes significance at the 1 percent level. $GDP_t = \alpha + \beta_1 GDP_{t-1} + \beta_2 RET_{t-1} + \beta_3 MKT_{t-1} + \beta_4 IND_{t-1} + \beta_4 FIRM_{t-1}$

GDP_{t-1}	RET_{t-1}	MKT_{t-1}	IND_{t-1}	$FIRM_{t-1}$	R^2 (p-value)
0.774***	0.016				0.260
(11.616)	(1.132)				(0.000)
0.679***	0.025*	0.141***			0.344
(8.489)	(1.765)	(7.368)			(0.000)
0.663***	0.016		0.139***		0.313
(7.661)	(1.136)		(3.144)		(0.000)
0.751***	0.018			0.011	0.258
(10.975)	(1.192)			(1.283)	(0.000)
0.661***	0.024	0.117***	0.043		0.340
(7.850)	(1.622)	(3.926)	(1.200)		(0.000)
0.686***	0.025*	0.148***		-0.006	0.339
(8.698)	(1.723)	(8.581)		(-0.709)	(0.000)
0.664***	0.013		0.192***	-0.020	0.318
(7.563)	(0.910)		(2.851)	(-1.458)	(0.000)
0.661***	0.021	0.110***	0.091*	-0.016	0.341
(7.796)	(1.385)	(3.893)	(1.806)	(-1.372)	(0.000)

We then turn to the Danish sample, shown in table XXXV. Contrary to the case of Sweden, stock market return has a low significance in the Danish sample, and only when used as the single explanatory variable in addition to lagged GDP growth. Likewise, the three volatility series are only significant when used on an individual basis. Thus, there is relatively weak support for the notion that stock market volatility affects total economic output in Denmark.

Table XXXVI reports the regression results from the Finnish sample. As was the case in Sweden, but unlike the case of Denmark, stock market return turns out to significantly affect total economic output. However, none of the volatility series are significant on reasonable levels.

Finally, in the Norwegian sample presented in table XXXVII, stock market return exhibits low significance in accordance with the Danish sample. There is however some support for the notion that market and industry level volatility affects economic output.

8 Results

The recent boom of dot.com and technology firms has left a strong impression in the public mind that the volatility of the stock market has increased over time. Surely, the widespread speculative behavior of the late 1990s and early 2000s, but also during the late 1980s, are examples of periods of increased volatility. Our analysis, however, shows that episodes of increased volatility have not persisted and that, on the aggregate level at least, the popular belief of increased stock market volatility is not correct. This contradicts some of the findings of Campbell et al. (2001), Savickas and Guo (2005) and Sternbrink and Tengvall (2001). However, like Savickas and Guo (2005) and Brandt, Brav and Graham (2005) we observe an increasing trend in industry and firm volatility over the late 1990's and early 2000's, which was reversed by the end of the sample.

We also find some support for the hypothesis of Bennet and Sias (2004) that changes in volatility may reflect changes in the composition of securities used in the estimation. The effects of this were particularly evident in the case of Finland and the emergence of Nokia as a company that dominates the market in terms of size.

Additionally, all time series prove to be stationary and we find that firm specific volatility is the largest component of the total volatility of common stocks in the Nordic markets, with the exception of Finland for reasons discussed previously. Autocorrelation is present, as well as relatively strong correlation between the three components of volatility as well as across countries, again with the exception of Finland. Our investigation of lead-lag relationships and the cyclical behavior of volatility did not provide any decisive conclusions as results varied between countries.

Several different factors affecting idiosyncratic volatility have been proposed in previous research, and in the following section we will comment on our findings with respect to these:

- An increase of the riskiness of industries in the market has been put forward as a factor contributing to increased idiosyncratic volatility. In the Nordic sample, we can establish that IT, Telecom and Biotech have emerged as important industries over the sample period. All of which can be considered relatively risky. Examples of how this affects the volatility components was observed especially in the late 1990's and this also had adverse effects on the estimation in the Finnish sample.

- Another factor which has been discussed in the literature is the small firm effect. An increase in the number of small firms, and a related drop in the average and median market capitalization can be expected to induce increased average idiosyncratic volatility. In the Nordic sample, both the average and median market capitalization have increased unambiguously over time, wherefore this explanation is deemed non-applicable in our case.
- Decreases in within-industry concentration has also been brought up as an explanation for the increasing idiosyncratic volatility observed by Campbell et al (2001). In our sample, we observe such decreases in concentration at the beginning of the sample as more and more firms are included in the dataset available through Datastream. However, we then observe increases in concentration during the late 1990's and around the turn of the millennium, which coincide with increases in industry and firm level volatility. Hence, even though we do not observe the very same pattern in concentration, we find some support for its proposed effect on the volatility estimation.
- The possibility that firms in general have become more risky over time has not been investigated in this thesis due to limitations of time and scope.
- Increasing institutional ownership has been discussed in the literature as a potential contributing factor to increased idiosyncratic volatility. We also know from previous Nordic research that institutional ownership has increased in the Nordic countries as an effect of the lifting on foreign ownership restrictions. However, the effects of this on volatility has not been investigated in the thesis.
- The notion that firm operations have become more focused over time has some support in general, also in the Nordic countries. Conglomerates have undiversified because of increased pressure from Private Equity firms and increased focus on shareholder value. Again, the effects have not been studied further in-depth in the thesis.
- Some authors have suggested that increasing competition in product markets has induced higher idiosyncratic volatility as customers are less loyal to individual firms. As a general observation, the Internet has reduced search costs dramatically and cross-border trade has increased over the sample period, but the effects have not been elaborated further in the thesis.
- The fact that stock options constitute a larger part of management compensation now than at the beginning of the sample period is true in general, but the extent to which this affects idiosyncratic volatility in the Nordic region has not been investigated.

9 Conclusion and Suggestions for Further Research

The fact that the topic of idiosyncratic volatility is one of the most actively researched topics in finance suggests that it is an interesting topic with important implications. Most studies have focused, primarily, on US data, but also on other G7 countries.

In this thesis we have, using the disaggregated approach to measuring volatility described in Campbell, Lettau, Malkiel, and Xu (2001), presented evidence on idiosyncratic volatility from the Nordic equity markets. In contrast to the findings of Campbell et al (2001), we do not find evidence of an increasing trend in idiosyncratic volatility over the sample period. However, we document some support for the critique that their method for estimating volatility components is sensitive to the composition of securities in industries and the market. This raises questions regarding the appropriateness of their method.

Through this thesis, we have provided empirical evidence of the development of the components of volatility in the Nordic markets. However, an in-depth study of the explanatory factors behind changes in volatility does not lie within the scope of the thesis. We have touched upon explanations related to firm size, the number of firms in the market and concentration measured on three levels, but we have not performed any formal tests to verify their explanatory power. Further research could therefore include elaborations on relationships between volatility and previously suggested explanatory factors. Also, investigating whether idiosyncratic risk is priced in the Nordic equity markets and whether it can be used to improve stock price predictions would provide interesting topics for further research. Additionally, it would be interesting to investigate whether our results change if longer time series are used, i.e. time series that stretch back further in time, and naturally to provide further empirical evidence from other markets which have not yet been researched.

Finally, we would like to point out that studying volatility over an extended period of time is a data intensive task that requires substantial computational power[6]. There are some issues that have been touched upon, but due to computational constraints their exploration has to be deferred to further research. One such aspect that has not been fully explored, and which is investigated in the original study by Campbell et al (2001), is how the correlations among individual stock returns have developed over time. However, this would require the calculation of several millions of correlations and thus lies outside the scope of our thesis.

[6] The data files used in this study have an aggregate size of more than one gigabyte, and approach the limit of what is possible to process on a normal personal computer equipped with Microsoft Excel

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11 Appendix

11.1 Quarterly GDP growth

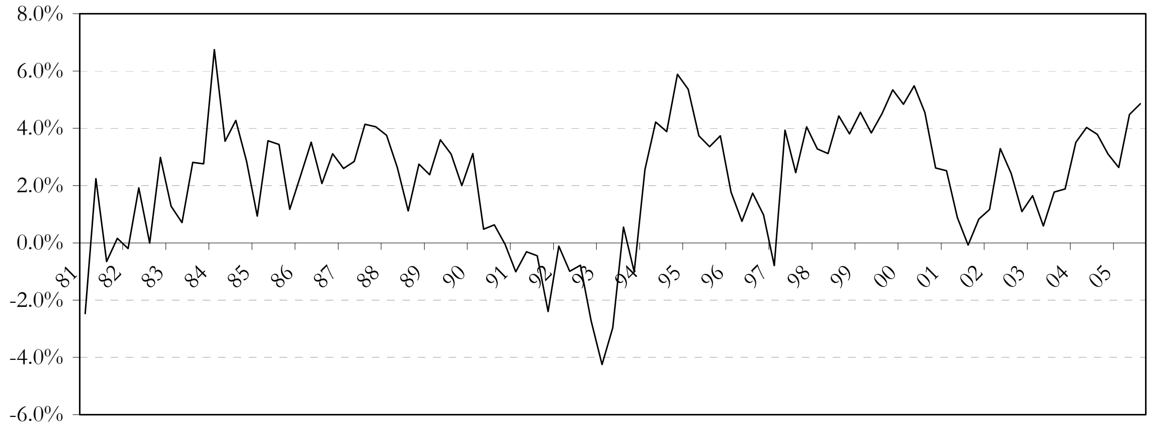

Figure 17. GDP growth, Sweden. Panel A shows the quarterly year-on-year GDP growth in Sweden from Q1 1981 to Q3 2005. Source: International Financial Statistics, IMF

