Index Futures Trading and Spot Market Volatility:

Evidence from the Swedish Market

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Master Thesis of Finance

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Abstract:

This paper investigates the effect of the introduction of the Swedish OMXS 30 Index Futures Market on the volatility of the OMXS 30 Index Spot Market. The futures market was introduced in April 1987 and this paper will use the ARCH family of models to test if spot market volatility increased, decreased, or stayed the same in the period after the futures were introduced. A discussion of previous theories and studies is followed by an analysis of the Swedish market. The data description and methodology are followed by the empirical testing and results which indicate that there was no change in the volatility of the OMXS 30 spot market due to the introduction of the futures market. The paper concludes by discussing the possible reasons why the introduction of the futures market did not impact spot volatility which include the trading mechanisms of the OMXS 30 futures market, the types of investors trading, and the characteristics of the data sample.

Key words: Futures index trading, volatility, Swedish market, GARCH

JEL classification: G1

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Master Thesis

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1 Introduction

1.1 Background

A stock index future contract is an agreement to buy or sell a certain value of a stock index on a future date at a predetermined price. The first stock index futures began trading on February 24, 1982 in the U.S. by the Kansas City board of trade (Thomas 2002). Since then researchers have been trying to determine the relationship between index futures and the underlying spot market. Stock index futures are important because they are used for many different purposes by different types of traders. For example, index futures are efficient tools for portfolio managers and other participants who want to hedge. They are also useful to speculators and arbitragers who can take positions in the futures market more easily than in the spot market. It has also been argued that index future markets increase overall market efficiency by allowing information to flow more freely and so the spot market can look to the futures market for the first signs of new information (Cox 1976). Based on the uses of index futures and the theories of how they affect the spot market, it is of interest to understand, in reality, how an index futures market actually affects the index spot market. In our study, we will be looking at the index futures effect on the volatility of the spot market. Volatility itself is an extremely important aspect of a stock, portfolio of stocks, or entire index because volatility is a proxy for risk. The more volatile the spot index is, the more exposed investors are to downside risk and this is an important factor when investors are deciding where to put their money. Information on volatility and its relation to the existence of an index futures market is useful to intuitional investors, portfolio managers, arbitragers, speculators, academics, and even regulators of market. It is for these reasons that we have chosen to investigate the effects of the introduction of an index futures market on the spot index.

After the introduction of index futures in the U.S. in 1982 many other markets outside the U.S. began to see the potential benefits of introducing index future contracts. In April 1987 Index futures on the Stockholm OMXS 30 market began trading. In 1987 1.7 million OMXS 30 index futures contracts were traded (Hou and Luengo 2004). The OMXS 30 market began just one year before, in January 1986 and comprises the 30 largest stocks on the Swedish Stock Exchange.

We will discuss somewhat interchangeably the characteristics of both the OMXS 30 and the entire Swedish Stock Exchange in our analysis since these 30 largest stocks account for most of the activity on the entire exchange and because information we obtained separates the markets to varying degrees.

1.2 Problem

We are undertaking this analysis because there exists a gap in research on the Swedish market with respect to the introduction of index futures in 1987. Previous literature has investigated the effects of introducing an index futures market in most of the world's major stock market indices; however this research has not been conducted in the Swedish market. In order to properly frame the problem we will further investigate the theories behind index futures and their relation to spot volatility. We will examine the Swedish market and identify factors which make the Swedish market different from other markets tested in previous research. We hope to provide conclusive evidence as to the effect of the introduction of the Swedish index futures market on volatility in the spot market.

There are different reasons to expect an increase or a decrease in volatility as a result of the index future introduction. The spot market could see increased volatility as a result of information moving faster in the futures market, or a decrease is possible if additional information is created in the futures market and this increases certainty and stability in the spot market. Previous literature has reached different conclusions on how the introduction of an index futures market affects the spot market volatility. We will discuss these other theories in the section on previous literature.

1.3 Purpose

Our objective is to determine if the introduction of the OMXS 30 index futures market in April 1987 impacted the volatility in the spot market of that index. We will investigate the effect of the introduction of futures by using statistical methods to compare data before and after the introduction of the futures market. We will test to see whether the introduction of the futures market caused an increase, decrease, or no change in the volatility of the underlying spot return of the index. We will then discuss possible reasons for the results we observe within the framework of theories on index futures and in the context of the Swedish market.

1.4 Outline

We will first review theories in the field of index futures including the potential benefits and risks created as well as the role of investors. Then we will look at previous research to help frame our current research and to give a background for our approach. We will then analyze the Swedish market in the mid 1980s including the market outlook, investors in the market, and unique features of the market. Next our empirical investigation will begin by introducing the data and methodology we will be using. We will then show the results from our empirical testing and provide analysis and further testing if needed. The last part of our paper will draw conclusions and make further qualifications if necessary.

2 Theory and Previous Research

2.1 Theory

2.1.1 Benefits of Index Futures

Index futures can benefit risk hedgers, speculators, arbitragers, and traders who are prevented from entering the spot market due to high transaction costs. The benefits of index futures markets include lower transaction costs compared to spot markets. This allows investors to take positions they would not otherwise be able to take due to transaction costs (Becketti and Roberts 1990). Another benefit of an index futures market is the ability given to hedge or manage a portfolio. The index futures provide a security with the underlying asset very similar to the market but not exactly the same. This allows for progressive hedging and portfolio reformation using futures with fewer commitments and costs than in the spot market. For example, selling futures would protect a portfolio against a slide in the spot price (Becketti and Roberts 1990). If this alternative did not exist for portfolio hedging then hedging would be done in the spot market which could increase volatility of the spot market directly (rather than the possible indirect effect of futures trading) (Becketti and Roberts 1990). In this way, futures markets could absorb and shelter the spot market from volatility.

