Non-linear exchange rate exposure around the introduction of the Euro

Master's Thesis Financial Economics

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Abstract

In this paper, the recently suggested non-linear exchange rate exposure is tested for a sample of European companies before and after the introduction of the Euro. In the overall period, 9% of the companies show a significant exposure. By constructing a net-investment portfolio based on absolute exchange rate exposure, a factor is created capturing non-linear exchange rate exposure. Adding this factor to existing asset pricing models significantly increases their explanatory power in the period before the Euro, resulting in a negative exchange risk premium for that period. This premium can be explained, using option pricing models, in line with Kolari, Sorescu and Moorman (2008). After the introduction of the Euro, the addition of the non-linear exchange rate exposure factor does not significantly enhance the explanatory power of existing asset pricing models, as expected.

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1. Introduction

> *"The introduction of the euro will be one of those epochal events that can only be understood in the context of long periods in history"* Robert Mundell[1]

Due to recent turmoil on European markets, the Euro is back in the centre of attention; once advocated by people from the entire political scope, recently increasingly criticized.

One of the most important arguments in favor of the introduction of the Euro was the dismissal of exchange rate risks between countries in the Eurozone. Although intuitively an interesting prospect, the magnitude of this advantage remains to be seen.

Empirical research regarding the exchange rate exposure of companies has always provided mixed results at best. These results are puzzling, especially since financial theory delivers a wide consensus on this subject stating that the value of a firm is influenced by exchange rate movements. The gap between theory and practice once again makes economic scholars talk about a "puzzle".

This "puzzle" could very well be caused by the methodology used to measure this exposure. Evidence regarding significant *linear* exchange rate exposure has thus far been unconvincing. Therefore, a *non-linear* relation between exchange rate exposure and firm value is proposed in this paper.

The central hypothesis of this paper is that the value of companies is significantly influenced by exchange rate exposure through a cross-sectional non-linear relation.

The assumed non-linearity lies in the concept that there is a relation between the return on a stock of a company and the *absolute* value of its exchange rate exposure. As a consequence, companies on either sides of the exposure spectrum are valued identically.

To investigate this hypothesis, a sample of 276 companies in 11 European countries is investigated in the period surrounding the introduction of the Euro. Using the exchange

[1] Robert Mundell is the 1999 Nobel Prize winner in Economic Science and considered one of the 'fathers of the Euro'.

rate sensitivity of these companies, a net investment portfolio is constructed with long positions in exposed companies and short positions in unexposed countries (in line with Kolari, Moorman and Sorescu (2008). The return on this portfolio is used as an explanatory variable (EMU-factor).

This factor will be added to the CAPM and a four factor model (including factors that incorporate size, book-to-market and momentum premiums). By analyzing the increase in explanatory power of these extended models compared to their original forms and the significance of the EMU-factor, the central hypothesis can be tested.

Furthermore, in the specific period that is investigated, the introduction of the Euro provides a natural test of the exchange rate exposure factor.

The remainder of this paper is organized as follows; chapter 2 provides the theoretical framework, chapter 3 describes the used methodology and chapter 4 the used data. Chapter 5 shows the results from the research described above and concluding remarks and suggestions for future research will be included in chapter 6. References and the appendix can be found at the end of this paper.

2. Theoretical framework

In this chapter, the theoretical framework regarding the main hypothesis will be outlined. First asset pricing will be discussed, then the international context and its influence on asset pricing is described with some important remarks regarding empirical testing of international asset pricing models. The chapter ends with two paragraphs dealing with the introduction of the Euro and the influence of hedging on empirical results.

2.1 Asset pricing models

According to Jensen and Smith (1984), the literature with regard to the theory of financial economics in the first half of last century, can be described as “undeveloped” and consisting “in large part of ad hoc theories”. From the 1950s on, this changes significantly, partly due to a shift from normative theories to positive theories. In the second half of last century, theories are developed that still form the most important components of modern financial theory. Jensen and Smith identify the Efficient Market Theory, Portfolio Theory, Capital Asset Pricing Model, Option Pricing Model and the Agency Theory. In this section, the Portfolio Theory, Capital Asset Pricing Model and the Option Pricing Theory will be discussed in more detail and be used as the basis for the empirical research.