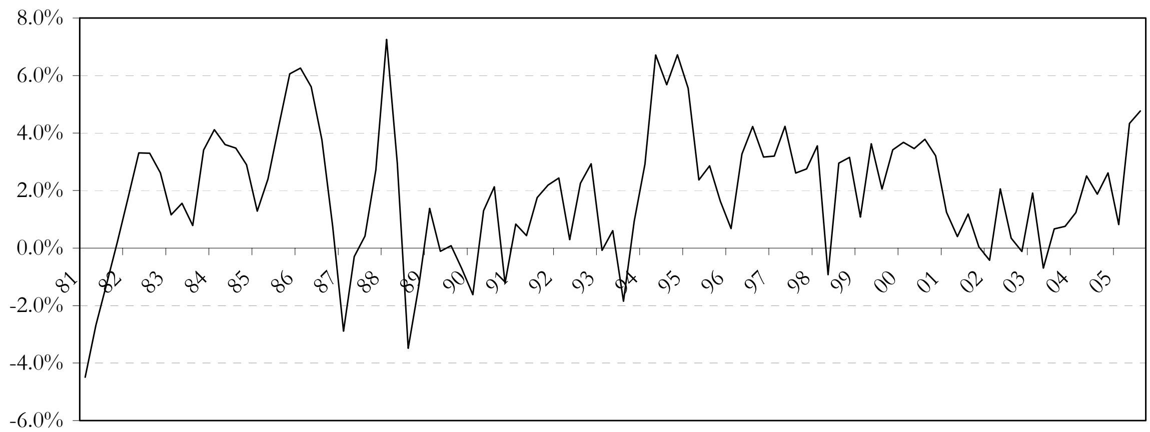

Figure 18. GDP growth, Denmark. Panel A shows the quarterly year-on-year GDP growth in Denmark from Q1 1981 to Q3 2005. Source: International Financial Statistics, IMF

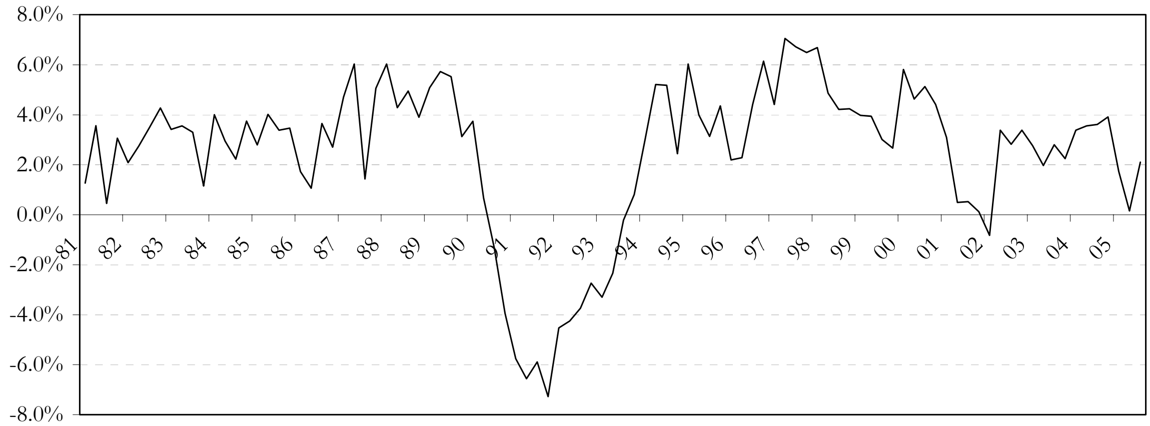

Figure 19. GDP growth, Finland. Panel A shows the quarterly year-on-year GDP growth in Finland from Q1 1981 to Q3 2005. Source: International Financial Statistics, IMF

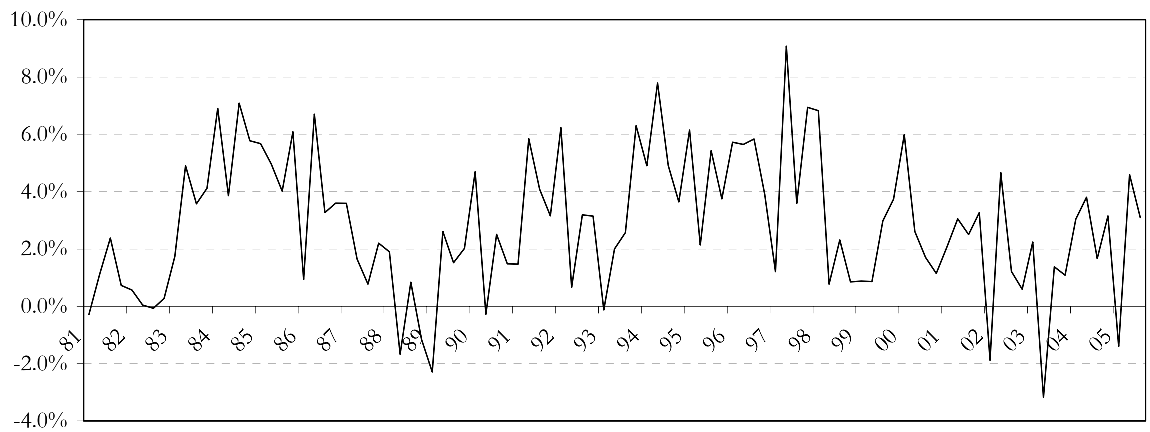

Figure 20. GDP growth, Norway. Panel A shows the quarterly year-on-year GDP growth in Finland from Q1 1981 to Q3 2005. Source: International Financial Statistics, IMF

11.2 Firm Quantity and Size

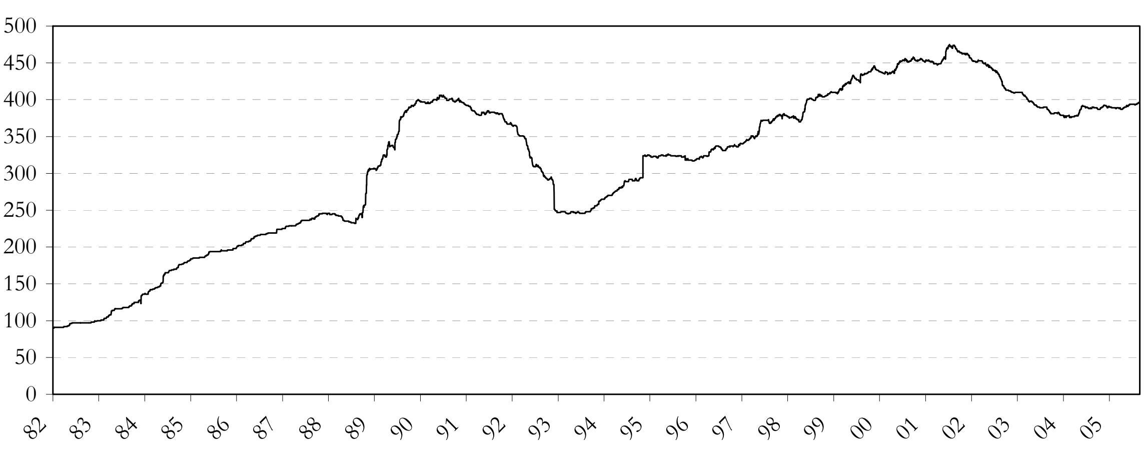

Figure 21. Listed stocks, Sweden. Panel A shows number of stocks traded over the sample period

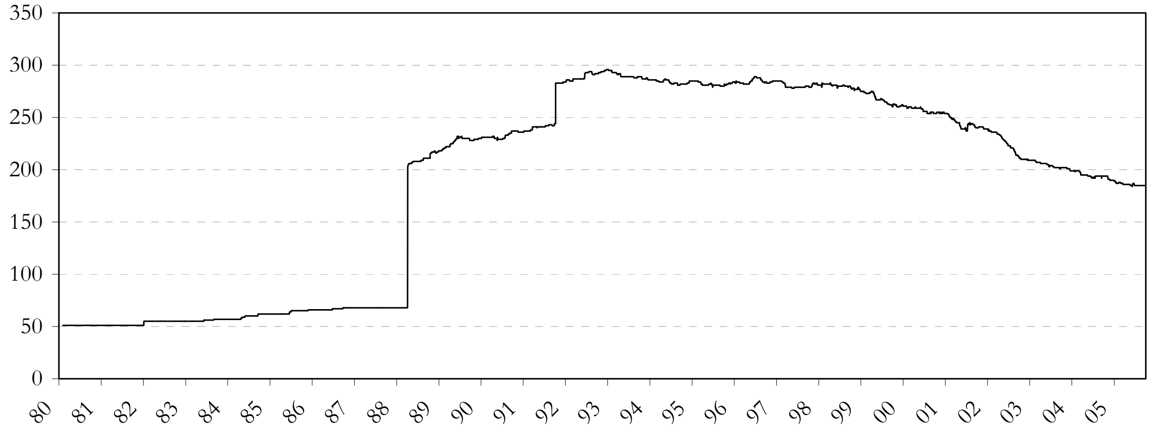

Figure 22. Listed stocks, Denmark. Panel A shows number of stocks traded over the sample period