Since there are more participants in the entire market with the inclusion of a futures market, it is likely that more information exists in the market (Cox 1976). Also, due to lower transaction costs than in the spot market, information can travel faster and this could also help market efficiency (Cox 1976). The increased market efficiency could increase certainty and stability in the spot market which might actually lower volatility (Edwards 1988).

2.1.2 Risks of Index Futures

If index futures do in fact create more spot market volatility, this could have a negative impact on the spot market. Because many traders use a risk return approach when they are investing, an increase in volatility, and thus downside risk, would cause an increase in the return demanded by investors. If a higher return does not occur then investors will sell in the spot market and this will drive prices down even if the fundamental value of the spot market remains unchanged.

Another potential drawback is related to the low transaction costs and fast information flow of an index futures market. If irrational trends and panics begin then they could spread more easily and quickly in the futures market and spill over into the spot market. If the futures market is driven by irrational behavior then any spillover effects into the spot market will likely have a negative impact. Some academics have even partially blamed the market crash of 1987 on this phenomenon (Becketti and

Roberts 1990).

2.1.3 Role of investors in the market

The types of investors trading in the spot and futures market will influence the efficiency of both markets as well as the spot market's reaction to introducing a futures market. In our analysis we will make the assertion that institutional investors are informed investors, or at least more informed than individual investors. There are a few different schools of thought on the ability of institutional investors to influence the market. Some theories say that institutional investors can actually react before movements in the market and can profit from these actions while others say that institutional investors react to the market and invest after market movements. Somewhere in the middle is the idea that institutional investors can temporarily impact the market when they enter and exit positions (Sellin 1994).

The role of speculators in the futures market is also of importance. Speculators play an important role in markets because they take up positions opposite to risk-averse participants who otherwise would not be able to reduce their risk as effectively. The low transaction costs of futures markets are attractive to speculators who can take positions otherwise prohibited by the higher transaction costs in the spot market (Becketti and Roberts 1990). Arbitrage possibilities also exist for speculators. These opportunities occur when the relationship between the futures and the spot markets does not behave normally (for example if future prices decrease and spot prices do not) (Becketti and Roberts 1990). There are opposing views on how speculation in the futures market can affect the spot market. One theory is that speculation evens out price variations and evens out the market by taking up positions opposite to risk-averse participants (Antonios and Holmes 1995). Other theories say that speculators tend to lose in aggregate while only a few speculators gain which would mean that the market is inefficient and the information spread into the spot market leads to destabilization from the speculation (Kaldor 1960).

2.1.4 Role of information in volatility

One important aspect of index futures theory is information. The flow of information regarding the future performance and cash flows of a company is one of the most important causes of volatility in a stock or stock index. Therefore, the cumulative information regarding the 30 companies on the OMXS 30 exchange should drive the volatility of the index. This information can be public or private information and this distinction relates to the difference between informed and uninformed investors. Public information is released to all traders at the same time whereas private information is not released into the market immediately. When public information enters the market, traders use the information to open or close additional positions and this causes volatility. Public information is available to both informed and uninformed traders so this information should not create an advantage for any trader. Private information is normally available only to informed traders and they can use this information to profit. When informed traders use this private information to profit, other traders can often see this as a signal and thus the rest of the market becomes effectively informed of the private information. Information flow is not the only factor which affects volatility. Uninformed traders and speculators can create volatility based on no new information. Trading, and thus volatility, can also occur for more practical reasons such as balancing of portfolios or investors' cash needs.

2.2 Previous Research

There has been a large amount of analysis on the effects of introducing a futures market on the volatility of the underlying spot market of the index. Some studies have shown that volatility of the spot market increases as a result of the introduction of index futures while others have shown that volatility declines or is unaffected. These studies have looked at different markets, used different models, and have made various assumptions in their models and their explanations. In the below above we have focused mainly on studies about the introduction of stock index futures contracts. There has been extensive research in this area for markets where the underlying asset is not a stock index however we have not included these in our table.

Table 1 Previous Studies

Name	Year	Data Type- Index Future unless otherwise noted	Method	Change in Volatility
Edwards	1988	S&P 500	Variance ratio test	Decrease
Harris	1989	S&P 500	OLS	Increase (not proved conclusively)
Antoniou, Holmes	1993	FTSE 100	GARCH	Increase
Oehley	1995	All Share indices and gold	Various	No conclusive effect
Butterworth	2000	FTSE 250 Index Futures, Daily Log Returns	GARCH	Increase
Yu, Shang-Wu	2001	S&P 500, FTSE 100, Nikkei 225, Hang Seng Index, Australian AOS	GARCH	Increase except FTSE and Hang Seng
Chang and Wang	2002	Taiwan Index Futures (Introduction of 2 types)	GJR Model	Increase (one futures) no effect from other
Mukhopadhyay, Kumar	2003	NSE Nifty (India)	GARCH	No effect/Decline in Persistent Volatility
Darrat, Otero, Zhong	2003	Mexico Stock Index	EGARCH	Increase
Illueca, Lafuente	2003	Spanish Stock market	GARCH	No effect
Bae, Kwon, Park	2004	Korean KOPSI 200	OLS	Increase
Spyrou	2005	Athens Stock Exchange	GARCH	No effect
Alexakis	2007	FTSE/ASE-20	GJR-GARCH	Increase

It is understandable that results have varied so much since different markets have different characteristics, including what is being traded, the type of investors trading in the market, and trading mechanisms. Choosing the appropriate model is also crucial in extracting useful and reliable data. In addition, macroeconomic factors and shocks to the market must also be considered when trying to isolate the effects of introducing a futures market on volatility. A key determining factor in most of these studies is how information is transferred within the market between investors. Butterworth (2000) highlights the fact that traders in a less established market, the FTSE 250, are often uninformed and are merely speculating in the market which could lead to increased volatility without increased information. In more developed markets such as the S&P 500, some research has suggested that volatility decreased after the introduction of index futures (Edwards 1988). The S&P 500 is a well devolved and well known market which means that there are probably a large number of informed traders participating in the index futures market.

