Stock Returns and Exchange rate Volatility

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Abstract

This paper examines the relationship between firm value and exchange rate volatility. By using empirical approved theory, different multiple regression models is generated. Exchange rate volatility is then tested against stock returns, representing firm value. Recognizing earlier research limited success in finding a significant correlation this paper investigate a global industry, selecting 4 companies. Stock returns are then tested against the major currencies of the selected companies. Scrutinizing the history, financial record and strategy pursued of the individual companies offer some insights into the regression analysis. The findings suggest that stock returns are to a certain degree sensitive to exchange rate volatility and that being more selective in the sampling process gave more significant result than earlier research.
Keywords

Exchange Rate, Arbitrage Pricing Theory, Capital Asset Pricing Model, Stock return, Risk
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<td>CAPM</td>
<td>Capital Asset Pricing</td>
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<td>APT</td>
<td>Arbitrage Pricing Theory</td>
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1 Introduction

To what degree are stock returns sensitive to exchange rate movements? Theoretical and empirical research has sought to answer this question, with ambiguous results. The question however has become increasingly important since the breakdown of the Bretton Wood system in 1970s. Early theoretical studies suggested exchange rate volatility should have an impact on the market value of companies (Dufey, 1972). Later empirical research found some connection between stock return and exchange rate risk (Adler and Dumas, 1984). However classical financial portfolio theory (Shapiro, 1974), suggests that optimal diversified portfolio should hedge against currency volatility (Adler and Dumas, 1983), assuming investors and managers holds the same quality of information concerning the company and market - Meaning a definition of exchange rate risk as unsystematic, in the words of CAPM theory. However an observed increase in the foreign exchange and derivatives market (Triennial Central Bank Survey, 2007), and the unlikelihood that the assumption of equal information holds true in reality has inspired/spurred extensive empirical research in this field. The majority of research is carried out based on, on the theoretical approach suggested/developed by Adler and Dumas’s (1984) statistical studies. However mixed result (see for example: Jorion 1990, He and Ng 1998, Nydahl), illustrate the complexity of the problem behind measuring and defining exchange rate exposure. All of life is about the management of risk, not its elimination (Walter Wriston, Value at risk, 2004). The quote can be seen as both the problem and solution to the problem. Recent data reveals that many firms devote substantial resources to control and manage foreign exchange risk. Foreign exchange and interest derivatives have roused almost exponential in the last decade (Bank of International Settlements). This implies that exchange rate risk is perceived as a risk that needs to be actively hedged against by companies, presumably therefore also by investors. This contradicts theoretical arguments that value cannot be added to the company through activities that investors can engage in themselves, illustrated by the “Irrelevance Theorem” constructed by Miller and Modigliani.

The seeming inconsistency between theory and reality implies specifying exchange risk may be more complex than originally perceived. Exploring the issue at hand further requires a clear analysis of the affect that exchange rates have on companies.

1 A general indicator of the degree of resources is used on hedging strategies.
Wriston’s earlier quote suggests that risk in itself is an ambiguous quality with respect to whether it is good or bad, right or wrong, presuming life in itself it not good or bad. Risk management in a business perspective can therefore be described as the art of identifying harmful risk and outsource it and/or obtain potential profitable risk. This also implies that risk in the business world is closely connected to a premium, as one party pays another to take on what the first party expects to be a harmful risk to their company. This can be the right move for not just the one removing risk, but also the one accepting risk. Jorion (2007) argues that; Corporations are in the business of managing risk”. Any investor whether a private person or large financial institution, when lending money will have to be compensated with a given interest over the time period in question. This is in response to the risk that the lender takes on, if the borrower defaults.

Modern portfolio theory claims that risk, which can be diversified, cannot be justified to be managed at a cost seen from the investors’ point of view (Jorion 1990). This is partly the issue that this paper seeks to investigate. It is indisputable that exchange rate volatilities create some kind of risk. The real question, however, is who will need to manage this risk. The underlying hypothesis may therefore also be; who is really affected by it?

Focusing on the risks that firms are exposed to, two broad definitions can be made: entitled business risks and financial risks. These can in turn be boiled down to the following definitions.

- Business risk refers to the risk companies are taking when operating in a given market. In order to exist a company needs to have some sort of competitive advantage, which is achieved through product development, investment decisions, marketing strategies etc. However macroeconomic changes or market conditions may change resulting in loss of revenue, influencing the profitability of the company.

- Financial risk is primarily related to the financial structure of a company. Most companies use debt as a way of financing new initiatives. Financial risk is for example encountered when interest rates or, exchange rate change and thus alter the cost of debt. A company who purely holds equity finance have almost no financial risk exposure.

Nobel Prize winner in Economics William F. Sharpe, developed the earlier mentioned capital asset pricing model or CAPM. The model, in simplified terms, predicts the relationship between risk and the expected return. Although the model cannot fully withstand empirical testing (Bodie et al., 1995), it is still acknowledged to offer an insight into the expected return with sufficient accuracy for a large number of applications. However it does hold a
series of simplifications and assumptions that are needed in order to make the theory applicable and meaningful.
Stephen Ross (1976) developed the Arbitrage Pricing Theory (APT) as a counterargument to the CAPM theory. This model has less restrictions and assumptions and has therefore gained popularity. The added flexibility created by the reduction in assumptions, makes adopting the model to the ever more complex financial world easier.
Using both CAPM and APT theory this study tries to establish a link between exchange rate volatility and stock return trough different regressions model. In contrast to the many earlier studies and their mixed result, this report limits itself to a few companies, acting within a highly international market and who are therefore theoretical more exposed to currency volatilities. This paper also considers the interference on the analysis of different risk management strategies used on currency exposure. Although it is not an objective to evaluate these strategies, totally disregarding seems improper. Furthermore, as stated earlier, Miller and Modigliani’s Irrelevance Theorem, clearly states that companies can not increase a firm’s value by undertaking activities investor can take on themselves, based on perfect capital market assumptions. Different market imperfections, however, can cause companies to undertake different hedging strategies, which will affect the results of the regressions made. Whether or not these strategies are profitable or not is not considered in this report, but the implications created by the use of these techniques are considered.
1.1 Problem Statement

The main objective of this study is to examine the relationship between stock returns and exchange rate movements, focusing on a few distinctive companies from highly international industry. This approach is applied in the light of the somewhat mixed result achieved by earlier studies, only finding weak correlations. Hence choosing a global industry should increase the likelihood of finding a significant relationship.

The chosen approach divides the problem into three main parts. First a theoretical discussion of how expectations on returns on investment are generated. In order to decompose the relevant theories, different presumptions are made on how risk is perceived. Different risk classifications are therefore generated in order to categorize what type of risk exchange rate can be defined as. Earlier research has devoted little attention to investigating the underlying assumptions, having built their analysis on earlier work, and instead focusing on establishing a significant relationship between the two factors. By adding a deeper level of analysis to discussion, it is hoped that additional insight into problem can be achieved.

Presuming some kind of theoretical connection is made in the first section, between stock return and exchange rate, using specific companies an empirical connection between the two variables is to be established if possible. This will be done through multiple regression analysis using historical data, while applying various statistical tools in order to strengthen the result of the analysis.

Analyzing the results of the multiple regressions, relevant Risk-Management tools used on exchange rate will be drawn into the discussion. Also historical and financial records from the different companies will be included in an attempt to explain the findings of the tests made.
2 Theory

The theoretical section of this paper will try to uncover whether or not existing theories suggest that currency exposures should be priced into the stock returns of individual companies. The section’s main purpose is to establish a solid foundation for the following empirical study, clarifying the underlying problems of the analysis.

2.1 Risk and Exchange rate

Starting the theoretical discussion of whether or not exchange rate exposure should be priced into stock return or not requires a precise definition of risk and how exchange rate exposure is related to the different kinds of risk.

Three main categories of risk can be identified when evaluating an investment scheme. These are; the firm, the industry and the country or macro-specific risks (Brealey et al 2007).

- Firm specific risk is related to the specific company in question. Meaning exogenous risk to that of both industry and country risk.
- Industry risk may be defined as the risk specific to an industry, not only to the individual company.
- Country specific risk is the risk across industries, also denoted as the market risk. Country specific risk is closely related to political risk. Political risk is among other changes in the fiscal and monetary policies pursued by the specific country.

The essence of this hypothesis of whether or not exchange rate movements should be independently priced into stock return is dependent on the residence of exchange rate risk. Should currency risk be considered a country specific risk e.g. a general market risk, meaning that the premium of the risk is already priced into the market risk, thus not adding extra risk to any individual company. The other possible outcome is that the exchange rate risk is deemed to be a specific risk to the company, resulting in the return of that individual stock being more sensitive to exchange rate change than the general market return. The true multinational companies can to a certain degree move above the country specific risk, diversifying their market profile, thus limiting their exposure to any one country.
2.2 Standing Theories

2.2.1 CAPM

Further exploring the underlying theory of whether or not exchange rate exposure should be priced into the stock return, one can consider the CAPM model.

\[ CAPM : R_i = r_f + \beta_i (r_m - r_f) \] \hspace{1em} (2.2.1)

The main concern of investors, when evaluating portfolio investment, is the total risk exposure measured by the variance or standard deviation of the return of the portfolio. The first commonly acknowledged model, the capital asset pricing model (CAPM), identifies two kinds of risk: systematic and unsystematic. According to Fletcher (2007) only systematic risk is rewarded as unsystematic is diversifiable. Unsystematic risk is also the firm or industry specific risk, which can be utilized in form of strikes, or natural disaster hitting specific industries e.g. bad weather could be a industry specific risk for farmers, hence according to the CAPM theory firm specific risk is not included in the return of the stock and thus not rewarded. Arguing that this risk can be diversified through portfolio management. Systematic risk can however not be diversified according to Moffett et al (2005) and is related to the risk of the market portfolio. Identifying the type of risk, which exchange rate is derived from, does in principle appear important for investors at least according to the capital asset pricing model.

2.2.2 APT model

According to Ross (1976) the arbitrate model of capital assets pricing was developed as an alternative to CAPM mean variance model, developed by Sharpe, Lintner and Treynor. The APT is also original a one period testing, which assume that stochastic properties of return of asset are correlated with a factor structure. This means that the expected return of an asset is approximately linear to the factor loading, or the “betas” (Fama and French, 2004). The APT model therefore alters the assumption of the CAPM theory, defining a linear relationship between the beta of an asset and its expected returns, to an interrelationship between various securities. This, in turn, means that while CAPM measures systematic risk, with an underlying equilibrium argument. The APT does not have this underlying assumption, as it, instead of relying on capturing the relation to the market, uses the underlying factors as variables to explain return. Factors will have to be chosen from theoretical and empirical research grounds. Chances for omitted variables in the analysis are
therefore also considerably larger than in the CAPM model. The APT-model can be illustrated as follows:

\[ R_i = \beta_o + \sum_{j=1}^{n} \delta_j \beta_j + \epsilon_i \]

…………………………………………………………(2.2.2)

where

- \( R_i \) is the return of company \( i \)
- \( \beta_o \) is some constant
- \( \beta_j \) is the loading of the macro-economic variables
- \( \delta_j \) is the factor included in the model
- \( \epsilon_i \) Disturbance / residual terms ideosymmetric

2.3 CAPM and APT theory: Similarities and differences

The CAPM assumes that all investors are rational and seeking an optimal mean-variance portfolio. This means that whenever an asset’s expected return lies outside the security market line (SML) investors would over or under price that particular asset. Since all investors have the same information and are rational they would come to the same conclusions and therefore the expected return of the asset will return to the SML line.