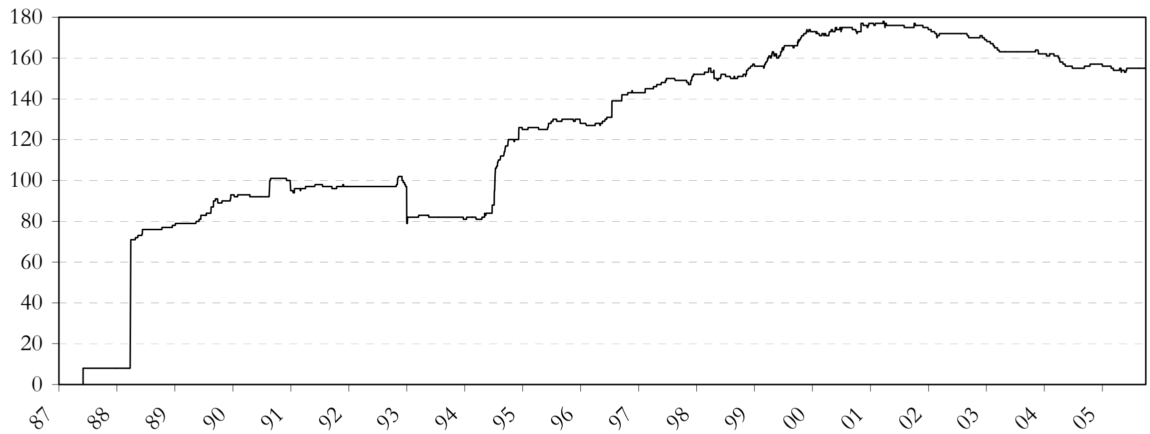

Figure 23. Listed stocks, Finland. Panel A shows number of stocks traded over the sample period

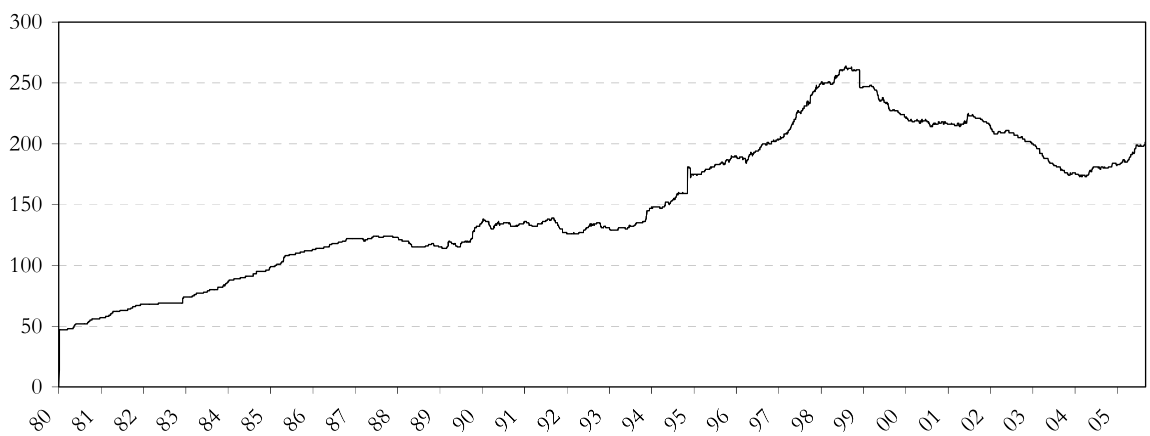

Figure 24. Listed stocks, Norway. Panel A shows number of stocks traded over the sample period

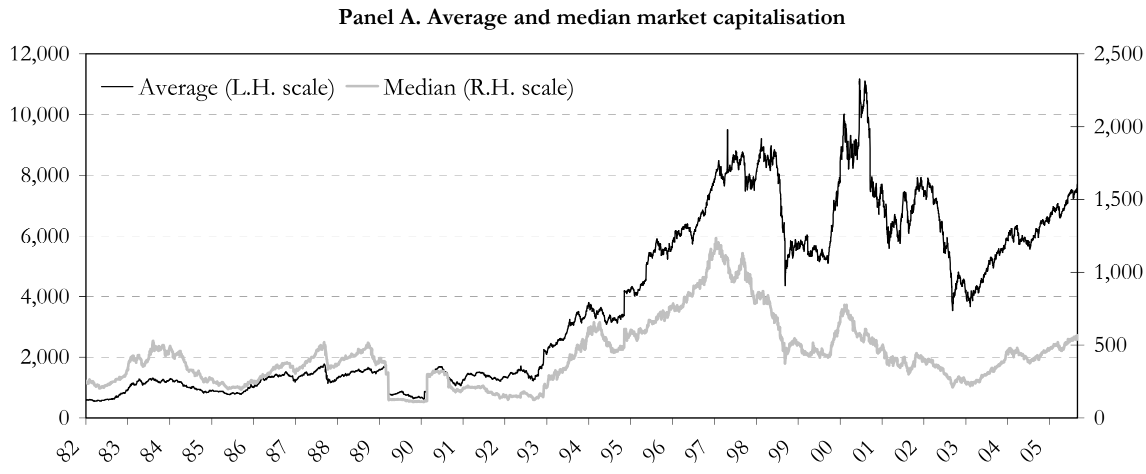

Figure 25. Average and median mkt cap, Sweden. Panel A shows (MSEK)

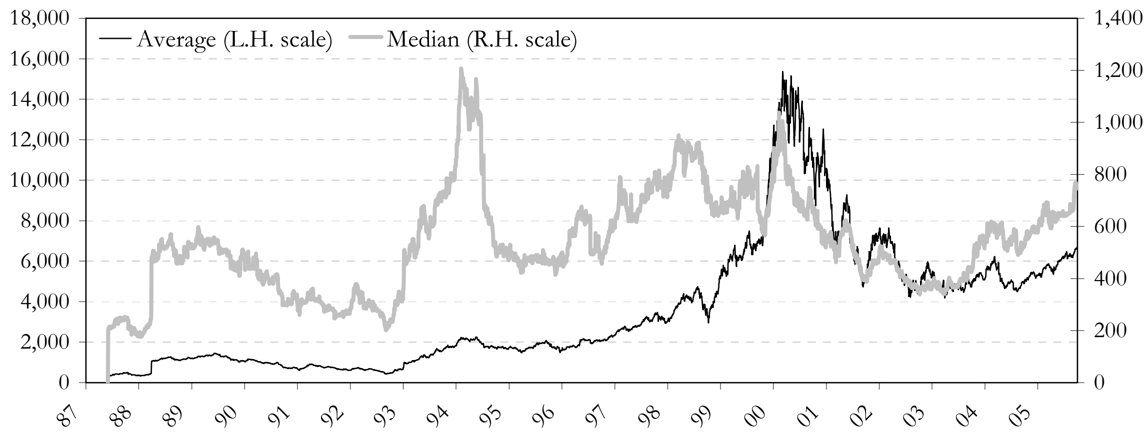

Figure 26. Average and median mkt cap, Finland. Panel A shows (MFMM)

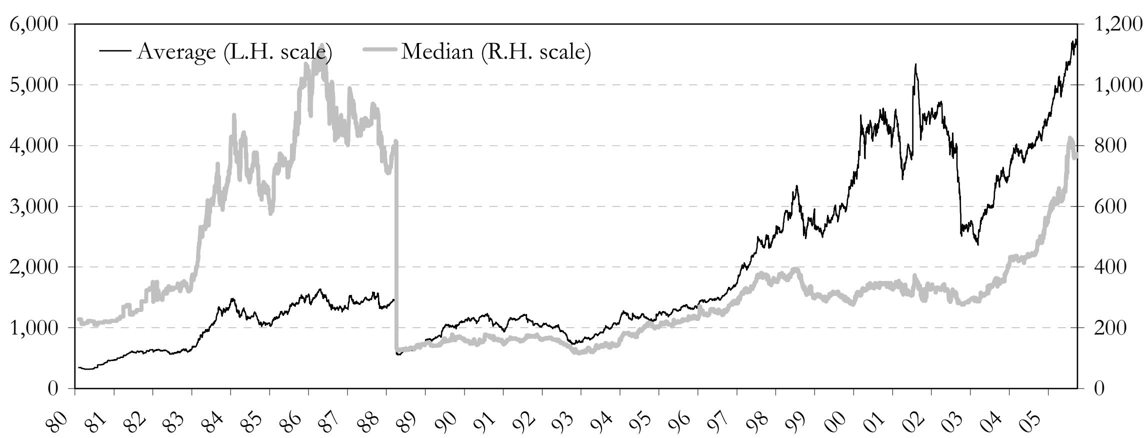

Figure 27. Average and median mkt cap, Denmark. Panel A shows (MDKK)