2.1.1 Modern Portfolio Theory

Merton H. Miller, the 1990 Noble Prize laureate, states that Markowitz’ “Portfolio Selection” can be seen as *“…the very beginning of modern finance…”* (Miller, 2000, p. 96).

In his paper, Markowitz (1952) constructs the Modern Portfolio Theory. Key element of this theory is the assumption that investors’ preferences can be described following a quadratic utility function, meaning that investors are only interested in the expected return and the variance of securities. This assumption is known as the “expected returns – variance of returns” rule.

The main message of this article is that investors should diversify: *”Not only does the E-V hypothesis imply diversification, it implies the “right kind” of diversification for the “right reason.””* (Markowitz (1952), p. 89).

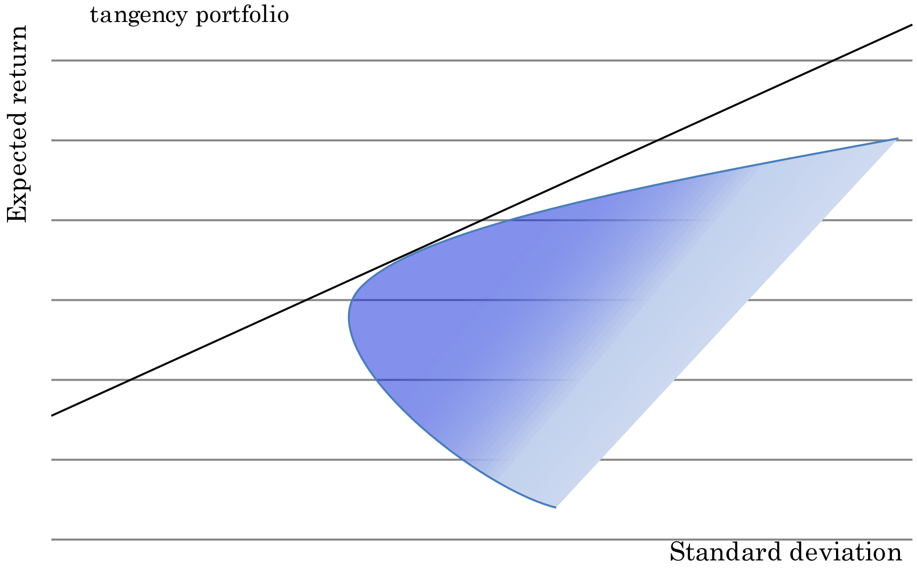
This diversification can diminish the portfolio variance, by combining securities with a low or negative covariance. To construct efficient portfolios, three asset characteristics are important:

i. Expected return
ii. Variance
iii. Covariance between the asset and other assets

When efficient portfolios are combined, they form an efficient frontier of portfolios. This frontier can be described as the set of portfolios with a higher expected return than other portfolios having the same variance (i.e. risk). The efficient frontier is depicted in figure 2.1, being the upper edge of the bullet of assets (when no risk free assets are available).

Figure 2.1 Efficient frontier

In the blue bullet are the risky assets, the black line represents the capital market line. Where this line is tangent to the bullet is the tangency portfolio



When a risk free asset is added in this setting, the line from this risk-free rate (on the y-axis) tangent to the efficient frontier is called the Capital Market Line (CML). The CML between the y-axis and the tangency portfolio consists of possible investments ranging from 100% risk free asset (and no risky assets) to 100% risky assets (and no risk free asset). If it is allowed to short sell assets, the part of this line above the tangency portfolio also consists of possible efficient asset allocations.

Markowitz advocates diversification across different companies and across different industries, so that either the variance can be minimized (when a desired return is formulated) or the expected return can be maximized (based on a maximum acceptable variance).

Markowitz' Portfolio Theory has since its formulation been used as the basis of different asset pricing models, most notably the models of Treynor (1962), Lintner (1965), Mossin (1966) and Sharpe (1964). Sharpe won the Nobel Prize for Economics in 1990 together with Markowitz and the before mentioned Miller, for their pioneering work in financial economics. Sharpe's part of this pioneering work consisted mainly of the development of the Capital Asset Pricing Model

2.1.2 Capital Asset Pricing Model

Sharpe states in his paper that the diversification promoted by Markowitz eliminates part of the risk of an asset, but that no clarity is provided regarding what risk is eliminated and what risk still remains.