Arbitrage Pricing Theory builds on riskless arbitrage opportunity. Arbitrage opportunity could arise when the “law of one price” is violated. For example because of changes in exchange rates. Any investor can, in theory, then make riskless arbitrage by going short in the high price market and buy in the low price market, earning a sure profit in form of the net price differential, without any real investment until the equilibrium is restores (Jorion 2007).

CAPM relies on collective consensus ss opposed to the APT theory, where few or even a single investor can restore market equilibrium.

2.4 Defining Exchange rate exposure

Defining exchange rate exposure as part of the systematic or unsystematic risk in the CAPM framework may be ambiguous from a theoretical point of view. However in order to understand the underlying problem in defining the risk of currency volatilities, one has to understand the principle of currency risk that companies are exposed to. Moffett et al (2005)
divide exchange rate exposure into two main risk categories: economic exposure and translation exposure. Economic exposure can be further divided into transactional and operational exposure.

Transactional exposure is the risk of changes in exchange rate after financial obligation is made but before it is settled.

Operational exposure is also called competitive exposure or strategic exposure. This is the risk of changes in exchange rates resulting in the company becoming less competitive (e.g. a appreciation of domestic currency enables foreign competitors to sell their product cheaper in the home market without losing profit (Feenstra and Taylor, 2008.)

Translation exposure also called accounting exposure. This is the possibility of losses in owners equity when consolidation foreign subsidiaries into a single currency. Translation exposure may seem less vital when considering the point of view taken in this article.

Investors, and thereby stock return, will mainly be sensitive to current and future cash flow. Consolidation is a snapshot of the business, and hence it is not seen as an appropriate indicator to use when evaluating the profitability of a given company.

Firms with no international activities can also be indirectly affected by exchange rate fluctuations. Derived from the above it can be computed that exposure not only depends on the amount of international transactions, but also on the openness of the economy and the characteristics of the specific industry/market (Nydahl, 1999). Economic exposure affects the present and future cash flow of international companies. This will again often be reflected in prices of both raw materials and end products, consequentially affecting entirely domestic companies. Another line of argument is that for example a appreciation of domestic currency benefits exporters to that country, as they are able to lower prices or increase profit margins, exclusively due to the change in exchange rate, which undeniable will affect domestic companies in a negative way (Feenstra and Taylor, 2008).

2.5 Casual effect or joint determination

The majority of research done on this field tries to establish a significant correlation between stock prices and exchange rate trough some sort of multiple regression, which is then assumed to be evidence of causal effect, e.g. the cause and effect assumption. However some studies dispute this assumption. Adler and Dumas (1984) point out that exchange rate and stock return may be jointly determined, thus being not endogenous but rather exogenous variables. Finding a causal relationship between stock return and exchange rate movement might simply be a reflection of a change in some macroeconomic factor. Counterarguments
postulate that inserting market return into the regression should account for such problems, as changes in general economic policies should be reflected in the expected market return. Some nuisance may still be present considering the CAPM theory from a statistical point of view. This can be explained as all companies, according to CAPM theory, have a different beta value to that of the market, meaning that a shock to the economy will affect companies differently. Hence the impact of some change in a macroeconomics factor is not necessarily fully captured by inserting the market return into the regression. Disregarding central macroeconomic variables could then bias the betas of a test, causing faulty results (Jorion 1991).

2.6 **Hedging Strategies**

Although empirical theories suggest that companies have no interest in hedging, assuming investors have the same information as managers. The reality of the world is often very different. Market imperfections, market regulations, arbitrage speculation and other factors might cause companies to pursue an active risk management, also without reducing shareholder value (He and Ng 1998).

There are different kinds of strategies the financial department can undertake in order to hedge their business from currency fluctuation, depending on the specific exposure, from which the company wishes to be hedged from. Different Kind of exposure was discussed earlier and each class of risk must be managed differently.

Translation exposure is less significant in this study, because the objective of the paper is not to evaluate existing value. Investors base their asset in the company by future expected cash flow\(^2\). That is not to say that Translation exposure is irrelevant, but it is an accounting principle, which will not be explained further in this paper.

Losses and gains of operations, being that of current or future contracts and obvious changes in competitiveness due to changes in exchanges rates are of greater interest for both the management of the company and for investors. This can affect the profit margin of any activity undertaken in foreign currency directly, which is easily recognized and evaluated by investors and managers.

\[^2\] Explained by the fact that firm value is basically the NPV of present and future cash flows (Bartram, 2008)
2.7 Different hedging techniques

2.7.1 Spot Transactions

This is a passive position to take, as the company uses the exchange rate that happen to be when signing the deal. The transaction will then take place within the following couple of days. Spot transactions are not a hedge, as the company does not revise the current exchange rate, but takes the deal as it is. Problems may occur when evaluating contracts stretching over several years, and where cost and revenues is paid continuously over the period of the contract.

2.7.2 Forwards

Forwards is one instrument that can be used in order to hedge against exchange rate risk. The parties agree on a specific exchange rate on a specific amount delivered at some point in time in the future. Forwards are usually undertaken with a time-horizon stretching up to a year, although they occasionally go longer.

2.7.3 Swaps

Swaps may seem like a more complicated hedging technique, but is as common as forwards. This is an agreement between two parties to give a certain amount of one currency in exchange for a certain amount of another currency. This is often used between two parties in different countries. The advantage is most apparent when on company finances its debt in currency A, but have its revenue in currency B. This company can then the finds another company, who have expenses in currency B and revenue in currency A. Both parties can then eliminate risk by entering a currency swap which each other.

2.7.4 Options

Currency options give the holder the right, but not an obligation, to buy (call option) or sell (put option) on a specific amount of currency to a specific exchange rate. A premium is then added. A small currency fluctuation, however, might still cause the option to be “out of the money”. In principle you pay a certain amount to lock any potential loss, by acquiring a small but known loss in form of a premium, you then keep the upside chance of the currency going opposite of what you feared.
Analysing the scope of hedging is outside the objective of this paper. The major hedging techniques are described above, as these strategies surely have an impact on the following analysis.

2.8 Currency Risk and Currency Exposure

Although not pursued further in the study, a short memo seems appropriate on this issue of currency risk and exposure. Following the argumentation of Adler and Dumas (1984), which define and differentiate currency risk and exposure as separate issues. This is explained by the following logic. The fact that a company have a large exposure to one currency, meaning a substantial amount of revenue of expenses in that currency, does not equal a strong currency risk. A weak but stable economy can be less risky than a strong but unpredictable one. Expectation is the key note, as expected de- or appreciations can be incorporated into any contracts or sales made, while the unexpected will usually appear as a loss or revenue on the bottom line of the contract.
3 Empirical research

This section aims at providing a literature overview of existing research done in the field studied by this report. Theoretical arguments seem to agree on giving some kind of risk factor to exchange rate risk, combined with the increasing use of foreign currency derivatives and other hedging instruments (Muffett et al, 2005). This suggests a strong relation between firm value and exchange rate exposure. However empirical work has found the correlation somewhat ambiguous. The following literature review implies that the risk associated with exchange rate volatility is not as easily identified as theory might suggest. Heckman (1972) did some of the earliest studies in this field in the beginning of the 1970’s, concentrating on changes in net present value (NPV) of foreign operations, due to currency fluctuations. This was followed by are series of articles, Shapiro (1977) and Adler and Dumas (1980) to mention a few, however these studies still only had their focus on current and future cash flow.

The first article that approaches the problem studied in this analysis comprehensively is Adler and Dumas (1984) article; “Exposure to Currency Risk: Definition and Measurement.” By evaluating exchange rate exposure trough the eyes of stockholder, Adler and Dumas moves the focus of the analysis from the previously predominant profitably of the managers and the firm as such, to a focus on the profitability of the investor. Adler and Dumas find little evidence that expensive risk management can be vindicated on the expense of stockholder. They, however, also point to a series of shortcomings in their analysis, which among others include problems of stationarity and multicollinearity, which they leave untouched. In a later article Adler et al (1986) suggest using stock return to overcome some of these problems. The specified capital market approach used by Adler (1986) can be defined as firm total exposure to exchange rate fluctuation. This stands in opposition to work done by, for example, Ungern-Sternberg and Von Weizäcker (1990), Allayannis and Ihrig (2001), Marston (2001) whose focus has been on a more decomposed and specific exchange rate exposure.

Adlers (1986) approach measures the variance of stock return with the variance of exchange rates, looking for significant correlations. The methodology may create some statistical problems when other macroeconomic variables covary with that of the exchange rate, hence excluding them might result in exaggerated estimation of the amount of stock variance, attributed to currency movements. Jorion (1990) therefore modifies the model, using the residual of exchange rate movement against other explanatory variables, making Exchange
rate exposure orthogonal to the other depended variables. Using this method Jorion finds, by using 287 US multinational firms, that the majority of companies tested were insignificantly exposed at a 5% significance level. Jorion supports these findings with the article; “The pricing of exchange rate risk in the stock market” (1991), in which he tests 20 industry portfolios, weighted against their respected value. Jorion’s conclusion validates his earlier hypotheses and conclusion from the 1990 article, namely that US firms are insensitive to exchange rate movements.

Theoretical arguments have been presented in this paper, postulating that all firm are exposed to currency fluctuation, further supported by additional research (Dodson 1987, Divino 2009). However the weak empirical result achieved by among other Adler (1986) and Jorion (1990, 1991) has caused other studies to become more selective in the sample definition. Amihud (1994) examine the 32 largest exporting firms in the US over a six-year period, but finds no significant exposure. Choi and Prasad (1995) have studied 409 US multinationals, however instead of using portfolio theory, which they criticize, arguing that exchange does not have the same effect on all US multinational. They instead depend on the individual firm operating profile, financial strategy and other firm specific variables. Because aggregate level analysis might obscure the true sensitivity. Instead they argue for a firm-level study. Their test showed that 40% of the significant exposed companies were positively correlated to the exchange rate, meaning depreciation would harm the return of the company. The remaining 60% were negatively correlated and gained when a potential depreciation occurred. Choi and Prasad continued with a portfolio study, dividing the 409 firms into 20 industry specific portfolios. Here they found little evidence of exchange rate exposure. This concur with their earlier critique, that although companies operate in the same industry, the operating profile and financial strategy may be different, making their exposures oppositely correlated to one another, creating significant statistical nuisance when doing portfolio testing. Their studies showed that 15% or 61 of the 419 companies were significantly exposed, when doing the individual testing. The portfolio returns showed only two industries being significantly exposed to exchange rates. Later studies by Miller and Reuer (1998) and Chow et al. (1997) were consistent with these findings, consolidating both the results and empirical methodology used.