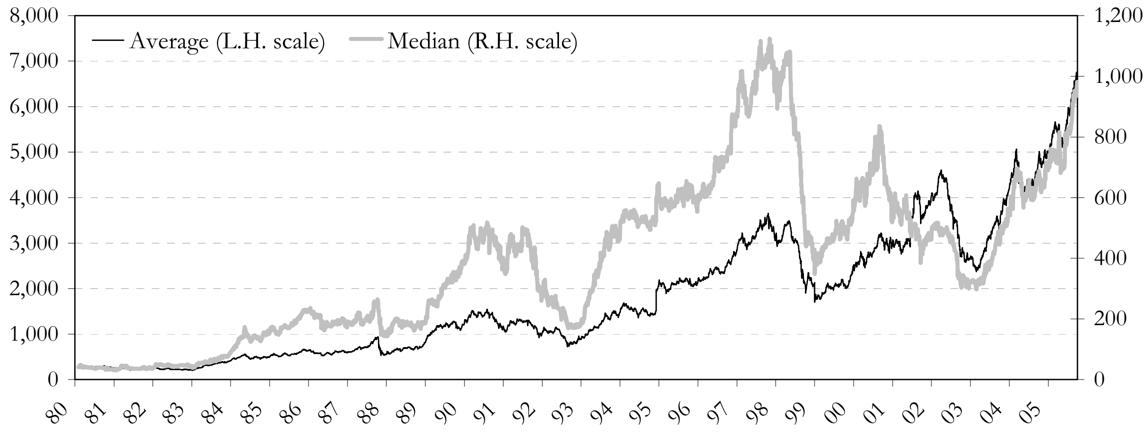

Figure 28. Average and median mkt cap, Norway. Panel A shows (MNOK)

11.3 Herfindahl-Hirschman Indices

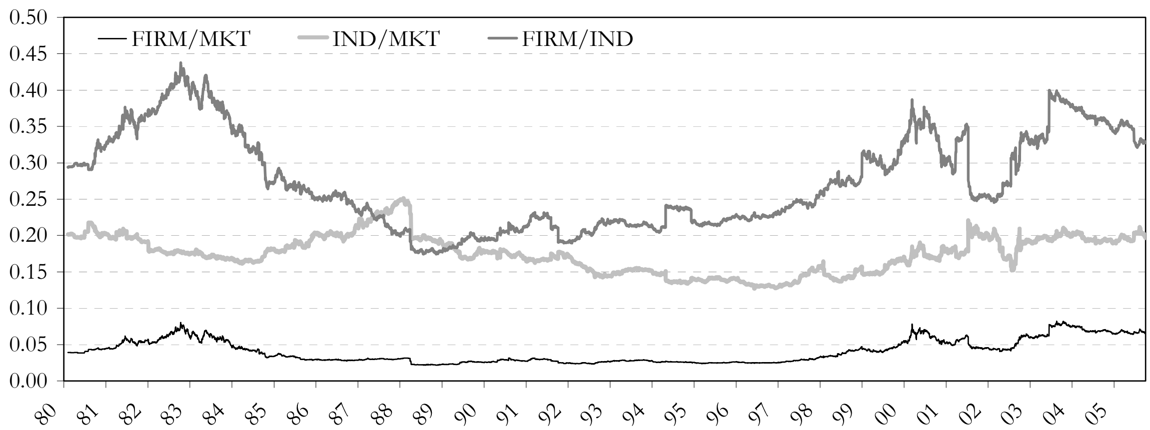

Figure 29. Herfindahl-Hirschman indices, Denmark.

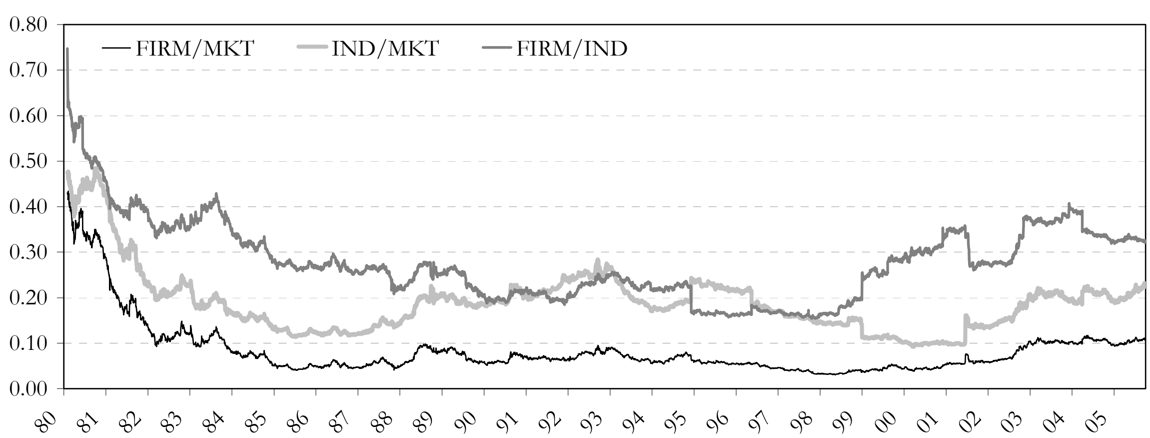

Figure 30. Herfindahl-Hirschman indices, Norway.

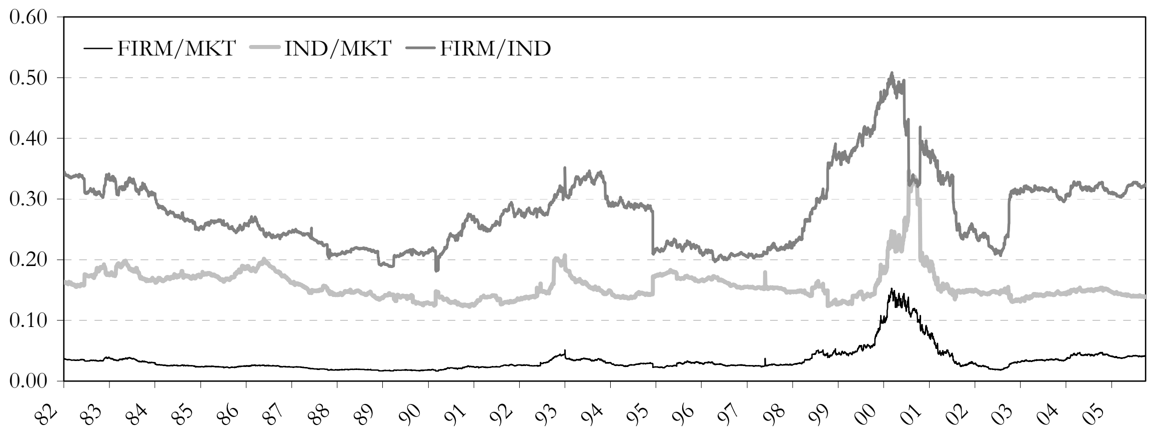

Figure 31. Herfindahl-Hirschman indices, Sweden.

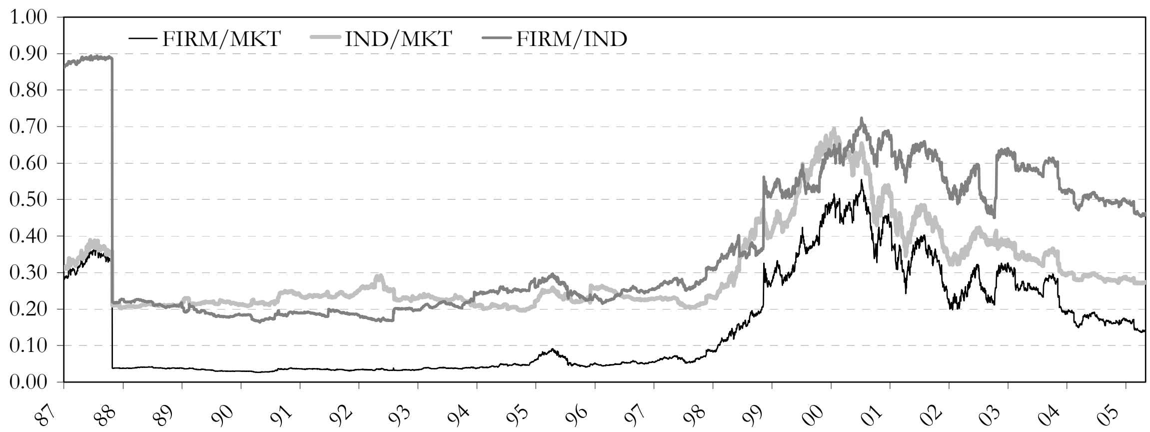

Figure 32. Herfindahl-Hirschman indices, Finland.