The earliest studies done on this topic did not use a GARCH model (defined in methodology section) which may have influenced their results. The GARCH model is an excellent way to measure volatility and we will discuss this aspect later in our methodology. More specifically, the most effective models we have seen use an asymmetric GARCH model with a dummy variable for the before and after periods of the introduction of futures. There have also been different variations of the GARCH model which have been applied. For example, Spyrou (2005) uses EGARCH and EGARCH in mean which are more advanced forms than GARCH (1,1). We will test if these methods are applicable in our case using an approach discussed in our methodology section.

3 The Swedish Market

Prior to 1986 the OMXS 30 did not exist. To get a better picture of the conditions of the OMX when index futures were introduced we will look at the overall state of the entire Swedish Stock Exchange as of 1986. Stockholm Stock Exchange was founded in 1863. The Stockholm Stock Exchange was the largest in Scandinavia as of August 1986 with market capitalization of SEK 445 billion which was about 4% of the European market at the time (Svenska Handelsbanken Group 1986).

3.1 Swedish Market outlook in mid 1980s

The 1980s, up to 1986, had been a boom period for the Swedish stock market. From 1980-1986 the Stockholm Stock Exchange was the best performing market, in terms of return, in the world. When compared with the world market performance in the early 1980s we can see that as in Table 2, the Swedish market outperformed the world in the early 1980s and then in the mid 1980s the trend became less clear. Table 2 shows the performance from 1980 though the end of our data sample period in 1988.

Table 2 Swedish Market return on investment compared with the world market

	1981	1982	1983	1984	1985	1986	1987	1988-June
World	-4%	11%	26%	2%	37%	39%	14%	11%
Sweden	36%	23%	66%	-11%	25%	51%	-8%	27%

Source: Svenska Handelsbanken Group, 1986

This high growth in the early 1980s posed a potential danger for the Swedish market going into the period of our data sample. Prices may have been over inflated and due to high interest rates, a political decision to freeze dividends, and a less positive outlook for Swedish business in 1985. Factors which helped the market were the falling U.S. dollar, decreasing interest rates, and decreasing oil prices (Svenska Handelsbanken Group 1986). As of 1986 it was unclear which direction the market would be headed. Since we are interested in the volatility of the market during our sample period which is in years 1986-1988, it is useful to get an initial idea of the volatility by looking at some general trends of volatility in the Swedish market. As shown graphically in the figure 2 of the data section of this paper, volatility is mainly clustered around the end of 1987.

This volatility is most likely associated with the crash which occurred across world markets on October 19, 1987. The market crash caused a one day loss of 23% in the Swedish market (Svenska Handelsbanken Group 1986). This offset many of the gains from 1980-1987 and caused a great deal of volatility in the market. Since the crash occurred after the introduction of the index futures, it is possible that we will see an increase in volatility after the introduction which was caused only by the market crash and resulting volatility. It is however, encouraging to note that previous research which focused on the crash of 1987 as a "breakpoint" was unable to find a shift in return or volatility to coincide with this breakpoint (Frennberg 1992a). If we assume this conclusion is true then we can proceed with optimism in looking for a new breakpoint for a change in volatility based on the introduction of the index future contract.

3.2 Features of the Swedish Market

One unique feature found in previous empirical investigation of the Swedish market was the seasonality effects in the market. Previous research showed that there was a January effect, which is common in markets, but evidence also showed a July effect and a September effect in the Swedish market (Frennberg 1992c). January and

July show positive abnormal returns and September shows negative abnormal returns (Frennberg 1992c). In addition to seasonality, the mid 1980s were an extremely volatile period in the Swedish market. As shown in the table below, 14 of the 20 most volatile months in the Swedish market from 1919-1990 occurred during the 1980s and 6 of these are during the period we are observing in our analysis.

Table 3 Extreme months on the Swedish Stock Market 1919-1990

Year	Month	Return	Rank	Year	Month	Return
1921	7	19.4	1	1932	3	-27.1
1983	2	18.6	2	1990	9	-21.6
1922	5	16.9	3	1987	10	-20.5
1983	1	15.3	4	1987	11	-14.2
1922	4	14.1	5	1940	4	-13
1987	2	13.5	6	1922	2	-12.7
1986	3	13.5	7	1931	9	-12.7
1924	3	13.1	8	1990	8	-11.8
1988	1	12.2	9	1987	1	-11.7
1982	11	12	10	1921	2	-10.7
1981	6	11.8	11	1970	4	-9.7
1985	11	11.1	12	1970	10	-9.5
1932	7	11	13	1938	3	-8.9
1981	2	10.5	14	1977	6	-8.6
1981	10	10.2	15	1947	10	-8.5