The majority of early studies made on this subject have investigated US financial market. However critics argue that the consistent and weak result found by most of the studies, may

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3 The fact that exchange rate exposure is insignificant does not mean that exchange rate movement does not affect the firms, but that it is affected the same way as the market.
be due to country specific factors. Kothcherlakota and Sack-Rittenhouse (2000) studied the openness of different countries. Their analysis was done using empirical approved mathematical formulas, including variables such as export and import to establish countries degree of openness. Their result suggested that the US is a considerably more closed economy than most other industrialized countries. This may indicate that stock markets in the US are less sensitive to exchange rate movement compared to more open economies. Khoo (1994) investigated the Australian mining industry, which per definition is seen as an industry heavily dependent on exports (as are all raw material producing industries). Hence, in theory, it should be significantly more exposed to exchange rate fluctuations, than that of more domestically orientated industries. However the study found only limited support for this. Khoo further emphasized that exchange rate exposure became even less significant when using portfolio theory, which supports the theory of Choi and Prasad (1995) accounted for earlier. Muller and Verschoor (2006) found, by using European data, that European firms seemed well hedged against short-term currency fluctuations. While around 65 % of the 817 firms used in the analysis were affected by exchange rate fluctuations in the longer run. This differentiation of short and long exposure is however not pursued to the same degree in this paper. He and Ng (1998) made a similar study of 171 Japanese firms. They found that almost 25 % of their sample was significantly exposed to exchange rate movements over a period of 14 years between 1979 to 1993. Williamson (2000) and Allayannis (2000) both did industry specific studies finding divergent results. Their studies showed some companies being significantly exposed to exchange rate fluctuations, while others did not indicate significant exposure. Their research furthermore implied significant cross sectional differences across firms and industries.
4 The models

In order to test the theoretical dilemma presented in this paper, using the empirical approved theories, different regression models is generated from both the CAPM and APT theory. This first two models test whether or not exchange rate have any explanatory effect on stock return. However statistical complications are put forward when interpreting the result of these tests. Consequently two new models are derived, which take into account the statistical nuances put forward by among others Ross (1976) and Jorion (1991).

4.1 Arbitrage Pricing model: Two-Factor

This two-factor model is derived from the popular CAPM theory, explained under theoretical section. One of the major strengths of the theory is the testability of the model suggested (Chen et al, 1986). The general consensus of acknowledgment also makes this a good model to use when examining whether or not currency fluctuations and exchange rate movements should be priced in the stock return or not, defined as part of the systematic or unsystematic risk explained under the CAPM theory. The model tested is thus illustrated as follows.

\[
R_{it} = \alpha_i + \beta_i^M \delta_{it}^M + \beta_i^S \delta_{it}^S + \epsilon_{it}
\]

where:

- \(R_{it}\) is the return of stock \(i\) in excess of the risk free rate, in time \(t\), dependent variable.
- \(\delta_{it}^M\) is the market return of company \(i\) in time \(t\) in excess of the risk free rate.
- \(\delta_{it}^S\) is the change in exchange rate for company \(i\)’s home currency in time \(t\).
- \(\beta_i^M\) and \(\beta_i^S\) is the loading of the independent variables to the stock return.

Finding exchange rate to be a significant would imply that currency fluctuations are priced and thus part of the systematic risk, which should be rewarded to investors. Finding no empirical grounds for exchange rates being priced, investors should not be rewarded, as it is part of the market or unsystematic risk. Attention should be given to the results of this test, as some statistical problems may occur using this method. These are accounted for later in the paper.
4.2 Arbitrage Pricing model: Multiple-Factor

The original CAPM theory assumes a linear relation between the market and the individual stocks. The theory also assumes that individual companies have different correlations to the market, articulated through the market beta. Several weaknesses of the two-factor CAPM model have later been pointed out, some originating from the CAPM theory - others from the derived two-factor model (Jorion 1990).

Chen et al (1986) and later Jorion (1990) criticise the underlying assumption concerning market return. They imply that correlation between returns and exchange rate movement might be caused by multicollinearity between exchange rate and some omitted variables left in the error term. Chen et al suggest a multiple-factor test building on the APT theory, where different macroeconomic factor is included.

The Multiple-factor model that is to be tested can be expressed as follows

\[
R_i = \alpha + \sum_{j=1}^{n} \beta_i^{\prime} \left[ F_j - E(F_j) \right] + \beta_i^{\prime} R_s
\]

where:

- \( R_i \) is the return of stock I in excess of the risk free rate, in time t
- \( F_j \) is the macroeconomics factor that include the market return
- \( \delta_i^M \) is the market return of company i in time t in excess of the risk free rate.
- \( R_s \) is the change in exchange rate for company i’s home currency in time t
- \( \beta_i^{\prime} \) and \( \beta_i^{\prime} \) are the loadings
5 Orthogonalization of Exchange rates

Finding statistical significance using the two derived regression models might only be signs of a correlation between dependent variables, hence a significant result of exchange rate in either of the tests may represent an already included effect, utilized as the market return variable. This means that some exchange rate might already be priced into the market return or some other included endogenous variable, which has an indirect effect on stock return (Horst, 2007) (e.g. collinearity between dependent variables). In order to resolve this statistical problem this paper proposes, in line with earlier research (Ross, 1986, Jorion 1990), that orthogonalization of exchange rates are used, thus only using the exchange rate uncorrelated with that of the other variables.

5.1 Two-Factor model

Following the thoughts of Ross (1976) and Jorion (1991), one could test the CAPM against the two-factor APT-model by Ross (1976), introduced earlier in this paper. This model implies a linear relationship between expected return and the sensitivity to market movement and exchange volatility.

\[ E(R_i) = \delta_0 + \delta_1 \beta_i^m + \beta_i^s \delta_s \] \hspace{1cm} (5.1.1)

where \( R_i \) is the expected nominal return in excess of the risk free rate of the stock or portfolio. \( \beta_i^m \) and \( \beta_i^s \) is the sensitivity to market and exchange rate changes.

Introducing the following assumption in order to remove any exchange rate sensitivity already included in the market

The exchange rate component is orthogonal to the market, given that

\[ E(R_i) = \delta_0 + \delta_i \beta_i^m + \delta_i^l \beta_i^l \] \hspace{1cm} where \( \beta_i^l = 0 \) must be true, since \( \beta_i^m \) logical equals one, as the expected return of the market rational has to be explained by the sensitivity to the market itself. The following mathematical rearrangement can then be made of 5.1.1.

\[ E(R_i) = \delta_0 = \delta_0 \implies E(R_i) = \delta_0 + \delta_i \cdot 1 + \delta_i \cdot 0 \]
\[ \implies \delta_i = E(R_i) - \delta_0 \]

Inserting this into equation (5.1.1)

\[ E(R_i) = \delta_0 + [E(R_m) - \delta_0] \beta_i^m + \delta_i \beta_i^l \] \hspace{1cm} (5.1.2)
Corollary the following decomposition can be made, such that the model can be tested for the rate of return on asset $i$ at time $t$ (Danø, 2003)

$$R_i = E(R_i) + \beta_i^n [R_{mt} - E(R_{mt})] + \beta_i^s F_s + \epsilon_i \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots 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\cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cd -
Assuming the linearity of expected return to the loadings of the factors. The following must be true.

\[ E(R_i) = \delta_o + \sum_{j=1}^{n} \delta_j \beta_{ij} + \delta_s \beta_{is} \] 

Equation (5.2.3)

This can be inserted into equation (5.2.1), such as to get the following.

\[ R_i = \delta_o + \sum_{j=1}^{n} \delta_j \beta_{ij} + \delta_s \beta_{is} + \sum_{j=1}^{n} \beta_j \left[ F_j - E(F_j) \right] + \beta_i F^n + \epsilon_i \] 

Equation (5.2.4)

The same logic follows as in the Two-factor model, this is if \( \delta_i \) differ significantly from zero, exchange rate can be said to be priced, and the weakness of the two-factor model, arguing that exchange rate can be interpreted as a proxy, is less dominant in this model assuming the correct factors are used.

The shortcomings of using APT’s multiple-factor model is that no clear practice has been established on how many factors should be included. Jorion (1991) and Ross et. al. (1986) argues for a six factor model, while other studies argue for a different number of factors (Entorf and Jamin, 2007) Using general economic theories and empirical research, explained further under the data section, five macro economics factors are chosen: GDP, inflation, risk free rate, market return and crude oil prices. Exchange rate is then added as the sixth factor.
6 Sample Selection

The goal of this paper is not to find universal empirical evidence, proving exchange rate exposure and stock return are correlated. Early research on this field have been heavily criticized for being to broad in their sample selection (Khoo 1995, Williamson 2001, Bartram 2004) and that the use of portfolio theory distort results even further, arguing that individual firms, although in the same market or industry, might have opposite correlation with a particular currency. Additional critic is pointed to the fact that the majority of research done in the field of study has been made using US companies and data. Referring to the earlier discussion on this subject, being more selective in the sample criteria is likely to generate more positive result, which might also be achieved by choosing more open economies.

Acknowledging some of the critique made of earlier studies, this report tries to evaluate and resolve some of the broadest and heaviest points of critique by being more selective in the sampling process. This is consciously done on the expense of the generalization and width of this study. By choosing only companies with high a high degree of foreign activity, chances of finding significant exposures to different currencies should increase. Furthermore limiting the number of companies enables an in-depth study of each company, making it possible to look for potential clarification of the test-result.

Earlier research has been done using the automobile industry, arguing that this industry is highly international, showing a few companies holding the majority of the world market (Williamson 2000). Using this selective sampling method, stronger empirical evidence was found on exchange rate movements significantly affect firm value.

The competitive characteristic of the car industry can be associated with that of the sustainable energy market, in particular the Wind-Power industry. 10 market players hold almost 90% of the world market share (BTM Consult, World Market Update 2008). This also means that these companies have business in numerous countries achieving both expenses and revenues in different currencies. Making this industry ideal for investigating the influence of currency fluctuations impact on returns.

A general critic made on earlier research concerns that openness of the chosen economy. The majority of test, although done on multinational firms, have been carried out in the US,
which according to common economic belief, is one of the least open economies to trade (Kotcherlakota and Sack-Rittenhouse, 2000)\(^4\).

Upon reflection one the above criteria, four companies have been chosen. Attention has also been given to the fact that the companies should represent:

- **Different markets shares.**
- **Different countries with regards to the openness of the economies.**
- **Exposures to different currencies.**

By allocating extra attention to this part of the analysis it is hoped to provide a more representative sample of the industry chosen, thus making the findings of this study more functional.