11.4 Classification of Listed Firms

Sweden

Major Industrials	Other Industrials	(cont'd)	Investment companies	Financial Services
ABB	504038n Invest	Lundgrens	Active capital	Adamas
Aga	Acrimo	Megacon	Affarsstrategerna	Adepten
Ainax	Almedahl	Meto	Asken inv.	Anhyp inv.click
Akzo Nobel	Altima	Morphic Technologies	Atle	Argentus
Alfa Laval	Aros Quality Group	Munters	Bure equity	Atlantica
Asea	Autofill	Narkes Electriska	Cardo inv.	Avanza
Assa Abloy	Autoliv	Nefab	Cominvest	Bcp
Assidoman	Bahco	Nibe Industrier	Custos	Bergaliden
Atlas Copco	Beijer Alma	Nilorngruppen	Empire	Bevaringen
Avena	Beijer Electronics	Nimbus Boats	Estinvest	Capinordic
Avesta	Beijer Invest	Nolato	Export invest	Carnegie&co
Avesta Sheffield	Bergman & Beving	Norden Export	Gyllenhammar	Centrecourt
Avestapolarit	Binar elektronik	Norditube Technologies	Hadronen	Comexchange
Berg & co	Bk Elektronik	Note	Industrivarden	Convexa
Billerud	Bongs Fabriker	Oden Control	Investor	D carnegie & co
Btgn	Bongs Ljungdahl	Omi Corporation	Inv.bahco	Ecovision
Cardo	Brukens Nordic	Opcon	Kinnevik	Foreningssparbanken
Conato	Bt Industries AB	Optima Batteries	Latour investment	Gamlestaden
Fagerlid Industrier	Bulten	Partnertech	Ledstiernan	Gnosjo bors
Finnveden	Business Improver Gr. in Europe	Pharos	Lundbergs	Gotabanken
Flakt	Cashguard	Plm	Midway holdings	Gotagruppen
Folkebolagen	Catech	Pm	Novyrost Invest	Hagstromer & qviberg
Fundia	Centrest	Polarator	Nycklen	Handbkn.hypotek
Geveko	Citarent	Pricer	Novestra	Havsfrun
Hoganas	Coldator Freshcool International	Printcom Etikett	Oresund Investment	Hoist intl.
Holmen	Componenta	Profilgruppen	Partnerinvest	Hq fonder
Isokern	Consilium	Push Development	Produra	Independent
Kalmar Industries	Countermine	Reculture	Protorp	Inter credit
Karolin Machine Tool	CTT Systems	Rejlers	Proventus	Invik & co
Klippan	Duroc	Sbt Landskrona	Ratos	Jp bank
Korsnas	El & Industriellmontering Svenska	Scandiafelt	Saki	Jp nordiska
Lindab	Eldon	Segerstrom & Svensson	Svolder	Kap N
Mo och Domsjö	Enstrom	Sevia	Sydostinvest	Matteus
Modo	Esab	Sintercast	Target Investment	Metallhytans
Munksjo	Esselte	SKF	The Empire	Neonet
NCB	Expanda	Societe Euro	Traction	Net Capital
Nobel Industrier	Fagerhult	Storheden	Trustor	Ngm Holding
Nordifagruppen	FB Industri	Stralfors	Vencap Industrier	Nordbanken
Nrs Technologies Holding	Firefly	Svedala	Vita nova Ventures	Nordea bank
Perstorp	Forsheda	Swegon		Nordnet Securities Bank
Rockhammars Bruks	Forsstrom High Frequency	Swepart mecanics	**Retail**	Norra Nordbanken
Rorvik Timber	Garph Heslmn.	Tivox	Axfood	Om
Rorviks Gruppen	Gorthon Invest	TMG Iinternational	Bilia	Om HEX
Rottneros	Gunnebo	Translink	Clas Ohlson	Omx
Saab	Haldex	Uddeholm	Ellos	Opus
Saab Scania	Hasselfors	Wartsil	Enqvistbolagen	Ost Gota Enskilda Banken
Sandvik	Heron	VBG	Fenix Outdoor	S E Banken
Sapa	Hexagon	Wermia	Fordonia	Salus Ansvar
SCA	HL Display	Westergyllen	Fotoquick	Sanndal
Scania	Horda	Viatech Systems	Friluftsbolaget E&S	SEB
Seco Tools	Impact Coatings	Xano Industri	Handskmakarn	SHB
Siab	Incentive	Zeteco	Hennes & Mauritz	Skandia
Skane Gripen	Inter Innovations		JC	Skanditek
Skultuna	Iro	**Technical consultants**	Kindwalls	Skanska Banken
Sorb Industri	Itab Shop Concept	Angpanneforeningen	Lindex	Solitair Kapital
SSAB	Jeppson Pac	Caran	Mekonomen	Stadshypotek
Stora	Johnson Pump	Epsilon	Miss Mary of Sweden	Svensk Fastighetsfond
Stora Enso	Kabe	J&W	Naturkompaniet	Svensk Kreditforening
Swanboard Masonite	Kanthal	Jaakko Poyry	Netonnet	Svenska Brand
Swedspan Industrier	LPI Precision	Scandiaconsult	Optimum Optik	Svenska handbk
Syngenta		Semcon	Peak Performance	Trygg - Hansa
System Separation		Studsvik	Rnb Retail and Brands	Turkronan
Trelleborg		Sweco	Ticket Travel	Wermlandsbruk
Volvo		Vbb	Wedins Skor & Accessories	
Zapp				

Food

Aarhuskarlshamn
Ahusglass
Aqua Terrena
Cloetta Fazer
Freia Marabou
Hemglass
Karlshamns
Magic House
Marabou
Sardus
Spendrups
Spira
Swedish Match
Svensk Vodka
Zeunerts

Business services

Academedia
Ark Travel
Bedminster
Ecta Resurs
Formo Service
Frontyard
Intrum justitia
Invent Management
Jobline International
Kontorsutveckling
Lm maklarna
Mercurias
Movexa
Mtin Eltn
Ngs Next Generation Systems Sw
Optimail
Poolia
Proffice
Securitas
Sifo
Sport Sponsor
Uniflex
Wwd Brand Management

Media

A - com
Artika Time
Bnl Information
Dacke Group Nordic
Displayit
Elanders
Eniro
Forum
Intellecta
Lmg Independent Media Group
Marieberg Tidningar
Metro International
Mnw Records Group
Modern Times Group
Observer
One Media Holding
Sydsvenska Dagbladet
Tax free
Tryckindustrier
Tryckinvest i Norden
Tv4
Vlt
Zodiak Television

Transport

Asg
Bilspedition
Brostrom
Brostroms Rederi
Btl Bilspeditionen
Concordia
Concordia Maritime
Fly Me Europe
Frigoscandia
Frontline
Gorthon Lines
Gotland Rederi
Lcb Shipping
Lcm Logistik
Linjebuss
N & t Argonaut
Nordsm. & Thulin
Osterman
Rederi Ab
SAS
Sibo Shipping
Sila
Srab Shipping
Stena Line
Svenska Orient
Svithoid Tankers
Tnsat Red
United Tankers

Power

Elverket Vallentuna
Graninge
Graningeverk
Gullspangs Kraft
Kraftkommission
Pwt
Renewable Energy in Sweden
Roslags Energi
Sydkraft
Vattenfall

Telecom

Alcatel
Allgon
Basiq Networks
Bip Bottnia Internet
Brand New World
C2sat
Ericsson
Europolitan Holding
Europolitan Vodafone
Glocalnet
LGP Allgon Holding
Sky Communication
Smarteq
Song Networks
Tele 5 Voice Services
Tele2
Teliasonera
Utfors
Viking Telecom

Resources

Boliden
Central Asia Gold
Forcenergy
Gexco
Ipc
Kvaerner
Lappland Goldminers
Ludvika Mining
Lundin Oil
Lundin Petroleum
Nan Resources
Norsk Hydro
Pa Resources
Petro Arctic
Riddarhyttan Resources
Scan mining
Secab
Sodra Petroleum
Svenska Kaolin
Taurus
Taurus Petroleum
Terra Mining
Tethys Oil
Tricorona
West Siberian Resources
Vostok Energo Invest
Vostok Nafta

Industrial wholesalers

Axtrade
Cyncrona
Dahl International
Elektronikgruppen
G & l Beijer
Malmbergs
OEM International
Sandblom & Stohne
Thomee Horle

Construction

Abv
Betonbygg
Betongindustri
Bgb i stockholm
Bpa
Cnst.byggnads
Conata
Dios Anders
Euroc Industrier
Jm
Johannson Claes
Kjessler & Mannerstråle
Ncc
Npl Conata
Peab
Platzer Bygg
Reinhold
Reinhold b
Reinhold city b
Roxi Stenhus Gruppen
Saint Gobain
Scancem
Sjolandergruppen
Skanska