Note: Nominal returns including dividends

Source: Frennberg, 1992b

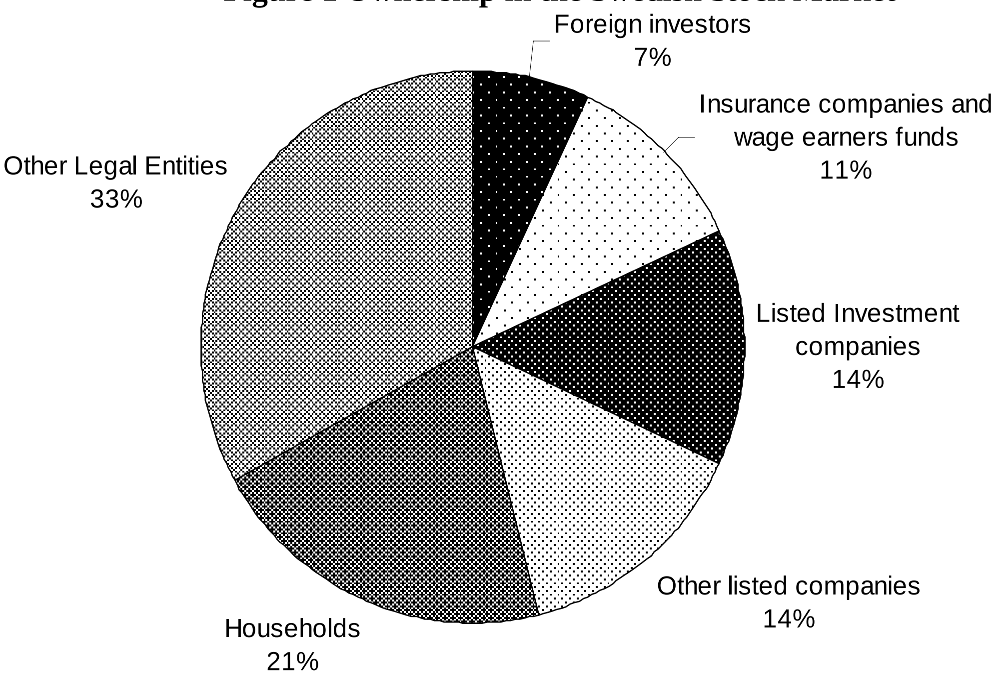
One important factor to consider in our investigation of the Swedish market is that the trading mechanism of the futures market was different from most other futures markets which have been researched. Until 2005 (so during our entire data sample) futures contacts in the Swedish market were not settled on a daily basis, in other words they were not marked to market. These futures contacts were thus more like forward contracts because they were only settled upon expiration.

During our data sample, investors in the index futures market were more committed to their position and could not simply exit the position. They could take a short position against their futures contact but they would still have to wait until expiration to fully exit the position and dealing with two contacts could increase transaction costs. Since the futures were not marked to the market, the trading of the futures before maturity was difficult because the price was determined in the market. We hypothesize that if we see no effect on the volatility of the spot market it is because of the nature of trading in the Swedish market. The market left individual investors responsible for their positions in the futures and did not allow for an easy exchange of futures which would allow information to flow quickly.

3.3 Investors Trading in the Market

The Swedish market had been dominated by institutional investors and the make up of the market was as follows in September 1986:

Figure 1 Ownership in the Swedish Stock Market



Source: Svenska Handelsbanken Group, 1986

Individuals represented only 21% of the investors in the Swedish market. The type of investors trading in the futures market is of particular interest to our investigation. In our investigation we will treat large institutional investors as "informed" investors. Examples are insurance companies, wage earners funds, investment companies, other listed companies, and other legal entities. It is difficult to determine if foreign investors are institutional investors but it is likely that they are, since individuals are less likely to enter into a foreign market on their own as information in a new market is easier to obtain for institutional investors. Since ownership in the Swedish market is dominated by institutional investors, most of the trading in the market was likely done by these institutions. In addition, it is likely that these same institutional investors will participate in the futures market for purposes of hedging, speculation, or arbitrage. It is less likely that households will be participating in the futures markets as households are less likely to hedge, speculate, and look for arbitrage possibilities than professional investors and portfolio managers. We can therefore conjecture that in the Swedish market for futures there were more institutional investors than individual investors.

4 Data collection and methodology

4.1 Data collection and characteristics

The data of the OMX STOCKHOLM 30 price index (OMXS 30) is collected from Datastream. The daily closing prices of OMXS 30 from January 1986 to June 1988 are employed in the empirical analysis. The returns are defined as the first difference of the logarithmic price levels. The OMXS 30 stock index[1] was first introduced in January 1986. The purpose of the stock index was to use it as the underlying security for trading in standardized options and futures contracts. Just over one year later, in April 1987, the corresponding index future (OMXS 30 index future) was launched. After excluding non-trading days, the daily time series consists of 650 observations: 325 observations relate to the period prior to the introduction of the index future and 325 observations after the introduction. We choose 325 observations because that is the number of observations available from the start of the OMXS 30 until April 1987. We will use an equal number of observations before and after the introduction of the index future contract. Using the same number of observations will

[1] OMXS 30 index was first called OMX index when it was introduced in January 2, 1986. In November 14, 2004, the name of the index was changed into OMXS 30 by OMX, but any aspect of calculation or derivatives contracts specification was not changed (Norden, 2008).

give equal weight to the before and after periods so that the two periods are more comparable in our analysis.