### 6.1 Industry and Company Description

The increased international focus on environmental sustainability and the political drive to move towards a post-carbon economy, the Wind-Power industry has flourished with growth that has largely made demand outstrip supply.

Having reached the milestone of providing 1% of global electricity consumption, and expecting to reach some 2.7% by the end of 2012 the industry is expected to grow annually by some 21 percent for the coming 5 years (Marc, 2008).

In other words, as Chicago based risk management consultancy Thilman Filippini argues wind energy has rapidly evolved from an unproven ‘green alternative’ into a fast growing industry with high profitability, and through that it has come to face some of the same risk issues as long-established fossil fuel-based utilities.

Based on the market condition of the sustainable energy market, briefly described, this industry seem appealing to an analysis of the influence of exchange rate. Being both a young and rapidly growing-

Four companies are chosen, representing different sizes and market shares of the sustainable energy market worldwide. The emphasis of this method is to generate a somewhat representative sample of this industry. An added criterion has been that the companies chosen have to have their main business in the Wind-Power market, excluding some high profile companies acting within this industry.

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\(^4\) Defining “Open” as the relationship between export and import, compared to the National GDP. For further explanation see Kotcherlakota and Sack-Rittenhouse; “Index of Openness: Measurement and Analysis”, 2000
6.1.1 Vestas

Vestas being the largest single company in this industry has been in Wind-Power market since 1978 and has consolidated its market position ever since. Being founded in 1898 where it made window frames from steel. Vestas has moved a lot since then, having its main business in the sustainable energy market today. The development of Vestas have been exponential since 1987 where the company had 60 employees, moving in to today having over 20,000 people employed all over the world. 2003 was a milestone for Vestas as it merged with NEG Micon, which at the time had a market share of between 5-10 percent of the world market. The merger was completed in 2004, giving Vestas a market share over 30 % globally.

In 2008 Vestas had a total turnover 6035 millions euro, which was an increase of 24 % compared to 2007. Vestas world market position in 2007 was 23 % (Vestas, Annual report 2008).

6.1.2 Nordex

Nordex was founded in 1985 in Germany. Today its activities spread wide across the world, with subsidiaries in more than 18 countries. Nordex employs more than 2200 people and have a turnover of 1135,7 millions Euro in 2008. Nordex have a world market share in the wind power market of around 4 %, with factories in both China and Germany.

6.1.3 Suzlon

Suzlon was founded in 1995 and is today the market leader in India, with a market share of over 50%. Today Suzlon have market activities in 21 countries spreading over 5 continent, and a turnover of 4304 millions dollars, employing over 13,000 people around the world. Suzlon went from a market share of 7,7 % in 2007 to a reported 10,5% in 2008. However it only became listed on the stock market in 2005.

6.1.4 Gamesa

Gamesa Corporación Tecnológica was established in 1976 in Spain. Although it started its business making robotics and microelectronics it entered the wind power market in 1994. In 2000 the company was listed on the stock market.
Gamesa sales in 2008 were around 3.651 billion euro, which was an increase of 27% compared to the previous year. With a workforce of 7200 employees, and operations in over 30 countries, Gamesa is a market leader in Spain and a world player with around 15% of the total market.

The company has been listed on the Stock Exchange since October 31, 2000 and has been included in the top Ibex-35 index since April 24, 2001.

The four companies were chosen not only to represent different market segments. Focus has also been on the fact that the companies main business remains within the specified industry, in order to keep the study focused. This limits the number of external variables that have to be considered when analysing the result of the tests. This approach has excluded some significant market players. However the gained ability to keep focus on a single industry is estimated to prevail over the drawback of such limitations.
7 The Data

The data used is all collected from Thomson DataStream, which is considered a highly reliable and accurate data source. Due to the specific industry analysed, data on stock returns are limited. This is explained by the fact that the wind energy industry can be considered emerging industry, Focus has only recently shifted to what is referred to as “green energy”. Consequently most companies in the industry are fairly young and so also only been listed on the stock exchange recently. The data on Danish, Spanish and German companies is synchronized such that the time span goes from May. 2001 to October 2008, making cross comparison easier. The Indian company has only been traded on the stock market since 2005, and therefore can only tested from 2005 to October 2008.

Most data used in this report can be measured in nominal or real terms, where real terms are the price adjusted nominal terms. Using real exchange rate changes, instead of nominal seem appropriate, as firm’s competitiveness is affected not only by nominal exchange rate movements, but also relative price changes. The argument of consistency however, requires all the variables used to be identical in their definition.

Consistency between inflation differentials and exchange rate movements suggest real exchange rate movements are dominated by nominal changes (Khoo 1994). Mark (1990) did further studies concerning this problem in his article “Real and nominal exchange rates in the long run”, where he found, by using monthly data, that nominal and real exchange rate are almost perfectly correlated.

Since nominal data in general is easier to obtain. Using the argument of consistency and the seemingly little extra knowledge gained by using real terms data. Data collection will be done in nominal terms.

7.1 The Variables

General stock and market return have already been specified by the nature of the CAPM model. The APT model requires multiple macroeconomic variables, not specified in its nature. Relying on work done by Blanchard (1981, 2006), Jorion (1990), among others, helps identify four additional factors deemed relevant when estimating the stock returns of the chosen companies. The definition and statistical process of each variable is explained in the following
- Stock returns are used instead of stock prices in computing return on the specific stocks. This is theoretical easier to analyse as it becomes scale free. The stock return is derived in the following manner.\(^5\)

\[
1 + r_t = \frac{P_t}{P_{t-1}} \tag{7.1.1.1}
\]

\(P_t\) is defined as the quoted stock price in month \(t\), for company \(i\).

\(P_{t-1}\) is defined as the quoted stock price in month \(t-1\), for company \(i\).

\(r_t\) is the return of the stock of company \(i\), in time \(t\), derived as;

\[
r_t = \frac{P_t - P_{t-1}}{P_{t-1}} \tag{7.1.1.2}
\]

The natural logarithm is the used for statistical reasons discussed later in this paper. This is done by taking Log to equation (1).

\[
\log(1 + r_t) = \log \left( \frac{P_t}{P_{t-1}} \right) = \log(P_t) - \log(P_{t-1}) \tag{7.1.1.3}
\]

- GDP growth is assumed to have a significant impact on stock prices, as it is a clear indicator of the general direction of a country’s economy. This is supported by earlier research (Jorion 1991, Ross 1976, Friberg and Nydahl 1999). GDP is, in most countries, only computed on a quarterly basis. Therefore Industrial Production is used as a proxy for GDP, although it is only a measure of the country specific output from the industrial sector. It may however be assumed that it is an approximately accurate indicator of the movements in GDP.

- Inflation, Risk Free rate, Interest rate are all long-established macroeconomic monetary variables, that are used to analyse the general state of the economy. Hence they are important factors to include when evaluating stock return.

The risk free rate is defined as the 1-month interbank lending rate. Inflation and general interest rate is adopted directly from the Thomson DataStream.

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\(^5\) The data is also dividend adjusted. According to ThomsonDatastream
Exchange rate is the wavering variable in this study. Neither theory nor empirical research is unanimous on whether or not exchange rate should be priced into the stock returns. Due to the industry and chosen companies, choosing a single currency to test seems inadequate. All four companies are multinational companies, with businesses all over the world. Analysing the individual companies and their exposure to different currencies, including estimation of the size and significance of the individual currencies, different currencies were found to be sizeable and of interest to the study. The relevant currencies was found to be US dollar, UK Pound Sterling, Euro and SDR.

Adding all the relevant currencies into one regression seems an attractive option. However Schnabel (1989), among others, raises several statistical problems in using this technique. Schnabel argues that when exchange rate exposure is expressed in two or more variables, statistical noise is created in form of multicollinearity.

Furthermore Nydahl (1999) finds evidence in his article “Exchange rate exposure, foreign involvement and currency hedging of firms: some Swedish evidence” that decomposing the exchange rate exposure into several individual currencies does not significantly change the result.

Consequently, this study will test the significance of the chosen currencies described below individually.

First a basket of currencies is chosen in the form of the Special Drawing Rights (SDR). SDR is an “artificial” currency made up of the major currencies in the world (US dollars, British Pound, Euro, Japanese Yen). Furthermore currencies like the US-dollar, UK Pound Sterling and the Euro is used depending on the “home” currency of the company in question.
The data is stated as a direct quote, defined as home currency price of one unit of foreign currency (Moffett et. al. 2005). This means that a positive change in the exchange rate indicates depreciation of the domestic or home currency and vice versa. Analyzing exchange rate also raises the additional concern of using nominal data in excess of the discussion already made (Refering to the beginning of the section, discussion of nominal and real exchange rates). Inflation might prove to be significantly different from country to country. However studying the Euro inflation rate indicates a somewhat low and stable tendency, which then to a large extent eliminates any bias caused by this problem. India is, however, more problematic. By having a high inflation rate this may create some bias in the result of the CAPM model, but in the interest of consistency and keeping the results logically comparable, as discussed earlier, the nominal exchange rate is used also in this case. The APT model should also unravel this problem, as inflation is an included variable.

- All the independent variable data is processed the same way as stock return, using the natural logarithm, for the same statistical reasoning, discussed in the next part of the paper.

7.2 Analysis of stationarity

Normal stock return in a multiple regression test will often result in statistical nuisance, as a result of seasonality or other significant disturbances. By making sure the data approximately stationary, the data is processed using the natural logarithm, which can move the time series data closer to stationarity (Krätzig, 2004), strengthening the analysis. To examine whether or not stock return of the selected companies is stationary through time and/or follows a random walk, times series plot of the stock return after the natural logarithm is used, as this should uniform the residual.

The purpose of testing for stationarity is to observe whether or not the mean or standard deviation changes through time. This should clarify whether or not the data used follows a random walk. If a strong indication of e.g. seasonality is apparent. The analysis can affect bias the result, but it can be accounted for by introducing a series of dummy variables on the variable in question (Wooldridge 2006). Simple time series plot of the variables is made to observe for any indication of seasonality and/or other trends. Only the dependent variables are shown below.
The general time series plot reveals that there are some indications of outliers, but that the data in general seem to be stationarity through time with no obvious trends over the period tested.

Supported by general economic consensus dealing with stationarity problems through the use of the natural logarithm (Ross, 1986, Jorion, 1990, Krätzig, 2004) and the fact no obvious problems are detected when examining time series plotting of the volatility of the different variables. Stationarity is assumed fulfilled, and no further test will be made.
8  The Regression models

The following section is an overview of the regression model used in the analysis.