Consumer

Aritmos
Ballingslov International
Boras Wafveri
Brio
Carli Gry
Cherry Foretagen
Doro
Electrolux
Facile
Fristads
Leksell Golv
Liljeholmen
Monark Stiga
New Wave Group
Nobia
Oriflame Cosmetics
Orrefors
Pergo
Persea
Procordia
Scapa International
Skane Mollan
Svedbergs
Unibet Group

Technology

Acsc
Addtech
Addvise
Arcam
Aspiro
Audiodev
Autodiagnos
Cellpoint
Cellpoint Connect
Celsius
Cool Guard
Diffchamb
Digital Vision
Emitor Holding
Exave
Fingerprint Cards
Hasselblad
Impact Europe Group
LC - Tec Holding
Lightlab
Micronic Laser Systems
Multiq International
Net Insight
Obducat
Pendax
Reguard
Sendit
Senea
Sensys Traffic
Spectra - Physics
Switchcore
Tagmaster
Teligent
Thorsman & co.
Xponcard

Real Estate

Amhult 2
Asticus
Balder fastighets
Bohus fastighets
Bostads ab drott
Brinova fastigheter
Cabanco
Capona
Castellum
Catena
Celtica fastighets
Diligentia
Evidentia
Fabege
Fast partner
Fastighets balder
Gotic
Halstrm.& nis.
Heba
Hemstaden bostads
Hilab
Hufvudstaden
Humlegarden
Klovern
Kungsleden
Ljungberggruppen
Lodet Fastighets
Lundbergs
M2 Fastigheter
Mandamus
Nackebro
NK City Fastighets
Nordiska Kompaniet
Norrporten
Nycklen
Pandox
Paul Anderson fastighets
Piren
Platzer ftgh.
Prifast
Pronator
Provobis
Realia
Regnbagen Fastighets
Regnbagen ftgh.b
Riksbyggen
Sagax
Scandic Hotels
Sifab
Skistar
Skoogs
Stancia
Svensk fastighetsfond
Tornet Fastighets
Wallenstam
Wihlborgs fastigheter

Lifescience	Information Technology	(cont'd)
Accelerator i Linkoping	3l system	Know IT
Active Biotech	Acandofrontec	Labs2group
Active i Malmo	Addnode	Lagercrantz
Althin Medical	Alfaskop	Lb Icon
Arjo AB	Anoto Group	Live Networks
Artema Medical	Arete	Luvit
Artimplant	Asit	M2s Sverige
Astra	Au System	Maldata
Bayer	Avalon Enterprise	Mandator
Biacore International	Axis	Martinsson
Biogaia	Bfe Benima Ferator Engr.	Memory Data
Bioinvent International	Bluemarx	Micro Systemation
Biolight	Boss Media	Mind
Biolin	Bts Group	Modul 1 Data
Biophausia	Cartesia Info systems	Mogul
Biora	Castcom	Msc Konsult
Biotage	Cell network	Multisimplex
Bringwell International	Cisl Gruppen	Netrevelation
Capio	Columna	Netwise
Conpharm	Confidence International	Nexus
Coronado	Connecta	Nocom
Decim	Cybercom Group Europe	Norsk Data
Diamyd Medical	Datema	Novacast
Elekta	Daydream Software	Novada
European Institute of Science	Dial n' Smile	Novotek
Feelgood Svenska	Dial nxt Group	Onetwocom
Gambro	Digital Illusion	Orc Software
Getinge	Dimension	Paynova
Gibeck	Effnet Holding	Personal cmp.
Glycorex	Enator	Powerit
Hebi Health Care	Enea	Precise biometrics
Human Care	Enlight international	Prevas
Idl Biotech	Entra Data	Proact It Group
Innate pharms	Eplay	Programator
Karo bio	Finansrutin	Pronyx
Lic Care	Focal Point	Prosolvia
Lifco	Followit Holding	Protect Data
Lifeassays	Formpipe Software	Readsoft
Meda	Framfab	Resco
Medirox	Frango	Rks
Medivir	Freetel	Scala International
Mini Doc	Gamers Paradise	Scandinavia Online
New Science	Genline	Scribona
Nobel Biocare	Getupdated Sweden	Sigma
Orasolv	Global Direct	Sign On
Ortivus	Guide Konsult	Skribo
Perbio Science	Hiq International	Softronic
Perfresh	Iar Systems	Spcs Scandinavian PC Systems
Pharmacia	Ibs	Starbreeze
Pharmacia & Upjohn	Ims Intel. Micro systems	Strand Interconnect
Probi	Indevo	Svenska Data
Q - Med	Industrial & Financial Systems	Syrico
Raysearch Laboratories	Intentia International	Teleca
Sectra	Inwarehouse	Telelogic
Skandigen	Iquity Systems	Thalamus Networks
Stille	Jeeves Info Systems	Tite
Synectics Medical	Jlt Mobile Computers	Tpc Security
Tripep	Kalldata	Trio Info Systems
W Sonesson	Kipling Holding	Turnit
Vitrolife	Klick Data	Verimation
		Vision Park
		Vitec
		WM - Data
		Worldwide Software

Denmark

Heavy Industries & power

Aalborg
ABB
Auriga Industries
Bloch & Andreson
Burmeister & Wain
Faxe Kalk
Flugger
Greentech Energy Systems
Hafslund
Lindab
NESA
Nobel Industrier
NTR Holding
Sadolin & Holm
Schaedes Papir
Up Ihaende

Food & agro

Aarhus United
Albani Brygg
BHJ
Biomar Holding
Carlsberg
Chrs. Hansen
Danisco
Dansk Spritfabrik
Danske Sukkerfabrik
Det Ostasiatiske Kompagni
DLF Trifolium
Harboes Bryggeri
Hatting Bageri
Hedegaard
Jyske Bryg
Nowaco Group
Royal Unibrew
Østeuropæisk Handelshus

Information Technology

2M Invest
Brandts ventures
Columbus IT Partner
Damgaard
Danware
Datalog
EDB Gruppen
Ehuset
Energy Solutions intl.
I - data Intl.
Live Networks Holding
Maconomy
Memory Card Tech.
Navision
Norsk Data
Olicom
SE 2000
Simcorp
Systemforum

Other Industrials

Blucher Metal
Brodrene Hartmann
Codan Gummi
Crisplant Inds.
Cubic
Danthern Holding
Dantruck - Heden
Dv Industri
Expedit
Fisker & Nilson
Flsmidth & Company
Funki
Gabriel Holding
Glunz & Jenses
Incentive
Ipf
Jacob Holm & Sonner
Julius Koch Group
Kompan
Louis Poulsen
Martin Gruppen
Micro Matic Holding
Migatronic
Ndsk. Fjerfab
Neg Micon
NKT
O K Holding Co.
Objective
Roblon
Samson Group
Scandin.Mbty.Intl.
Scandinavian Brake Systems
Schouw & Co
Silcon
SP Group
Superfos
Thrige - Titan
UP
Vestas Wind Systems
Vestas Windsystems
Vt holding
VTH

Business services

Color Print
Falck
FE Bording
Group 4
Group 4 falck
Intermail
ISS
Marius pedersen
Norhaven
Ratin
Sophus Berendsen

Financial Services

Aars Bank
Aktivbanken
Alm Brand
Alm Brand Pantebreve
Almanij Brand
Amagerbanken
Andelsbanken
Asgaard Dev.
Bonusbanken
Capinordic
Carnegie Worldwide
Codan
Commercial Leasing
Copen.Rein.
Dai Holding
Dansk Kapitalanlaeg
Danske Bank
Danske Kautionforsikring
Dgk Invest
Diba Bank
Djurslands Bank
Dsk.provinsbank
Egnsbank Fyn
Egnsbank Han Herred
EPA Invest
Euro Invest fx
Fih
Fionia Bank
First Inv.Partner
Forstaedernes Bank
Girobank
Gredana Pr.
Gronlandsbanken
Gudme Raaschou Vision
Hadsten Bank
Hafnia Holding
Handbk.Kjob.
Hellebaek Fbrk.
Hvidbjerg Bank
Interbank
Investeringsselskapet
Jensen & mol.invest
Jyske Bank
Kreditbanken
Laan & Spar Bank
Lex Invest
Lokalbanken i Nord
Lollands Bank
Luxor
Lyskaer Lyfa
Max Bank
Midtbank
Midtinvest
Mons Bank
Morso Bank
Nordfyns Bank
Nordjyske Bank

(cont'd)