Sharpe assumes that investors value an investment based on a probability function: different possible outcomes of the investment are associated with the probability of that outcome. As with Markowitz, Sharpe assumes that only the expected return and its standard deviation (or variation) are of concern to the investor. Investors are assumed to prefer higher expected future wealth to lower and to be risk averse. When creating an equilibrium in his model, Sharpe adds a risk free asset and assumes homogeneity of the expectations of the investor.

The conclusions drawn from Sharpe's paper are what we know as the major implications of the Capital Asset Pricing Model (CAPM). CAPM describes the relationship between the expected return on an asset and its risk and is often depicted as following:

$$\bar{r}_i = r_f + \beta_i(\bar{r}_m - r_f) \qquad (2.1)$$

Where r_f is the risk-free rate, β_i is the beta of the asset (a coefficient describing to what extent the return on the asset correlates with the market return) and $\bar{r}_m$ is the expected market return.

The implication of this model is that idiosyncratic or diversifiable risk should not be priced, only systematic risk (risk correlated to the market-risk, with beta as its measure).

The model shows that investors are compensated in two ways for their investment, through the risk-free rate (representing the time value of money) and through a market premium they receive ($\bar{r}_m - r_f$) for taking on additional risk (correlated with the market risk). The riskier the asset (meaning a higher beta), the more an investor should be compensated for that risk by receiving a higher expected return.

2.1.3 Multiple factor models

According to Fama and French (1993), the average returns in the U.S. show little relation to the market beta that is being used in the CAPM-model. They state that other factors that are not included in asset pricing models, however, do explain the returns. Therefore they create a model where five factors explain the returns on stocks (and bonds). These factors are related to maturity and default risk for bonds and an overall market factor (like in the CAPM) and two factors related to relative firm size and book to market equity for stocks. The stock market factors are not chosen at random, but are motivated by Fama and French. They state that a low stock price relative to the book value of the company (meaning a high book-to-market value (B/M)), usually implies low earnings on assets, and these earnings remain relatively low for at least the next five years (Fama and French 1992).

Regarding the size factor they state that small firms tend to have lower earnings on assets than big firms. Fama and French suggest that both factors are associated with a common risk factor, for which a higher return is the compensation.

Fama and French show that the market factor is particularly good in explaining the returns of big, low book-to-market portfolios. For the other portfolios, the SMB (size factor, Small minus Big) and HML (book-to-market factor, High book-to-market minus low book-to-market) explain the largest part of the return.

Carhart (1997) describes in his paper the two main asset pricing models, the CAPM as described in Sharpe (1964) and Lintner (1965) and his own four-factor model, which is an extension of the above described three-factor model (with regard to stocks only) of Fama and French (1993). His extension consists of a fourth factor which accounts for the momentum anomaly.

This anomaly and its use is described in more detail by Jegadeesh and Titman (1993). They describe strategies where long positions are taken in stocks that have performed well in the past while stocks that performed poorly in the past are sold. These strategies generate significant returns in holding periods between 3 to 12 months. This abnormal return is partly corrected in the following two years; half of the excess return of the first year disappears in the next two years. Their test is based on a dataset of returns over the 1965-1989 period. The abnormal returns found are not based on systematic risk or delayed reactions on common factors, but consistent with firm-specific information.

Table 2.1

Asset pricing				
Author(s)	Title	Describing	Outline	Period
Markowitz	*Portfolio Selection*	**Modern Portfolio Theory**	By combining securities, the portfolio variance can be diminished	1952
Treynor	*Toward a Theory of Market Value of Risky Assets*	**Asset pricing models**	Diversifiable risk should not be priced in the market, only systematic risk	1962-1966
Lintner	*The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets*			
Mossin	*Equilibrium in a Capital Asset Market*			
Sharpe	*Capital asset prices: A theory of market equilibrium under conditions of risk*			
Fama & French	*Common risk factors in the returns on stocks and bonds*	**Multiple factor models**	More factors are needed to explain stock (and bond) returns, besides the market return	1993-1997
Carhart	*On persistence in Mutual Fund Performance*			

2.2 International context

The asset pricing models described in the previous paragraph, seem to ignore the international context companies are in. The question is, whether fluctuations of the exchange rates that a company faces, influence the value of the company. If that is the case, asset pricing models should be adjusted in such a way, that the sensitivity of a company's value to exchange rate movements is incorporated in asset pricing models. In this section, the international context of a company and the influence it has on the firm's value are investigated.