8.1  Two-Factor

The regression model based on the CAPM theorem and the inferred mathematical equation explained could be illustrated as:

\[ R_{it} = \alpha_0 + \beta_i \delta_m + \beta_s R_s + \epsilon_{it} \]  

(8.1.1)

Since the mean variance of the error term is expected to be zero, the model can be reduced to:

\[ R_{it} = \alpha_0 + \beta_i \delta_m + \beta_s R_s \]  

(8.1.2)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Denotation</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta</td>
<td>( \beta )</td>
<td>The betas is the sensitivity of the stock to the market return and exchange rate</td>
</tr>
<tr>
<td>Rate of return</td>
<td>( R_s )</td>
<td>Return of the specific firm in excess of the risk free return.</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>( R_{st} )</td>
<td>Change in exchange rate</td>
</tr>
</tbody>
</table>

The second test against the CAPM theory is simply applied by replacing the Exchange rate variables with the residual of the projected exchange rate against the market return.

\[ R_{it} = \alpha_0 + \beta_i \delta_m + \beta_i F_s \]  

(8.1.3)

where \( F_s \) is the residual of the regression shown in appendix A

8.2  APT-model

In the article; “Economic Forces and the Stock Market”, Chen et al (1986) argue that stocks are responding to external forces, and although macroeconomic variables cannot be seen as truly exogenous, the assumption is made such that the individual stock market is made

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6 This assumption generalized to all the specified models
endogenous, relative to other markets and factors.

The APT model assumes that in a perfectly competitive market, stock returns are a linear function of $k$, economics variable (Yli-Olli and I. Virtanen 1992).

The model can thus be described as follows.

$$ R_i = \beta X_1 + \beta_2 X_2 + \ldots + \beta_k X_k $$

$$ \Rightarrow R_i = \alpha + \sum_{j=1}^{5} \beta_j F_j + \beta_i R_s $$

where $F_s$ is the residual of the regression shown in Appendix B

### 8.3 Systematic Mispricing

To comply with the problematic issues raised by among others Bartov and Bodnar (1994) and Nydahl (1999), it is argued that systematic mispricing may exist. This mispricing arises when investors approximate the relation between exchange rate movements and firm value. Systematic errors might occur because the relation is too complex to be understood instantaneously. Hence the real impact on firm value, and therefore also on stock return, might only be understood some time after the change has happened. Bartov and Bodnar (1994) suggest an introduction of lagged changes in exchanges rates in order to capture the impact of exchange rate volatility in earlier periods effecting returns in time $t$. Adding a
lagged effect to the contemporaneously market return and exchange rate movements to the regression equation.

\[ R_{it} = \alpha + \beta_i^m R_{mt} + \beta_i^s R_{st} + \beta_i R_{s,t-1} \]  

where \( R_{s,t-1} \) is the exchange rate movement in \( t \) minus one month. Further analysis could be made varying the lag times, which could generate different result. However based on former studies on this field (Mark 1988, Nydahl 1999) it has been deemed that a one month lag testing is sufficient for the purposes of this study. The lagged variable is also added to the multiple-factor model, following the same procedure.
9  The Regression analysis

The multiple regressions analyses are produced using the data presented, by means of the statistical program E-View 5.0. The normal Ordinary Least Squared (OLS) method is replaced by the Newey-West standard errors test. This method is less sensitive toward multicollinearity across time and variables, meaning that stock returns might be correlated trough time and also with the other variables included in the test. By applying the Newey-West test the analysis will generate more reliable result (Thomas, 19??)

9.1  Interpretation of result

The generated data have been processed such that the results of the analysis are not directly readable (a change of $\Delta$ in an independent variable does not mean an increase of $\beta,\Delta x$ in the dependent variable y). The model used can be described in the words of Wooldridge (2006) as a log-log model. This means that $\beta_i$ is the elasticity of y with respect to x. The following mathematical formulation can be derived$^7$.

<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>Interpretation of $\beta_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log-Log</td>
<td>Log(y)</td>
<td>Log($x_i$)</td>
<td>$%\Delta y = \beta_i%\Delta x$</td>
</tr>
</tbody>
</table>

$^7$ Wooldrigde (2006) pp. 49
9.2 Regression test using exchange rates

Table 9.1.

Exchange rate Exposure on Selected Windpower Companies

- Using US-Exchange rate

Two-Factor Model: \( R_t = \alpha_0 + \beta_i^m \delta_{mt} + \beta_i^s R_s \)

Multiple-Factor Model: \( R_t = \alpha_i + \sum_{j=1}^{5} \beta_{ij} F_j \text{ } + \beta_i^s R_s \)

<table>
<thead>
<tr>
<th>Company</th>
<th>Index Beta</th>
<th>Exchange rate Beta</th>
<th>R-Squares</th>
<th>Index Beta</th>
<th>Exchange rate Beta</th>
<th>R-Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas</td>
<td>1.86(^*)</td>
<td>0.50</td>
<td>0.45</td>
<td>1.88(^*)</td>
<td>0.88(^*)</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>(0.26)(^*)</td>
<td>(0.44)</td>
<td>(0.44)</td>
<td>(0.26)</td>
<td>(0.39)</td>
<td>0.44</td>
</tr>
<tr>
<td>Nordex</td>
<td>1.40(^*)</td>
<td>-0.044</td>
<td>0.21</td>
<td>1.24(^*)</td>
<td>-0.11</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>(0.26)</td>
<td>(0.44)</td>
<td>(0.19)</td>
<td>(0.40)</td>
<td>(0.93)</td>
<td>0.20</td>
</tr>
<tr>
<td>Suzlon</td>
<td>2.36(^*)</td>
<td>0.19</td>
<td>0.84</td>
<td>2.14(^*)</td>
<td>-0.37</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>(0.35)</td>
<td>(0.24)</td>
<td>(0.84)</td>
<td>(0.32)</td>
<td>(0.52)</td>
<td>0.86</td>
</tr>
<tr>
<td>Gamesa</td>
<td>1.44(^*)</td>
<td>0.17</td>
<td>0.55</td>
<td>1.47(^*)</td>
<td>-0.027</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td>(0.30)</td>
<td>(0.52)</td>
<td>(0.54)</td>
<td>(0.24)</td>
<td>(0.35)</td>
<td>0.63</td>
</tr>
</tbody>
</table>

\(^*\)Significant at the 5% level.
\(^*\)\(^*\)The standard deviation div.
Using US exchange rates as an independent explanatory variable shows little significance. Only Vestas indicate a positive significant exposure to DK-US exchange rate, when using the APT model, but remain insignificant using the CAPM model. Neither Nordex nor Gamesa stock returns shows any sensitivity towards changes in the Euro-US exchanges rate. A change in the Indian Rupee-US exchange rate is also an insignificant variable when explaining the return on stocks for Suzlon.

Table 9.2

Exchange rate Exposure on Selected Windpower Companies

-Using UK-Pound Sterling

Two-Factor Model: \( R_i = \alpha + \beta^m \delta + \beta^s R_s \)

Multiple-Factor Model: \( R_i = \alpha + \sum_{j=1}^5 \beta^j F_j + \beta^s R_s \)

<table>
<thead>
<tr>
<th>Company</th>
<th>Index Beta</th>
<th>Exchange rate Beta</th>
<th>R-Squares</th>
<th>Index Beta</th>
<th>Exchange rate Beta</th>
<th>R-Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas</td>
<td>1.86*</td>
<td>-0.14</td>
<td>0.45</td>
<td>1.89*</td>
<td>0.41</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>(0.24)</td>
<td>(0.92)</td>
<td>(0.45)</td>
<td>(0.24)</td>
<td>(0.45)</td>
<td>(0.44)</td>
</tr>
<tr>
<td>Nordex</td>
<td>1.41*</td>
<td>0.74</td>
<td>0.21</td>
<td>1.25*</td>
<td>-0.094</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>(0.39)</td>
<td>(1.00)</td>
<td>(0.38)</td>
<td>(1.47)</td>
<td>(1.47)</td>
<td>(0.20)</td>
</tr>
<tr>
<td>Suzlon</td>
<td>2.34*</td>
<td>0.19</td>
<td>0.84</td>
<td>2.10*</td>
<td>-0.77</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>(0.35)</td>
<td>(0.24)</td>
<td>(0.28)</td>
<td>(0.33)</td>
<td>(0.33)</td>
<td>(0.87)</td>
</tr>
<tr>
<td>Gamesa</td>
<td>1.44*</td>
<td>0.40</td>
<td>0.55</td>
<td>1.47*</td>
<td>0.64**</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>(0.32)</td>
<td>(0.38)</td>
<td>(0.24)</td>
<td>(0.40)</td>
<td>(0.40)</td>
<td>(0.64)</td>
</tr>
</tbody>
</table>

*Significant at the 5% level
**Significant at the 10% level

None of the four selected companies show any significant exposure to the UK exchange rate, assuming an alpha of 5%. Gamesa becomes significantly exposed when slackening the
criteria, using an alfa of 10%, when including the 4 macroeconomic variables. This indicates that the UK market for wind energy, although the biggest and closest trading partner of many European countries, is not large enough to make the stock returns of the selected companies fluctuate solely as a result of UK exchange volatility. This can be interpreted, as the risk of movement in the value of UK pound Sterling is not priced into the individual stock returns of the tested companies. The variance of the stock returns explained by the dependent variables is expressed as the R-squares. Only limited success has been achieved in finding the explanatory variables. However the factors explaining variance in stock returns appear to be different from country to country, as the explained affect found on the individual countries diverge. Being only around 20% for Nordex, but almost 95% for Suzlon. We also see that the added variables do not add considerable extra explanation to the stock returns, which might raise some concern as to the relevance of the chosen variables. The low R-squares may not be a problem in itself, as it is not the purpose of the study to explain stock return, but to investigate exchange rate volatilities effect on stock returns. However the low explanatory effect captured by the independent variables increase the chance of correlation with the error term, or in other word, chances of omitted variables is more likely.

9.3 Regression test using orthogonalized data

Using the residual of exchange rate on the other independent variables, means a orthogonalization of the exchange rate vis-à-vis respectively the market returns and the 4 others factors. The first side regression done to generate the residual data is showed in appendix A. The interpretation of having an observed zero exposure should be considered carefully, as it no longer implies that the company is not exposed, but that the firms are exposed to the same degree as the general market portfolio (Muller and Verschoor, 2005).
Table 9.3
Exchange rate Exposure on Selected Windpower Companies

- Orthogonalized US-Exchange rate

Two-Factor Model: \( R_{it} = \alpha_i + \beta_i^m \delta_{it} + \beta_i^s F_{st} \)

Multiple-Factor Model: \( R_{it} = \alpha_i + \sum_{j=1}^{5} \beta_i^j F_{jt} + \beta_i^s F_{st} \)

<table>
<thead>
<tr>
<th>Company</th>
<th>Index Beta</th>
<th>Exchange rate Beta</th>
<th>Index Beta</th>
<th>Exchange rate Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Two-factor)</td>
<td>(Multiple-factor)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vestas</td>
<td>1.88∗</td>
<td>0.50</td>
<td>1.92</td>
<td>0.88∗</td>
</tr>
<tr>
<td></td>
<td>(0.19)</td>
<td>(0.38)</td>
<td>(0.26)</td>
<td>(0.39)</td>
</tr>
<tr>
<td>Nordex</td>
<td>1.41∗</td>
<td>-0.044</td>
<td>1.25</td>
<td>-0.11</td>
</tr>
<tr>
<td></td>
<td>(0.28)</td>
<td>(1.43)</td>
<td>(0.38)</td>
<td>(0.93)</td>
</tr>
<tr>
<td>Suzlon</td>
<td>2.34∗</td>
<td>0.19</td>
<td>2.17</td>
<td>-0.38</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.56)</td>
<td>(0.31)</td>
<td>(0.52)</td>
</tr>
<tr>
<td>Gamesa</td>
<td>1.45∗</td>
<td>0.17</td>
<td>1.47</td>
<td>-0.027</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(0.37)</td>
<td>(0.24)</td>
<td>(0.35)</td>
</tr>
</tbody>
</table>

∗Significant at the 5% level.