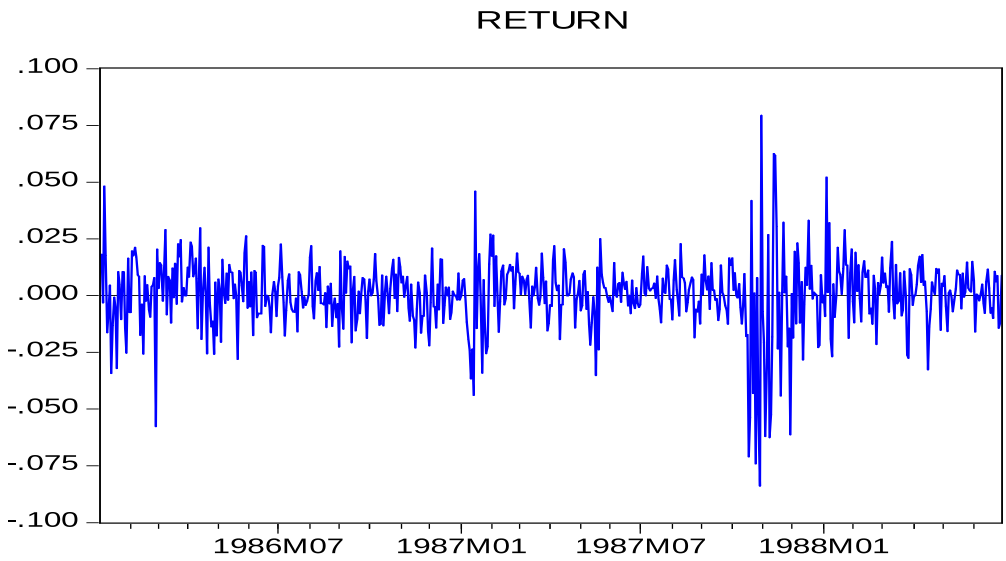
4.2 Methodology

We have chosen quantitative methods in our analysis. We have done so because we are trying to measure volatility numerically. In addition, we are using numerical data as inputs in our model, and the output given is also numerical. In our analysis we are deriving our conclusions from a limited set of data and this is a deductive approach. We will use other market information in our analysis but our main results will be obtained from the data sample. We have chosen a deductive approach because the models we are using demand specific input in order to produce accurate information.

One important decision to make in our methods is whether to adjust the data in our sample for the seasonality and volatility exhibited in the market. Seasonality in January, June, and September would cause 8 of the months in our sample to be affected. In addition, 6 of the months in our sample are very extreme periods in Swedish market history. Since our data sample is relatively short, if we adjusted for seasonality and exceptional months this would mean that only one half of our sample (16 of 30 months) would be treated as normal data. Making adjustments for half of the data would change the whole nature of our testing and we do not want to do this. Also, because we are using daily observations and not monthly, it would be harder to adjust for the monthly seasonality and exceptional months. One event which we will look at closer in our investigation is the market crash of October 1987. In our testing we will see if excluding observations which were volatile after this event improves the results of our testing.

In order to examine if the introduction of index futures has an effect on the underlying spot return volatility, we apply the ARCH (ARCH stands for 'autoregressive conditionally heteroscedastic') family of models to test the spot volatility before and after the introduction of futures trading. The ARCH model is widely used in finance because of two important features of financial data series. First, it is unlikely in the context of financial time series data that the variance of the errors will be constant over time, so it is important for the model to assume the variance is not constant and the change of the variance of the error terms should also be described. Second, an important feature of financial data series is so called 'volatility clustering', which describes the tendency of large changes in asset price (of either sign) to follow large changes and small changes (of either sign) to follow small changes. In other words, the current level of volatility tends to be positively correlated with its level during the immediately preceding periods (Brooks 2002). From Figure 2, we can see that the daily returns of OMXS 30 show clustering.

Figure 2 OMXS 30 daily returns



One way to model the features mentioned above is using an ARCH model. Take ARCH(1) model for example:

$$y_t = \beta_1 + \beta_2 x_{2t} + \beta_3 x_{3t} + \beta_4 x_{4t} + u_t \qquad u_t \sim N(0, \sigma_t^2) \tag{1}$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 \tag{2}$$

Equation (1) is the conditional mean equation which could take almost any form that the researcher wishes. In equation (2), the 'autocorrelation in volatility' is modeled by allowing the conditional variance of error term, σ_t^2, to depend on the immediately previous value of the squared error. The model given by (1) and (2) could be extended to the general ARCH(q) model, where the error variance depends on q lags of squared errors:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 + \cdots + \alpha_q u_{t-q}^2 \tag{3}$$

A more general process is the generalized ARCH (GARCH) model, which was developed independently by Bollerslev (1986) and Taylor (1986). The GARCH model allows the conditional variance to be dependent upon previous own lags, so the conditional variance can be represented as:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta \sigma_{t-1}^2 \tag{4}$$

This is a GARCH (1,1) model. In the GARCH model, the conditional variance is a weighted function of a long-term average value (dependent on α_0), information about volatility during the previous period ($\alpha_1 u_{t-1}^2$) and the fitted variance from the model during the previous period ($\beta \sigma_{t-1}^2$). The GARCH (1,1) model can be extended to a GARCH (p,q) formulation:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \tag{5}$$

For a well-defined GARCH (q,p) model, there exists the restrictions that $\alpha_0 > 0, \alpha_i \geq 0$ and $\beta_j \geq 0$. The sum of the coefficients α_i and β_j measures the volatility persistence: as it moves close to unity, the persistence of shocks to volatility will become greater. When α_i and β_j sum to unity, it is known as a 'unit root in variance', also termed 'Integrated GARCH' or IGARCH (Engle and Bollerslev 1986). In this case, volatility persistence is permanent and past volatility is significant in predicting future volatility over finite horizons (Spyrou 2005).

Brooks (2002) stated that in general a GARCH (1,1) model will be sufficient to capture the volatility clustering in the data, and rarely is any higher order model estimated or even entertained in academic finance literature. So in this paper we apply a GARCH (1,1) model for the empirical test.