Norresundby Bank
Ostjydsk Bank
Phonix
Potagua Kapital
Privatbkn.kjob.
Realdanmark
Regional Invest Fyn
Ringkjobing Bank
Ringkjobing lndobk
Rolemu
Roskilde Bank
Salling Bank
Skaelskor Bank
Skandia
Skjern Bank
Small Cap Danmark
Spar Nord Bank
Spar Nord Formueinvest
Sparbank Vest
Sparekassen Faaborg
Svendborg Sparekasse
Sydbank
Tarm Bank
Tonder Bank
Topdanmark
Totalbanken
Tryg - Baltica Fors.
Unidanmark
Valuta
Varde Bank
Vendsyssel Bank
Vestfyns Bank
Vestjsk Bank
Vestjysk bank
Vinderup Bank
Vordingborg Bank

Transportation

A P Moller - Maersk
Bilspedition
BTL
D/s 1912
D/S Norden
D/s Orion
D/s Progress
D/S Torm
DFDS
DSV
Elite Shipping
Gredana Shipping
J Lauritzen Holding
Kobenhavns Lufthavne
Mols - Linien
Motortramp
Rederiet Knud I Lar.
SAS Danmark
Sydfyenske

Constr. materials

Consenta Holding
A & O Johansen
Calkas
Dahl Intl.
DLH
Dsk.Traelastkompagni
F junckers indr.
H&H International
ITH
Potagua
Rationel Vinduer
Rockwool
Sanistal
Skako
Spaencom
Walter Jessen
Vejen Traelast
Vest - Wood
Wewers

Consumer

Aalborg Boldspilklub
Akademisk Boldklub
Andersen & Martini
Arhus Elite
Badeanstalten
Ballin & Hertz
Bang & Olufsen
Bodilsen Holding
Brondby IF
Dantax
Denka Holding
Egetaepper
Fr Invest
G Falbe
GT.Unvl.Stores
Gyldendal
Hlj Industri
IC Companys
Inwear Group
Jamo
Kansas Wenaas
Kildemoes Cykelfabrik
Royal Copenhagen
Royal Scandinavia
SIF Fodbold
SIS Internatonal
Sondagsavisen
System B8 Mobler
UIE
Viborg Handbold Klub

Wholesalers	Real estate	Lifesciences	Construction	Tech & telecom
Brd Klee	Britannia Invest	Ambu International	Christiani & Nielsen	Chemitalic
DG Holding	C w obel	Bavarian Nordic	Hoffmann & sonner	Danionics
Ford Motor Co.	Cederholm & Voss	Bioporto	Hojgaard Holding	Eurocom Ind.
Lastas	Commercial Hold	Bioscan	Icopal	GN Store Nord Holding
Nordisk Solar	Dan Ejendomme Holding	CIC	L & N Holding	GPV Industri
Rias	Di Ejendoms Invest	Coloplast	Monberg & Thorsen	Rtx Telecom
Satair	Ejendoms Tyskland	Genmab	Ove - Arkil Holding	SDC Dandisc
Solar Holding	Ejendomsinvest	Lundbeck	Per Aarsleff	Systems
	Ejendomsselskabet Norden	Meco Holding	Potagua FLS	TDC
	Foras Holding	Ndsk.Gentofte	TK Development	Tele Danmark
	Jeudan	Neurosearch	Wessel & Vett	Thrane & Thrane
	Kalkvaerksgrundene	Novo Nordisk		Topsil Semicon.Mats.
	Keops	Novozymes		
	Land & Leisure	Nycomed Amersham		
	Nordicom	Pharmexa		
	Parken Sport & Ent.	Radiometer		
	Sjaelsoe Gruppen	Topotarget		
	Tellus Ejendom Invt.	Torsana		
	Theodor Ej.Invt.	William Demant Holding		
	Tivoli			
	Victor International			

Finland

Heavy Industries & power

AvestaPolarit
E on Finland
Enso - Gutzeit
Fortum corp.
Haemeen Saehkoe
Jaakko Poyry Group
Kemi
Kemira
Kymmene
Lansivoima
M - real
Metsa
Metsae Tissue
Metsa-Serla
Metso
Neste Oil
Nokian Renkaat
Nordic aluminium
Outokumpu
Rauma
Rautaruukki
Repola corp.
Starckjohann
Stora Enso
Stromsdal
Tamrock
Upm - Kymmene
Utd.paper mills
Wartsila

Lifescience

Biohit
Biotie Therapies
Orion
Plandent
Tamro

Technology

Aspocomp Group
Benefon
Etteplan
Okmetic
Pi Consulting
Pkc Group
Polar
Polar Kiinteistot
Tekla
Teleste
Valtameri

Other Industrials

Aspo
Beltton - Group
Cargotec
Cencorp
Componenta
Efore
Eimo
Elecster
Elektrobit Group
Evox rifa Group
Exel
Honkarakenne
Incap
Jamera
Kajaani
Kajaani Fria
Kasola
Kci konecranes
Kekkila
Kemira Growhow
Kesla
Kone
Kontram - Yhtioet
Kyro
Larox
Lassila & tikanoja
Leolonglife
Martela
Metra
Panostaja
Partek
Perlos
Ponsse
Rakentajain kone
Ramirent
Rauma - Repola
Raute
Rocla
Sakkivaline
Sanitec corp
Saunatec
Scanfil
Suomen Helasto
Suominen
Tamfelt Etu
Tamfelt Kanta
Tampella
Trikoo
Tulikivi
Uponor
Vaahto group 'a'
Vacon
Vaisala
Yleiselektronikka

Information Technology

Affectogenimap
Aldata Solutions
Basware
Comptel
Done Solutions
Endero
F - secure
Heikki Marttila
Network Communicat
Proha
Qpr software
Satama Interactive
Sentera
Solteq
Sophistics
Ssh Comms
Stonesoft
Sysopen Digia
Tecnomen corp.
Tieto
Tietoenator
Tj Group
Visma Software
WM - Data Novo

Telecom

Elcoteq Network
Elcoteq se
Elisa
Helsinki Telephone
Nokia
REACH - U Holding
Saunalahti
Sonera
SONERA Vaihto-Osake
Soon Communications
Yomi plc

Real estate & construction

Castrum
Citycon
Interavanti
Julius Tallberg
Kylpylakasino
Lemminkainen
Puuharyhma
Servi Systems
Sponda
Ssk Suomen Saastajien
Technopolis
Tilamarkkinat
Yit - Yhtyma
Yit Kiinteistot

Financial Services

Alandsbanken
Amanda Capital
Arctos Capital
Capman
Conventum
Eesti Uhispankin
Eq Corporation
Eq Holding
Finvest
Foresta
Hansabank
Hex 25
Interbank
Kansallis
Kop
Mandatum Bank
Merita
Mit
Neomarkka
Nordbanken
Norvestia
Okobank
Pohjola
Ruukki Group
Sampo
Skop Finance
Skopbank
SYP - Invest
Talous - Osakek
Turun Arvokiinieis
Turvatiimi Corporation
Vestcap
Yrityspankki Skop

Transport

Birka line
Finnair
Finnlines
Neptune maritime
Silja
Viking line

Media

Aamulehti
Alma Media
Almanova
E - S Kustannus
Evia
Fazer Musiikki
Ilkka
Janton
Kauppakaari
Keski Pohjamaan ki
Keskisuomalainen
Otava pbl.
Pohjoiskarjalan
Pojohlan Sanomat
Rautakirja
Sanoma - Wsoy
Savon Sanomat
Soprano
Talentum

Consumer

Amer
Asko
Atria
Chips
Corum
Cultor
Fiskars
Ford Finland
Hackman
Hartwall
Hk ruokatalo Group
Huhtamaki
Instrumentarium
Isko
Kesko
Lannen Tehtaat
Margariini
Marimekko
Olvi
Raisio
Rapala Vmc
Stockmann
Suomen Spar
Suunto

Norway

Resources & power

- Altinex
- Arendals Fossekompani
- Artumas Group
- Canargo Energy Co.
- Dno
- Hafslund
- International Gold Exploration
- Kenor
- Kirkland
- Mindex
- Nordic Water Supply
- Norse Energy Corp
- Norsk Hydro
- Revus Energy
- Rocksource
- Saga
- Statoil
- Sydvaranger

Technology

- Dynapel Systems
- Goodtech
- Kitron
- Kongsberg Gruppen
- Navia
- Nordic Semiconductor
- Oceanor Holding
- Otrum
- Proxima
- Q - free
- Simonsen Elektro
- Simrad Optronics
- Tandberg
- Tandberg Data
- Tandberg Storage
- Tandberg Television

Business Services

- Andvord Tybring Gjedde
- Blom
- Cri - Gruppen
- Ekd. Einersen
- ICS
- Igroup
- Ivananc Rodoni
- Komplett
- Mercurius
- Mikkelservice
- Norsk Lotteridrift
- Office Line
- Santech Micro Group
- Scribona
- Stavdal
- Stepstone
- Via Travel Group

Heavy Industries

- Aker
- Aker Kvaerner
- Aker Yards
- Bjolvefossen
- Borregaard
- Burm.& Wain
- Dyno industrier
- Elkem
- Fesil
- Hunsfos
- Hydralift
- Kverneland
- Maritime Group
- Moelven Industrier
- Norcem
- Norske Skog
- Polimoon
- Rena Karton
- Scana Industrier
- TTS Marine
- Ulstein Holding ASA
- Yara International