Only Vestas show a significant exposure to movements in the US dollar in line with the first analysis. This indicates that the exchange rate is priced into the stock price additional to that of the market. This is opposed to the theoretical viewpoint that exchange rate volatility is diversifiable, hence part of the unsystematic risk assessment.

The beta is positive meaning that a depreciation of the Danish Krone will have a positive impact on the stock return of Vestas. None of the three other firms show any significant exposure to changes in the value of the US dollar additional to that of the market.
Table 9.4
Exchange rate Exposure on Selected Windpower Companies

- Orthogonalized UK-Exchange rate

Two-Factor Model: $R_i = \alpha + \beta^{m} \delta + \beta^{s} F_s$

Multiple-Factor Model: $R_i = \alpha_i + \sum_{j=1}^{5} \beta^{j} F_j + \beta^{s} F_s$

<table>
<thead>
<tr>
<th>Company</th>
<th>Index Beta $\beta^{m}$</th>
<th>Exchange rate Beta $\beta^{s}$ (Two-factor)</th>
<th>Index Beta $\beta^{m}$</th>
<th>Exchange rate Beta $\beta^{s}$ (Multiple-factor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas</td>
<td>1.87∗&lt;br&gt;(0.19)</td>
<td>-0.14&lt;br&gt;(0.60)</td>
<td>1.91∗&lt;br&gt;(0.23)</td>
<td>0.41&lt;br&gt;(0.95)</td>
</tr>
<tr>
<td>Nordex</td>
<td>1.41∗&lt;br&gt;(0.29)</td>
<td>0.74&lt;br&gt;(1.18)</td>
<td>2.17∗&lt;br&gt;(0.31)</td>
<td>-0.38&lt;br&gt;(0.53)</td>
</tr>
<tr>
<td>Suzlon</td>
<td>2.36∗&lt;br&gt;(0.16)</td>
<td>-0.19&lt;br&gt;(0.51)</td>
<td>2.10∗&lt;br&gt;(0.28)</td>
<td>-0.77&lt;br&gt;(0.33)</td>
</tr>
<tr>
<td>Gamesa</td>
<td>1.45∗&lt;br&gt;(0.13)</td>
<td>0.40&lt;br&gt;(0.46)</td>
<td>1.47∗&lt;br&gt;(0.46)</td>
<td>0.64∗∗&lt;br&gt;(0.40)</td>
</tr>
</tbody>
</table>

∗Significant at the 5% level
∗∗Significant at the 10% level

Examining the UK exposure to the selected companies showed limited exposure. No company showed any significant exposure to the UK Pound Sterling above that of the market. Gamesa however became significant at the 10% level, showing a positive relation, meaning a depreciation of the euro\(^8\) would indicate a raise in the return of Gamesa stocks.

\(^8\) Before the introduction of the Euro, Spain used the Spanish Pesos. The Euro-UK exchange rate has been calculated back, using the Pesos-Ecu and Ecu-Uk Exchange rates. For further detail go to www.datastream.com
The overall analysis showed that the market index was a significant factor in explaining stock return. In using the two-factor model, not much information was found as exchange rate movement proved insignificant for both US and UK exchange rate changes. Adding additional macroeconomic variables, testing for omitted variables provided some new insight, as Gamesa now showed some exposure to the Pound Sterling.

No conformity was however found in adding new variables. Seemingly most of the economics variables were tested as insignificant and removing them did not alter the results. The effect of adding the significant variables proved that Vestas has been exposed to US currency movement at the 5% level and Gamesa exposed to the UK Pound Sterling at the 10% level.

The effect of using direct exchange rate movement or orthogonal exchange rate movement showed little difference. This might also be explained by the fact that the side regression made to orthogonalize exchange rates, showed that the market index and other variables was mostly insignificant in explaining changes in exchange rates, exhausting the argument of orthogonalization.

Cross comparison is made difficult as the sample period differs across the sampled companies. Taking two sub-samples from our original samples makes the following section easier to compare across companies, synchronising the data as much as possible. Using the period of 2001-2004 and 2005-2008 makes the first period approximately identical for Vestas, Nordex and Gamesa, and the second period identical for all four companies. However the argument can be made that this is done on the expense of the validity of the test, since the number of sample observation is limited to 48 for each period.

However, doing sub-sampling is supported by earlier research (Jorion 1990, He and Ng 1998 among others). Taking the industry analysed into consideration also add extra incentive for sub sampling. All four companies have been founded within the last couple of decades, having experienced considerable growth both financial and structural. Exchange rate exposure might change over the whole time period, due to market changes, financial changes etc., which may result in potential exposures becoming insignificant, when testing the entire period.

9.4 Sub-period testing

The following section presents the result of the sub-period testing, using the same procedure as earlier.
### 9.4.1 Normal Test

Table 9.5

Exchange rate Exposure on Selected Windpower Companies

- Using US-Exchange rate

Two-Factor Model: $R_{it} = \alpha_0 + \beta_i^m \delta_{mt} + \beta_i R_{m,t}

Multiple-Factor Model: $R_{it} = \sum_{j=1}^{s} \beta_j^i F_{jt} + \beta_i R_{s,t}$

<table>
<thead>
<tr>
<th>Company</th>
<th>Two-Factor test</th>
<th>Multiple-Factor test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On US</td>
<td>On US</td>
</tr>
<tr>
<td>Vestas</td>
<td>$\beta^m$ 1.70$^*$</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>(0.21)</td>
<td>(0.48)</td>
</tr>
<tr>
<td>Nordex</td>
<td>$\beta^s 1.10^*$</td>
<td>2.21$^*$</td>
</tr>
<tr>
<td></td>
<td>(0.52)</td>
<td>(0.37)</td>
</tr>
<tr>
<td>Suzlon</td>
<td>-</td>
<td>2.36$^*$</td>
</tr>
<tr>
<td></td>
<td>(0.35)</td>
<td>(0.82)</td>
</tr>
<tr>
<td>Gamesa</td>
<td>$\beta^m 0.92^*$</td>
<td>2.45$^*$</td>
</tr>
<tr>
<td></td>
<td>(0.39)</td>
<td>(0.34)</td>
</tr>
</tbody>
</table>

$^*$Significant at the 5% level

The sub-period test indicates that several companies where exposed to US dollar over the first period, using the two-factor test. Vestas and Nordex show a positive correlation and Gamesa a negative correlation. There is also an indication that changing exposure to the US dollar, (ex. Gamesa) is negative exposed at the 5% significance level in period 1, but positive exposed in the second period, however only at the 10% level. Adding additional variables, reduce the number of significant observations, implying some of the potential statistical problems stated earlier are relevant. Only Vestas and Gamesa are found to be significantly exposed in the first period, and no companies were found to be exposed in the second period using the APT model.
Table 9.6

Exchange rate Exposure on Selected Windpower Companies

- Using UK-Exchange rate

Two-Factor Model: \( R_{it} = \alpha_0 + \beta_i^m \delta_{mt} + \beta_i^s R_{st} \)

Multiple-Factor Model: \( R_{it} = \alpha_i + \sum_{j=1}^{s} \beta_i^j F_{jt} + \beta_i^s R_{st} \)

<table>
<thead>
<tr>
<th>Company</th>
<th>Two-Factor test</th>
<th>Multiple-Factor test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas</td>
<td>( \beta^m )</td>
<td>( \beta^s )</td>
</tr>
<tr>
<td></td>
<td>(0.21)</td>
<td>(0.83)</td>
</tr>
<tr>
<td>Nordex</td>
<td>0.73*</td>
<td>4.41*</td>
</tr>
<tr>
<td></td>
<td>(0.31)</td>
<td>(1.79)</td>
</tr>
<tr>
<td>Suzlon</td>
<td>2.34*</td>
<td>0.19*</td>
</tr>
<tr>
<td></td>
<td>(0.35)</td>
<td>(0.24)</td>
</tr>
<tr>
<td>Gamesa</td>
<td>0.96*</td>
<td>2.16*</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
<td>(0.67)</td>
</tr>
</tbody>
</table>

*Significant at the 5% level
**Significant at the 10% level

The result of using UK Pound Sterling also shows different outcomes from the analysis of the whole period. Earlier only Gamesa showed signs of exposure to the pound sterling. The sub-sampling implies that some nuisance might have been present in the earlier analysis. This is derived from the fact that a change in the exposure coefficient over the two periods; or the fact that the second period is insignificant for three of the four companies for the two-factor test - and for all in the multiple-factor test.
9.4.2 Orthogonal Exchange rate

Table 9.7

Exchange rate Exposure on Selected Windpower Companies

-Orthogonalized US-Exchange rate

Two-Factor Model: \( R_i = \alpha_0 + \beta_i^m \delta_m + \beta_i^s F_s \)

Multiple-Factor Model: \( R_i = \alpha_i + \sum_{j=1}^{5} \beta_i^j F_j + \beta_i^s F_s \)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas</td>
<td>( \beta^m )</td>
<td>( \beta^s )</td>
<td>( \beta^m )</td>
<td>( \beta^s )</td>
</tr>
<tr>
<td></td>
<td>1.88*</td>
<td>1.94*</td>
<td>2.02</td>
<td>1.61*</td>
</tr>
<tr>
<td></td>
<td>(0.33)</td>
<td>(0.24)</td>
<td>(0.54)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>Nordex</td>
<td>0.80*</td>
<td>2.44*</td>
<td>0.89</td>
<td>2.04*</td>
</tr>
<tr>
<td></td>
<td>(0.34)</td>
<td>(3.31)</td>
<td>(1.67)</td>
<td>(1.06)</td>
</tr>
<tr>
<td>Suzlon</td>
<td>1.41*</td>
<td>-0.044</td>
<td>1.25*</td>
<td>-0.11</td>
</tr>
<tr>
<td></td>
<td>(0.28)</td>
<td>(1.43)</td>
<td>(0.38)</td>
<td>(0.93)</td>
</tr>
<tr>
<td>Gamesa</td>
<td>1.04*</td>
<td>-0.89*</td>
<td>0.83*</td>
<td>1.73*</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.48)</td>
<td>(0.19)</td>
<td>(0.46)</td>
</tr>
</tbody>
</table>

*Significant at the 5% level
**Significant at the 10% level
***Becomes significant at the 10% level when removing insignificant variables.