Since we want to know if the introduction of futures trading has any effect on volatility in Swedish market, we augment the conditional variance equation (4) with a dummy variable:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta \sigma_{t-1}^2 + \gamma Dummy_F \tag{6}$$

In equation (6), $Dummy_F$ is a dummy variable which takes the value zero for pre-future and one for post-future. The sign and statistical significance of the coefficient of the dummy variable will show us if the introduction of OMXS 30 futures has any effect on the volatility of the underlying spot market. If the dummy is statistically significant, this shows that the introduction of futures had an impact on spot market volatility. Furthermore, a positive sign of γ means the volatility increased following the introduction of futures trading, while a negative sign implies the volatility decreased.

One of the restrictions of the GARCH model is that it assumes both positive and negative shocks will lead to a symmetric response of volatility. However, it has been argued that it is more likely in financial data series that a negative shock will have a larger effect on the volatility than a positive shock of the same magnitude. In order to capture the asymmetric phenomenon if it exists, we will apply the exponential GARCH (EGARCH) model, which is one of many popular asymmetric formulations, in our empirical test. One way to express the conditional variance in the EGARCH model is given by:

$$\ln(\sigma_t^2) = \omega + \beta \ln(\sigma_{t-1}^2) + \alpha \frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} + \gamma \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} \tag{7}$$

There are some advantages for the EGARCH model compared with the pure GARCH model. One is that the dependent variable on the left-hand side of the equation above is in ln() form, so even if the parameters on the right-hand side are negative, we still have a positive σ_t^2 . Therefore there is no need to impose non-negative constraints on the model parameters. Another important feature of the EGARCH model is, as mentioned above, that asymmetry is allowed under the EGARCH model, since if the relationship between volatility and returns is negative, γ will be negative.

One more thing we have to consider in our empirical tests is that in some of the previous studies (Spyrou 2005), EGARCH-M model is applied. The underlying economic theory in finance is that investors should be rewarded for taking additional risk by obtaining a higher return. One way to present this idea is by allowing the return be partly determined by its risk. So the mean equation will be changed into a form as below:

$$y_t = \mu + \delta\sigma_{t-1} + u_t \sim N(0, \sigma_{t-1}^2) \quad (8)$$

In this equation, if δ is positive and statistically significant, then increased risk, which is represented by an increase in the conditional variance, will lead to a rise in the mean return. Thus δ can be interpreted as a risk premium. So after the EGARCH model, we will also apply the EGARCH-M model in the Swedish market to test the sign and the significance level of δ .

5 Empirical Tests and Results

5.1 Summary Statistics

The descriptive statistics for the OMXS 30 are shown in Table 4 for two periods—the pre-futures period and the post-futures period. The statistics for the whole sample period are also reported. As observed in the table below, the standard deviation of the return series increases in the post-futures data sample. This is what we would expect to see if index futures were responsible for increasing volatility in the spot market. The results are also consistent with the market trends in our sample periods, specifically the crash of October 1987 and resulting volatility. In addition, the average return has also decreased significantly. The Kurtosis is not equal to 3 and Skewness is present so we reject the assumption of a normal distribution. We can also see that the data is even more erratic and less normal in the post-futures period. The Jarque-Bera statistic and its *p*-value in Table 4 are used to test the null hypothesis that the return series of OMXS 30 index is normally distributed. All *p*-values are smaller than the .01 significance level indicates that the null hypothesis is rejected.

Table 4
OMXS 30: Descriptive Return Statistics

	Full Sample
Mean	0.00055
Median	0.00121
Maximum	0.07941
Minimum	-0.08385
Std. Dev.	0.01565
Skewness	-0.73420
Kurtosis	8.46577
Jarque-Bera	866.16690
Probability	0.00000

	Pre-futures	*Post-futures*
Mean	0.00094	0.00019
Median	0.00092	0.00146
Maximum	0.04819	0.07941
Minimum	-0.05762	-0.08385
Std. Dev.	0.01341	0.01764
Skewness	-0.36075	-0.84587
Kurtosis	4.50719	8.96884
Jarque-Bera	37.69427	519.60200
Probability	0.00000	0.00000

Stationary Test

The econometric consequences of nonstationarity can be quite severe, leading to least squares estimators that are unreliable. We want to test the volatility of the return on the OMXS 30, although the return is normally stationary in most cases. As a precaution we will run a stationary test of the variables before the regression estimation just to double check. We apply the Augmented Dickey-Fuller (ADF) test for stationarity of the variables and the output is shown in Table 5 as below:

Table 5

ADF Unit Root Test

	ADF Level		ADF: 1st difference	
	ADF Statistics	Critical value*	ADF Statistics	Critical value*
log(Price)	-2.23572	-2.86578	-22.97352	-2.86578

Note: the MacKinnon critical value noted refers to the value obtained in the ADF test in which the hypothesis of a unit root is rejected.

* Indicates the critical value at 5% significant level

From the output reported in the table above, we can see the log(price) is integrated of order 1, or I(1), Since the OMXS 30 daily return is our dependent variable and we have seen that the first difference of log(price) is stationary, we are confident using it in our empirical test.

5.2 Results from the Volatility Models

We first apply the GARCH (1, 1) model for the two periods—before and after the introduction of index future in Sweden, and the results are shown in Table 6 below. We also applied both normal distribution and *t*-distribution for the two periods. The AICs of *t*-distribution for both periods (-5.86256 for pre-future and -5.86657 for post-future) are smaller than those of normal distribution (-5.84636 for pre-future and -5.81508 for post-future), which means we should apply the *t*-distribution, although the difference is not very big. The sum of the coefficients ($\alpha 1+\beta$) which measures the volatility persistence is less than unity for pre-and post-future under both normal and *t*-distribution. We employ the Wald statistic to test the null hypothesis that the sum of ($\alpha 1+\beta$) is equal to unity and the high *p*-value shows that we can not reject the null hypothesis that ($\alpha 1+\beta=1$), so it seems that we should apply I-GARCH model in the following test.