Other Industrials

- Anker Batterier
- Autronica
- Bachke
- Byggma
- Corrocean
- Elektrisk Bureau
- Enwa
- Framnes
- Hexagon Composites
- Iplast ASA
- Klippen Invest
- Kongsberg Automotive
- Kongsberg Techmatic
- Legra
- Linde Group ASA
- Luxo
- Mg
- Navis
- NEK kabel
- Nobo Fabrikker
- Noral
- Norcool Holding ASA
- Norway En.& Marine In.
- Notodden
- Ohi
- Raufoss
- Rc gruppen
- Scanvest
- Se labels
- Stromme
- Technor
- Teco coating services
- Tomra
- Tomra Systems
- Unitor
- Winder

Information Technology

- Active 24
- Agresso
- Allianse
- Apptix
- Ark
- Avenir
- Axxessit
- Birdstep Technology
- Consorte Group
- Contextvision
- Customax
- Data Respons
- EDB Business Partner
- EDB Elektronisk Data
- Ementor
- Evercom Network
- Exense
- Fast Search and Transfer
- GPI
- Hands
- Ibas Holding
- Ignis
- Infocus
- Infostream
- Inmeta
- Intellinet
- Itera Consulting Group
- Mamut
- Mediabin
- Mefjorden
- Micro Software Group
- Minard
- Multisoft
- Norman
- Norsk Data
- Officeshop Holding
- Opera Software
- Opticom
- PC Lan
- Profdoc
- Provida
- PSI group
- Roxar
- Scandinavia Online
- Software Innovation
- SPCS - Gruppen
- Superoffice
- Sysdeco
- Tecmar techs.intl.
- Telecomputing
- Tiki - Data
- Transworld Comm.
- Unit 4 Agresso
- Visma
- Vmetro

Financial Services

- ABG Sundal Collier
- Acta Holdings
- Aktiv Kapital
- Aurskog Sparebank
- Bergensbanken
- Bolig - og naeringsbanken
- Chr bk. Og kreditkasse
- Christiana Bank
- Den Norske Bank
- Dnb Holding
- Dnb Nor
- Finansbanken
- Fokus Bank
- Forenede - Gruppen
- Gjensidige Nor
- Gjensidige Sparebk
- Helgeland Sparebank
- Hol Sparebank
- Holand sparebank
- Indre Sogn Sparebank
- Kjobmandbanken
- Kredittbanken
- Melhus Sparebank
- Nbk New
- Nes Prestegjeld Sparbk.
- Nordlandsbanken
- Norgeskreditt Holding
- Nors.Forsikring
- Norske Creditbk
- Nydalens
- Oslo Handelsbank
- Oslo Reinsurance
- Privatbanken
- Protector
- Ringerike Sparebank
- Rogalandsbanken
- Sadg nye grunnfondsbevis
- Sandnes Sparebank
- Sandnes Sparebank
- Sandsvaer Sparebank
- Skipskredittforeningen
- Spare bk.eiker drammen new
- Sparebanken Midt - Norge
- Sparebanken More
- Sparebanken Nord - Norge
- Sparebanken Oest
- Sparebanken Pluss
- Sparebanken Rana
- Sparebanken Rogaland
- Sparebanken Vest
- Sparebanken Vestfold
- Spbk.flora - bremanger
- Storebrand
- Totens Sparebank
- Uni Storebrand
- Vesta - Gruppen
- Vestenfjelske Byk.
- Vital Forsikring
- Voss Veksel

Offshore services

- Aker Maritime
- Aker Rgi
- Apl
- Arcade Drilling
- Awilco Offshore
- Bjorge
- Consafe Offshore ASA
- Crystal Production
- Deep Sea Supply ASA
- Discoverer ASA
- District Offshore
- Dof
- Dsnd Subsea
- Dual Invest
- Eastern Drilling
- Exploration Resources
- Fred Olsen Energy
- Frontier
- Frontier Drilling
- Geophysical
- Global Geo Services
- Havila Shipping ASA
- Havila Supply
- Hitec
- Intl.Maritime ex.
- Kvaerner
- Loki
- Marine Drilling ASA
- Norex Offshore
- Norminol
- Nortrans Offshore
- Ocean Rig
- Odfjell Invest
- Petrojack
- Petroleum Geo Services
- Petrolia Drilling
- Procon Offshore
- Prosafe
- Ptl.geo Services
- Seateam Technology
- Sevan Marine
- Siem Industries
- Siem Offshore
- Sinvest
- Smedvig
- Solstad Offshore
- Stolt Offshore
- Subsea 7
- TGS Nopec Geophs.
- Transnor Rig
- Transocean Drilling
- Transocean Sedco
- Wilrig

Real estate & Construction

- AF Gruppen
- Avantor
- Bohler Gruppen
- Choice Hotels Scandinavia
- Eeg Henriksen Gruppen
- Eien.Aker Brygge
- Eiendomsutvik.
- G Block - Watne
- Grand Hotel
- Home Invest
- Iby Eiendom
- Indri.Fin.Boligeiendom
- Linstow
- Olav Thon
- Oslo Areal
- Oslo Havnelager
- Realia
- Rica Hotels
- Selmer
- Steen & Strom
- Veidekke

Media

- A - pressen
- Adresseavisen
- Alvern
- Findexa
- Gambit
- Gyldendal
- Laboremus
- Media and resh.group
- Media Holding ASA
- P4 Radio Hele Norge
- Reitan Narvesen
- Schibsted
- Stavanger Aftenblad
- Thrane - Gruppen

Consumer goods

- Adelsten
- Auto - Agder
- Bik Bok
- Conseptor
- Ekornes
- Elkjep Norge
- Elkjop
- Expert
- Gresvig
- Hag
- Hansa
- Hjellegjerde
- Kansas Workwear
- Kristiansand Dyrepark
- Liva Bil
- Nora
- Norema
- Norsk Kjokkeninvest
- Orkla
- Porsgrunds Porselaens
- Tofte
- Tou
- Wenaas
- Viking - Askim
- Voice

Investment companies

- David
- Hca Melbye
- Ifa
- Industrifinans frv.
- Industrifinans Naeringse
- Investa
- Investra
- Norsk Vekst
- RGI (antilles)
- Skiens Aktiemoelle
- Star Holding
- Star papr.b

Food

- Aker Seafoods
- Domstein
- Fjord Seafood
- Globus
- Leroy Seafood Group
- Norway Seafoods ASA
- Pan fish
- Pan Pelagic
- Peppe's Pizza
- Rieber & Son
- Rosshavet
- Seafarm
- Synnoeve Finden

Life science

- Amersham
- Axis Biochemicals
- Diagenic
- Kaldnes
- Medi - Stim
- Medicult
- Natural
- Nutripharma
- Nycomed
- Nycomed Amersham
- Photocure
- Pronova

Telecom

- Alcatel stk
- Catch Communications
- Eltek
- Enitel
- Nera
- Netcom
- Nextgentel
- Sense Communications
- Stento
- Stentofon
- Telecast
- Telenor
- Zenitel

Transport

- Actinor Shipping
- Aker American Shipping
- Arcade Shipping
- Atlantic Ctnr.line
- Awilco
- Bananfart
- Belships
- Benor Tankers
- Bergen n Rutelag
- Bergesen
- Bona Shipholding
- Bonheur
- Borgestad
- Braathens
- Brovig Supply ASA
- Camillo Eitzen & Co
- Color Group
- Den Norske Amerikalinje
- Det Norden Damp.
- Dyvi
- Eidesvik Offshore
- Eidsiva Rederi
- Farstad shipping
- First Olsen Tankers
- Fosen Trafikklag
- Frontline
- Ganger Rolf
- Golar lng
- Golden Ocean Group
- Green Reefers
- Hard Sunnhord DS
- Havtor
- Helicopter Services gp.
- I m Skaugen
- Ivar Holding
- Jinhui Ship.& Trsp.
- Jonas Oglaendn
- Kosmos
- Kvaerner Ship.
- Larvik Scandi Line
- Leif Hoegh
- Mercur Tankers

(cont'd)

- Mosvold Shipping
- Namsos Traffikkselskap
- NCL Holding
- Nordic Am.tkr.ship.
- Nordsm.& Thulin
- Norwegian Air Shuttle
- Odfjell
- Oslo Shipholding
- Rieber Shipping
- Ross Offshore
- S D S Shipping
- Saevik Supply ASA
- SAS Norge
- Skaugen Petrotrans
- Smedvig Tankship
- Solvang
- Star Reefer
- Stavangerske
- Stolt Nielsen
- Stolt partner
- Swan Reefer
- Team shipping
- Tordenskjold Ship.
- Troms fylkes dampsibsselskap
- Tsakos energy nav.ltd
- Ugland Nordic Ship.
- Ugland Nordic Tankers
- Wabo
- Vard
- Waterfront Shipping
- Western Bulk Ship.
- Wilhs.Wilhelmsen
- Wilson