We see that orthogonalizing the exchange rate reduces the number of significant exposures. However the values and relation, expressed as negative or positive, seems to be coherent with that of the direct exchange rate test. The small reduction in significant exposure could indicate that some of the exchange rate volatility is priced into the market return, hence making exchange rate orthogonal to market return and other macro economic variables.

Isolating the company specific exposure then captures the true exchange rate risk experienced by the investors, as he cannot diversify the market risk associated with currency fluctuations.
Table 9.8

Exchange rate Exposure on Selected Windpower Companies

- Orthogonalized US-Exchange rate

Two-Factor Model: \( R_{it} = \alpha_i + \beta_{im} \delta_{mt} + \beta_i F_{st} \)

Multiple-Factor Model: \( R_{it} = \alpha_i + \sum_{j=1}^{s} \beta_{ij} F_{jt} + \beta_i F_{st} \)

<table>
<thead>
<tr>
<th>Company</th>
<th>( \beta^m )</th>
<th>( \beta^s )</th>
<th>( \beta^m )</th>
<th>( \beta^s )</th>
<th>( \beta^m )</th>
<th>( \beta^s )</th>
<th>( \beta^m )</th>
<th>( \beta^s )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas</td>
<td>1.88*</td>
<td>2.26*</td>
<td>1.94*</td>
<td>-2.06*</td>
<td>2.02*</td>
<td>2.36**</td>
<td>1.61*</td>
<td>-1.24</td>
</tr>
<tr>
<td></td>
<td>(0.33)</td>
<td>(1.14)</td>
<td>(0.22)</td>
<td>(0.69)</td>
<td>(0.35)</td>
<td>(1.23)</td>
<td>(0.28)</td>
<td>(0.80)</td>
</tr>
<tr>
<td>Nordex</td>
<td>0.81*</td>
<td>4.41*</td>
<td>2.44*</td>
<td>-1.17</td>
<td>0.89*</td>
<td>4.61*</td>
<td>2.40*</td>
<td>-1.61</td>
</tr>
<tr>
<td></td>
<td>(0.33)</td>
<td>(2.05)</td>
<td>(0.49)</td>
<td>(1.44)</td>
<td>(0.41)</td>
<td>(1.98)</td>
<td>(0.33)</td>
<td>(1.65)</td>
</tr>
<tr>
<td>Suzlon</td>
<td>-</td>
<td>-</td>
<td>2.36*</td>
<td>-0.19</td>
<td>-</td>
<td>-</td>
<td>2.10*</td>
<td>-0.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.16)</td>
<td>(0.51)</td>
<td></td>
<td></td>
<td>(0.28)</td>
<td>(0.33)</td>
</tr>
<tr>
<td>Gamesa</td>
<td>1.04*</td>
<td>2.16*</td>
<td>0.06*</td>
<td>0.20</td>
<td>1.08*</td>
<td>2.19*</td>
<td>1.73*</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
<td>(0.70)</td>
<td>(0.20)</td>
<td>(0.59)</td>
<td>(0.18)</td>
<td>(0.70)</td>
<td>(0.26)</td>
<td>(0.48)</td>
</tr>
</tbody>
</table>

*Significant at the 5% level
**Significant at the 10% level

The tendency discussed in table 7 is also apparent when analysing the Pound Sterling exposure. The signs remain the same. The beta values become somewhat smaller or stay the same, as the exposure priced into the market is removed.
Analysing The Result

Most empirical research done on this field has been built on a quantitative foundation in order to validate the results to a wider spectrum. This paper has tried to be more selective in its sampling process, which also seems to have generated more significant result. The subsequent section is derived from the regressions analysis, where the observed values are put in context with the financial and strategic policies pursued by the individual companies. This will seek to uncover eventual hedging strategies pursued by the companies, or other structural, market or competitive changes that might have an effect on the observed test result.

10.1 Vestas

Vestas, being the flagship of the windmill industry, located in Denmark, and having a world market share of over 23% with many foreign activities, implied that one could assume, exchange rate movements would have a sizeable impact of profit and thus presumably on stock returns too. Vestas was first tested for the period 2000-2008 on three different exchange rate, i.e. Danish Krone to Pound Sterling, US Dollars and the SDR basket. No effect was found on movement of the pound Sterling and SDR exchange rate using both change in exchange rate movement and orthogonalized movements against both the CAPM two-factor model and the APT’s multiple-factor model. Some exposure was found to the US dollar. Using Sub-period testing offered more interesting result. Vestas showed significant exposure to the Pound Sterling and the US dollar at both the 5% and 10% significant level. The first series of testing showed conflicting results. The two-factor model indicated no significant exposure while the multiple-factor model implied some exposure. Analysing the US dollar first, which showed some conformity between the two models used, indicated the exposure was located in the first period. Studying Vestas history, financial record and annual reports provide some clues as to the reason for this. Reading the annual report offers some information on which financial hedging activities being practised by Vestas, a small note on page 24, in the 2008 report states that Vestas is engaged in some hedging activities with respect to acquiring raw material. Furthermore, the use of swaps is mentioned, in the form of interest swaps. Further study of the cash flow statement shows that Vestas is also engages in other currency management operations. Specific attention is given to US interest rate, which theoretically and historically is closely
linked to the US exchange rate, through among other things the purchasing power parity (Feenstra and Taylor, 2008).
Without further insight into the specific details, and access to the specifications of hedging strategies, it remains difficult to assess and determine the impact these activities have on the result of the test made in this paper.
Additional potential problems to the regression are apparent when considering the whole period, in combination with an investigation into the history of Vestas. Vestas engaged in a major merger in 2004 with NEG-Micon, which consolidated Vestas as the world market leader. Similarly, in 2005, Vestas received their biggest single order at that time to a US company called Horizon Wind Energy, which might have put focus on currency risk towards the US dollar.
The sub-period testing for the UK Pound Sterling indicated a slight positive exposure in the first period, which shifted to a negative relation in the second period. Reasons for this might be explained by the financial hedging discussed above, but also by the decision to build a factory in Scotland in 2002. The positive relation implied in the first period, indicates that cash flows from the United Kingdom was dominated by revenues, as a devaluation of the Pound would mean more Danish krone’s per Sterling Pound. Thus it is reasonable to assume that this would have a positive impact on stock return. The decision to establish a factory would mean increased expenses in UK Pound Sterling in form of salaries, and materials acquired in the Unit Kingdom. In the second period these expenses might have surpassed the revenues. This could mean that Vestas add resources (money) from other currencies to the pound sterling, selling the product in other currencies again, not receiving pounds in return. A devaluation of the Danish Krone in relation to the pound sterling would then mean increased costs, and thus presumably have a negative impact on the stock return.
The argument used can, however, also be turned around, disputing that for example a depreciation of the Danish krone to the Pound Sterling would decrease competitiveness for Vestas in the first period, as domestic company’s would be less effected by any change in exchange rate, while Vestas would have to lower profit margins or increase prices. However this impact is less transparent and might first be realized later, while the direct impact on cash flows are easier for investors to understand. But as mentioned earlier the attempt to capture this affect by introducing lags seems unsuccessful.
10.2 Nordex

The regression made on Nordex gave somewhat more wage result. The first series of tests showed no significant exposure to any of the chosen currencies. The second series of tests gave a small indication of exposure to the US dollar at the 10% significant level, but only derived from the two-factor model.

The second series gave a more positive result towards exchange rate exposure. The results seem to indicate a higher exposure to the UK pound, especially in the first period, which is established from both the two- and multiple-factor model. However we see rather large standard deviations, compared to the other test results, which could indicate nuisance with the test and suggests a diminished accuracy of the result.

By studying the history and financial reports of Nordex, it can be established that Nordex main business activities are in Europe. More than 80% of Nordex’s order-intake in 2007 thus came form Europe. This supports the results derived from the regression analysis, implying that the Sterling Pound is a significant risk when evaluating currency movement.

Nordex’s annual report also reveals that they are pursuing an active hedging policy, controlled by their treasury department. They are engaged in both derivative and non-derivative hedging, with the main purpose of minimizing operating risk. This means that they do not try to speculate or take advantage of arbitrage possibilities. The positive relation to the UK pound indicates, as argued with Vestas, that Nordex mainly takes its orders or revenues from the UK and Europe. In a longer time perspective this development can be argued to harm the company more it helps it, as unexpected currency gains in the short run, following the argument of decreased competitiveness, which was explained under the section concerning Vestas.

10.3 Suzlon

Suzlon, the only non-European founded company, showed no real exposure to any of the currencies tested. However the very limited data on their stock return could question the validity of these results. Suzlon’s annual report claims that Suzlon operational risks are diminished trough their wide international manufacturing operations, creating both expenses and revenues in most of the major currencies, which they claim acts as a natural hedge, terminating any potential gains or losses created by currency fluctuations. Some operational loss on exchange rate fluctuation is however mentioned in their annual report (2008), where
a loss in 2007 and a gain in 2008 is recognised. The specification of forwards and options is also mention as a standard procedure when doing business in foreign currencies. Judging from the annual report, cash flows and other activities undertaken by Suzlon compared to the other companies investigated, it seems as if Suzlon have a more active foreign exchange risk management. This might be the reason for the weak or non-existing link between stock return and exchange rate fluctuation found in the analysis made.

10.4 Gamesa

The initial testing showed only a weak exposure to the Sterling Pound for Gamesa, and no apparent exposure to the US dollars. Applying the sub-period regression revealed a negative exposure to the US dollar in the first period, using both the two-factor and multiple factor model. The second period is somewhat more blurred. The two-factor model showed a positive correlation, which might explain the lack of evidence found in the first analysis. The multiple-factor model, however, showed no significant exposure in the second period. Conformity between the two models is more apparent when studying the Pound Sterling. Both tests imply a significant positive exposure in the first period and no apparent exposure in the second period.