Table 6
OMXS 30: Results for GARCH (1,1)

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta\sigma_{t-1}^2$$

	Pre-futures	*Post-futures*
	Assuming a Normal Distribution	
α0	0.00001**	0.00001**
	(0.00001)	(0.00000)
α1	0.06581*	0.19972*
	(0.02134)	(0.03335)
β	0.87296*	0.78321*
	(0.03275)	(0.02929)
α1+β	0.93877	0.98293
α1+β=1	χ^2=3.5677	χ^2=2.2920
	[0.05890]	[0.13000]
AIC	-5.84636	-5.81508
	Assuming a *t*-Distribution	
α0	0.00001**	0.00001**
	(0.00001)	(0.00000)
α1	0.08490*	0.15263*
	(0.03727)	(0.05195)
β	0.83998*	0.80877*
	(0.06470)	(0.05115)
α1+β	0.92488	0.96139
α1+β=1	χ^2=0.327889	χ^2=1.325328
	[0.56690]	[0.24960]
AIC	-5.86256	-5.86657

Note: The Wald test is a chi-square (1) test.
( ) = Standard errors; [ ] = probabilities
**Significance at 10%; *Significance at 5%

Next we apply the GARCH (1, 1) model for the entire sample with the dummy variable; the results are shown in Table 7. In this initial model, the coefficient on the dummy variable is negative. This suggests that the volatility of the market decreased after the introduction of the index futures, although the effect is very small because the coefficient on γ is close to zero. When looking at the significance of the coefficient on the dummy variable we get a *p*-value of 0.37 which means that the dummy variable is not significant and thus not reliable. We will show in the following text how we adjust our model to try to get a significant dummy variable.

Table 7
OMXS 30: Results for GARCH (1,1) without and with a Dummy Variable

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta\sigma_{t-1}^2 + (\gamma Dummy_F)$$

	Without Dummy	With Dummy
Coefficients	*Estimates*	*Estimates*
α0	0.00001*	0.00001*
	(0.00000)	(0.00000)
α1	0.12508*	0.12374*
	(0.03158)	(0.03154)
β	0.82513*	0.82283*
	(0.03649)	(0.03726)
γ		-0.00000
		(0.00000)
α1+β	0.95021	0.94657
α1+β=1	χ^2=4.052547	χ^2=4.628983
	[0.04410]	[0.03140]

Note: The Wald test is a chi-square (1) test.

( ) = Standard errors; [ ] = probabilities

*Significance at 5%

We also notice that the sum (*α1+β)* which measures volatility persistence is always less than 1 for both models. We tested the null hypothesis that *α1+β=1* using Wald coefficient test. Based on the *p*-values of 0.0441 for the no dummy and 0.0314 for the dummy equation, we can reject the null hypothesis that *α1+β=1*. Thus there is no need to use the I-GARCH model since the data does not exhibit unit root variance.

We will now test the GARCH (1, 1) model for asymmetry. If asymmetry is present then our results will be biased and unreliable. We will therefore use the EGARCH (1, 1) model to test for asymmetry in our data sample. As shown in Table 8 below, we first use the EGARCH model without a dummy variable to detect if asymmetry exists. By looking at the asymmetry term $\frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}}$, the coefficient estimate γ=-0.09254 (with *p*-value 0.0021 which is significant at a 5% significance level) suggests, as expected, that negative shocks imply a higher conditional variance than positive shocks of the same magnitude for the next period which means asymmetry is present.

Table 8
OMXS 30: Results for EGARCH (1,1) without and with Dummy Variable

$$\ln(\sigma_t^2) = \omega + \beta \ln(\sigma_{t-1}^2) + \alpha \frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} + \gamma \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + (\lambda Dummy_F)$$

	Without Dummy	With Dummy
Coefficients	*Estimates*	*Estimates*
ω	-0.57785*	-0.57881*
	(0.15061)	(0.15070)
β	0.95411*	0.95379*
	(0.01606)	(0.01612)
α	0.22354*	0.22328*
	(0.05213)	(0.05238)
γ	-0.09254*	-0.09307*
	(0.03007)	(0.03032)
λ		-0.00316
		(0.01746)

Note: ( ) = Standard errors

*Significance at 5%

Based on the existence of asymmetry, next we add the dummy variable into the EGARCH model to test the sign of the coefficient and its significance level. The results are also shown in Table 8 above. The sign of the coefficient λ is negative which suggests that the volatility of the spot market decreased after the introduction of the index future. However, its *p*-value which is 0.8566 is much larger; it is not significant even at 10% significant level. Since we can not reject the null hypothesis that λ equals to 0, the interpretation is that the introduction of the index future has no effect on the underlying spot market.

In the literature review, some previous studies applied the EGARCH-M model for the volatility. Here we also follow the same model to see if this model can improve our results. The results from EGARCH-M model are shown in Table 9 below. The sign of the coefficient δ is negative for both models with and without dummy variable, which conflicts with the assumptions of EGARCH-M model. However, it is not statistically significant at 5% significance level (with *p*-values 0.7555 and 0.7508 for models without and with dummy variable respectively). This means that the conditional variance has no effect on the mean return. Also, we notice that the sign of the dummy variable's coefficient is negative and it is still not significant at 5% significance level (*p*-value is 0.8470).

Table 9
OMXS 30: Results for EGARCH-M (1,1) without and with Dummy Variable

$$y_t = \mu + \delta\sigma_{t-1} + u_t \sim N(0, \sigma_{t-1}^2)$$

$$\ln(\sigma_t^2) = \omega + \beta \ln(\sigma_{t-1}^2) + \alpha \frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} + \gamma \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + (\lambda Dummy_F)$$

	Without Dummy	With Dummy
Coefficients	*Estimates*	*Estimates*
μ	0.00175	0.00176
	(0.00152)	(0.00152)
δ	-0.04118	-0.04183
	(0.13221)	(0.13174)
ω	-0.56901*	-0.56973*
	(0.15163)	(0.15169)
β	0.95502*	0.95472*
	(0.01607)	(0.01612)
α	0.22274*	0.22243*
	(0.05221)	(0.05245)
γ	-0.09400*	-0.09457*
	(0.02999)	(0.03025)
λ		-0.00336
		(0.01740)

Note: ( ) = Standard errors
*Significance at 5%

As stated before, we see volatility is mainly clustered around the end of 1987. We think this volatility is most likely associated with the crash which occurred across world markets on October 19, 1987. We consider this crash might affect our study, so we further apply the EGARCH model, which is our best model, to test the whole sample excluding 20 observations after the crash on October 19, 1987. The results which are not shown here indicate that neither the sign nor the significance of the dummy variable has changed in any significant way, so our most accurate results are still shown by the EGARCH model with the full sample.

In our testing we started by looking at a basic statistical summary of the data noticing that the volatility did appear to change from the before to the after period. We then confirmed that our data was stationary and applied the basic GARCH (1,1) model also noticing that the volatility was different when we tested the pre and post introduction samples separately. Our first attempt to use the dummy variable resulted in a negative, but not statistically significant, dummy coefficient. We then tested for asymmetry and found that it was present in our data. As a result we came to our best model, the EGARCH model, which takes asymmetry into consideration. We used the dummy variable within the EGARCH framework and again the results showed the dummy variable was not statically significant at the 5% level. This indicates that the introduction of futures had no effect on the spot market volatility for the OMXS 30 index. This outcome of no effect is the main result from our empirical testing.

6 Conclusion

We have conducted an empirical analysis to determine whether the introduction of the index futures market in the OMXS 30 affected the volatility of that index. In our testing we employed GARCH family models with a dummy variable which we hoped would show us whether volatility was affected by the introduction of index futures and if volatility increased or decreased. As discussed in the results section of our paper, the coefficient of the dummy variable showed that volatility decreased in the post-introduction period, however, the dummy variable was not statistically significant which indicates that there was no definite effect. We therefore have not derived conclusive evidence from our modeling. This is consistent with some previous studies which either showed evidence that volatility was not affected at all, or that it was affected but due to statistical or other issues, the reliability of the results were not conclusive.

There are several factors which may have affected our results. These factors relate to our discussions of the Swedish market as well as to theories describing index futures. There are several problems which create difficulties in drawing clear conclusions from our analysis. One problem is that the Swedish market was very erratic during our sample period. Six of the most extreme months in the history of the Swedish market occurred in our data sample. We can conclude with some certainty that not all of these fluctuations were related to the introduction of index futures, particularly the crash of October 1987 which was felt worldwide. However, when we excluded the observations associated with the October 1987 crash, our results did not change. The reason we chose not to adjust for the other extreme points in our data is that half of the data would then been subject to adjustment (extreme months plus months influenced by seasonality).

Another problem in our analysis was the ability to obtain data on who was trading the index futures market during our sample period. The best data we were able to obtain was the ownership structure of the entire Swedish market in 1986. This is a problem for several reasons. We are looking at the OMXS 30 market not the entire Swedish market. Also, the data we have is for the spot market not the futures market and is related to ownership not trades conducted. We have attempted to obtain the trading data from the OMXS 30 index futures market during our sample period from the Swedish "Vardepapperscentral" and the NASDAQ-OMX Group however they have not been able to provide us with the data we need. One possible future study that could be conducted would be to see exactly which type of traders were in the futures market and use this information to formulate theories on what type of information was being created in the futures market and passed to the spot market.

Looking at the ownership structure in the Swedish market in 1986 we would expect the futures market to be dominated by institutional investors. Since the spot market was up to 80% institutional investors it is also likely that the futures market mainly consisted of these types of investors since futures' trading is more sophisticated and institutional investors are more sophisticated investors than individuals. If we assume that institutional investors are informed traders (more informed than individuals) it would be reasonable to expect that any information which was created by these investors in the futures market and then passed to the spot market would make the market more efficient which could create more certainty and less volatility. Based on empirical testing this is not the case. There is no significant change in the volatility, however, the coefficient on the dummy variable is negative which suggests volatility might have been decreasing. We can conclude that either the information created in the futures market is not being passed effectively to the spot market, or that there is very little information being created in the futures market.

Another reason why the introduction of the index futures contact might have had no effect or inconclusive effect on the spot market volatility relates to the mechanism of trading of the futures contact in the Swedish market. Since the futures contacts were not marked to market on a daily basis, the contact was designed more like a forward contract. Since the contracts were not priced frequently on the market their value remained more difficult to ascertain. This probably led to reduced or no trading of existing contacts among contract holders. If the contacts were not valued on the market and traded much less frequently than typical futures contracts, the flow of information created by the futures market would be significantly lower than in a typical futures market. Therefore it is very possible that the mechanism of buying, selling, and trading OMXS 30 index futures contract limited the flow of information within the market which also means that information from the futures market never made it into the spot market. With no additional information flowing form the futures market to the spot market there would be no reason for volatility to increase except by other factors. This trading mechanism is the strongest reason why we might see no significant change in the volatility after the introduction of the index futures contact.

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