Gamesa’s focus has been on the US, European and Chinese markets, which have all grown, and in which Gamesa has increased its market shares; and by implication also its exposure to these currencies. Studying the cash flow of Gamesa shows that in 2008 around 21% the revenues came from the United States while 8 % came from China. This indicates that the US dollar is major currency for Gamesa. Roughly 8 % comes from the rest of Europe, outside Spain. Evaluation Gamesa’s foreign assets and liabilities, as done on page 16 of their annual report, it is seen that the company have a majority of their assets compared to liabilities in both US dollars and UK Pounds. Gamesa recognizes that it has a significant exchange rate risk exposure, especially to volatility in the Euro-US dollar exchange rate. Several initiatives and policies are in place, in order to minimize this risk. The annual report also emphasises that no arbitrage speculation strategy is pursued, as Gamesa’s focus is on earning money on their core business, namely the energy market (Annual report 2008, p. 22). Gamesa also states that their hedging strategy has a horizon of maximum 3 years, and their main method and focus is on interest rate swaps and forwards. No direct reason is found to the support the findings of the analysis. Gamesa focused their strategy on the US, China and Europe which can be an indirect reason for the findings.
However the more explicit changes in structural and/or financial is not found as it was for some of the other companies.
11 Conclusion

This paper works on the assumption that companies’ main purpose is to create value. Value is an abstract expression when used in such a context. This study takes the standpoint that value is measured in the form of returns on investment. This logic is based on the assumption that that investors require a certain return for “lending” their money to the company. If no return is imminent, it can be presumed that investors would find somewhere else to place their money. Different models have been developed in order to help evaluate investment and return. Common to them all is that they evaluate risk compared to return. This paper therefore acknowledges the importance of the theoretical discussion and precise definition of risk.

The preliminary approach to this problem was build around the breakdown of the Bretton-Woods system in the beginning of the 1970, which have increased the volatility of most exchange rates. Furthermore there have been an increased tendency to trade across countries and more companies can be categories as true multinational companies as ever before. Combined with increasingly international value- and production chains, this has caused increased interest in exchange rate movements and their impact on the return of stocks. The increased complexity of the financial world has decreased the transparency not only for the investor but also for managers. Conformity in defining and evaluating currency risk is ambiguous. This paper started with a definition of risk and discussion of risk, realising the importance of understanding the basic of a problem before confronting it. The study swiftly discussed the risks companies faced, both in the purely domestic market and the internationally market. Different kinds of exchange risk were identified and were shown to influence companies in different ways. This early discussion may seem peripheral when considering the main problem investigated in this paper. However failing to understand these basic principles, would surely decrease the chance of understanding and appreciate the full complexity of the problem. Recognizing the strengths and weaknesses of both the capital asset pricing model, with its stricter assumptions, and the more open arbitrage pricing theory, are important aspects in attempting to fully comprehend the problems of measuring exchange rate risks.

By looking at both empirical and theoretical studies it became clear that no clear consensus or superiority of either models has been established. Consequently both models are used to generate different regression models, which are then again used to test the significance of exchange volatilities’ impact on stock returns. Appreciating the underlying complexity of the
problem presented by the theoretical discussion, aided the understanding and interpretation of the regressions analyses.

The CAPM model only required one variable additional to stock return; namely market return, defined as the principal index in the country over the most traded stocks. The chosen exchange rates is then added to see if any additional explanation can be found on the return of the stock.

The APT model did not dictate the definition or numbers of variables to use. This forced an indebt study of earlier research done on macroeconomic factors influencing both stock returns and exchange rates, and a theoretical review. This allowed us to identify the four macroeconomic variables added to the CAPM regression first made.

Due to statistical reasoning the data was exposed to a series of statistical processes. Some basic procedures were carried out in order to comply with the underlying assumptions of general multiple regression analysis, thus making the result more reliable. Further processing was later made in order to comply with interpretation problems, as exchange rate was made orthogonal to the other independent variables.

The preliminary analysis was surprisingly negative. Although focus was set on a highly international market, with few companies possessing the majority of the market globally. The SDR exchange rate was found to be uninteresting, while US-dollars and UK-pound sterling suggested more exposure. However if more detailed results are to be acquired further studies were needed.

Realising the intense growth rates common to the industry. The fast changing infrastructure and financial structure of the selected companies, added to vastly expanding market of wind power, suggested that companies might not be exposed to the same exchange rate or with the same correlation for longer periods of time. Balancing between keeping the reliability of the test, keeping the sample size to a reasonable level, but also capturing shorter-term exposure, two periods were chosen spanning a period of four years. This meant reducing the number of observations to 48, however referring to central limit theorem should keep the testing reliable. The sub-period testing gave more workable result, finding significant exposure to both currencies. The intuition concerning the market and company condition in the industry was supported by these results. The general picture was that the different companies only were exposed to a currency in one period or changing signs between the to, e. g. a positive correlation may be observed in the first period, which changes to a negative correlation in the second period.
By scrutinizing the history and annual reports of the companies offered some initial insights supporting the findings of the statistical analysis. The first and most important finding in this research, presumably biasing the result, was the use of different hedging techniques. Lacking both the information on the type and technicalities of these hedges makes their influence on the result hard to determine. No effort has been made in this study to neutralize any nuisances that arise as a consequence of this. However the theoretical background of risk management through hedging and a short explanation of hedging techniques were presented. A further note should be taken that it is not within the scope of this paper to evaluate the use of individual hedging techniques.

Lacking the expertise to deem either of the used theories, CAMP and APT, superior to the other, both were tested. Seemingly no major differences were found. Some clarification of this was found in the lack of significance in the chosen macroeconomic variables, however both theoretical and empirical research underpins the relevance of these variables. No attempt was made to evaluate CAPM and APT theory against one another. The theoretical and empirical differences are accounted for, however an individual evaluations of each theory is outside the scope of this investigation.

Overall, the analysis of the two-factor and multi-factor model confirms earlier research. The exchange rate test indicate that exchange have an insignificant influence on stock returns over longer periods. Furthermore does the residual exchange rate imply that exchange rate is not systematically related to expected returns. Investor does not appear to price foreign exchange risk additional to that of the general market risk, which seems logical considering the weak result found on exchanges rates general influence on stock returns earlier research have found. However by doing a detailed sample selection this report managed to find a stronger relationship then earlier research, whether or not this can be imperial used is not valued in this study.
Further research

During the production of this report some limitations were encountered, and some aspects were kept out, in order to maintain the focus of the paper. The following section is a quick review of some of these topics.

Among the limitations already mentioned is the extent of the analysis, which could be improved by including more companies. Such an expansion of the study could enlarge the insights and strengthen the conclusion. Not discussed in detail in this paper is also the time period over which the study was made. The number of observations and the processing of the data. Further insight might have been achieved by changing the data from monthly to weekly or daily observations. Also introducing more lags might have increased the significance of the macroeconomic variables, assuming changes in such variables is realised with some sort of delay.

The variable chosen as exchange rate could also have been generated differently. Arguments could be made that only unexpected changes in exchange rate should have an impact on stock returns, as expected exchange rates presumably is incorporated in the financial strategies and contracts of the individual companies. This variable could have been created by e.g. taking the difference of 3-month forward rates, 3 month back in time with the contemporaneous exchange rate.

Bartram (2004), Koutmos and Martin (2003), Miller and Reuer, (1998) inter alia criticises the general empirical work on exchange rate. Arguing for nonlinear correlation between firm value and exchange rate risk. The specific line of reasoning made by these researchers and their reported result is not covered further, but the idea of a nonlinear correlation, abandoning the logic of Ross (1986), Jorion (1990) and many others sounds intriguing, particularly in the light of the mixed result accomplished by most researchers.


Dodson, J. M., (1997) “United States-Based Multinational Firms versus Primarily Domestic Firms: Total Return Performance during Selected Downward, Upward and


Appendix A

Table 9
Residual Test: $R_{st} = -y_{st} + y_{1}R_{mt} + F_{st}$

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable $R_{mt}$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US-Dollar</td>
<td>0.043</td>
<td>0.0074</td>
</tr>
<tr>
<td></td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>UK Pound Sterling</td>
<td>0.059*</td>
<td>0.028</td>
</tr>
<tr>
<td></td>
<td>0.028</td>
<td></td>
</tr>
<tr>
<td>Nordex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US-Dollar</td>
<td>0.0069</td>
<td>0.00067</td>
</tr>
<tr>
<td></td>
<td>0.031</td>
<td></td>
</tr>
<tr>
<td>UK Pound Sterling</td>
<td>-0.075*</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>0.021</td>
<td></td>
</tr>
<tr>
<td>Pound Sterling</td>
<td>-0.0051</td>
<td>0.00043</td>
</tr>
<tr>
<td></td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Suzlon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US-Dollar</td>
<td>-0.025</td>
<td>0.0074</td>
</tr>
<tr>
<td></td>
<td>0.047</td>
<td></td>
</tr>
<tr>
<td>UK Pound Sterling</td>
<td>-0.058</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>0.051</td>
<td></td>
</tr>
<tr>
<td>Gamesa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US-Dollar</td>
<td>1.45*</td>
<td>0.088</td>
</tr>
<tr>
<td></td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>UK Pound Sterling</td>
<td>0.023</td>
<td>0.0062</td>
</tr>
<tr>
<td></td>
<td>0.03</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at the 5% level

The following Table represent the first side regression made, suggest by Jorion (1990). The low R-squares are to be expected, as exchange rate is to complex to be captured only by the
market return. However the market return was found to be insignificant is more than one test, which can reduce the meaning of orthogonalization.

The same procedure was used using the multiple-factor model. This is however not shown, but an output from E-View is shown below from one of the residual test made. The test show that we have some insignificant variables, removing them however did not alter the number of significant variables. The residual from the table below is used in the analysis of Suzlon. It can be observed that both the R-squared and Adjusted R-squared have increased compared to the earlier test, which make sense since the number of variables is increased, and the fact that macroeconomic factors is more likely to have a significant affect on exchange rates.
Appendix B

Dependent Variable: EXUK
Method: Least Squares
Date: 03/25/09   Time: 14:03
Sample (adjusted): 2 39
Included observations: 38 after adjustments
Newey-West HAC Standard Errors & Covariance (lag truncation=3)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDEX</td>
<td>-0.090227</td>
<td>0.051703</td>
<td>-1.745093</td>
<td>0.0906</td>
</tr>
<tr>
<td>GDP</td>
<td>0.194423</td>
<td>0.053298</td>
<td>3.647807</td>
<td>0.0009</td>
</tr>
<tr>
<td>INF</td>
<td>1.364048</td>
<td>0.461019</td>
<td>2.958769</td>
<td>0.0058</td>
</tr>
<tr>
<td>INT</td>
<td>-0.058748</td>
<td>0.205316</td>
<td>-0.286133</td>
<td>0.7766</td>
</tr>
<tr>
<td>OIL</td>
<td>0.083924</td>
<td>0.034795</td>
<td>2.411941</td>
<td>0.0218</td>
</tr>
<tr>
<td>C</td>
<td>-0.004563</td>
<td>0.002419</td>
<td>-1.886769</td>
<td>0.0683</td>
</tr>
</tbody>
</table>

R-squared 0.233755  Mean dependent var -0.000854
Adjusted R-squared 0.114030  S.D. dependent var 0.015130
S.E. of regression 0.014241  Akaike info criterion -5.521412
Sum squared resid 0.006490  Schwarz criterion -5.262846
Log likelihood 110.9068  F-statistic 1.952424
Durbin-Watson stat 2.530632  Prob(F-statistic) 0.112968