2.2.1 Exchange rate exposure

Shapiro (1975) investigates whether the accounting view on the influence of exchange rates (the prevailing view in that time) fully grasps all components of exchange rate movements that influence the company, or that certain sources of exposure are neglected. The accounting view relates to the financial items on the balance sheet and assumes that these items are the only assets of the company that change in value when exchange rates move.

Shapiro starts by taking the traditional finance view on the value of the firm, i.e. the value of the firm is the sum of all future (discounted) cash flows. He develops an oligopolistic model where a firm's subsidiary produces for its home market and a foreign market. An important assumption he makes, is that the company can engage in price discrimination, due to imperfections in the market. These imperfections are not ceased by arbitrage possibilities. This assumption is based on empirical evidence and the cited behaviour of companies. Shapiro quotes statements of different companies, e.g. British Leyland Motor Corp, who price their product on *"what the market will bear, not to a devaluation."* (Shapiro 1975, p. 490).

Shapiro examines what the effects are of movements in exchange rates and inflation on both the market circumstances and the exchange rate risk that follows from that.

Shapiro's model results in some important and striking results. First of all, intuitively, an export-oriented firm will clearly gain in profitability from a devaluation. Second, a firm that produces for its home market and has no foreign competition will be affected negatively from a devaluation (because its production factors are partly imported or traded). When Shapiro however includes inflation to look at the entire inflation-devaluation cycle, there are no obvious circumstances in which such a firm will clearly win or lose. Third, a firm that is undergoing heavy import competition can profit from a devaluation, but will be harmed when the complete inflation-devaluation cycle is studied.

Shapiro concludes that a firm is exposed to exchange rate changes from import from foreign markets, export to foreign markets or competition from foreign companies. Major factors affect this exchange risk; the distribution of its sales between domestic and export markets, the amount of import competition it faces domestically and the degree of substitutability between local and imported factors of production.

Shapiro's paper cleared the way to look at exchange rate risk in a broader context; not only is the company influenced by the accounting consequences of exchange rate movements, the economical effects may be even more important.

To distinguish between the different exchange rate exposure components, the total exposure can be split in the following three categories (in line with Marshall (2000) int. al.):

i. Transaction risk: this relates to the influence of exchange rate fluctuations on committed cash flows. These cash flows still have to take place, but its magnitude is determined (by contract e.g.).
ii. Translation risk: this relates to the influence of exchange rate fluctuation on the valuation of assets abroad.
iii. Economic risk: this relates to uncertain future cash flows. It indicates the effect of exchange rate fluctuations on the economic circumstances, like the level of competition.

If the cash flows (and therefore the value) of a firm are affected by the exposure of that firm towards exchange rate fluctuations, pricing models should incorporate the international context of the company.

2.2.2 Purchasing Power Parity

Adler and Dumas (1983) provide a meaningful insight in this, by putting pricing models in an international context. Their starting point is the Purchasing Power Parity (PPP). The PPP describes the relationship between weighted average price levels of different countries. The PPP is based on a basket of products, in contrast to the Commodity Price Parity (CPP), which describes the relationship between individual commodity prices. The PPP argutes that purchasing powers should be equal across countries.

Adler and Dumas show that the PPP is a questionable hypothesis in the short-run. The most important reasons are that the CPP is often violated (mostly due to non-homogenous goods and measurement errors in prices) and differences in the composition of national baskets of goods, used for the PPP. Differences in national consumption tastes contribute to PPP deviations. Empirical results suggest that the PPP is violated instantaneously and can be expected to be violated for any forecasting horizon. De Santis and Gérard (1998) state that the debate about the validity of the PPP is still open, but the "(…) idea that national investors are identified by deviations from PPP (…) has been widely used (…)" (De Santis and Gérard, 1998, p. 378).

This violation has some important implications. Ng (2004) describes these consequences. Deviations from the PPP mean that an exchange rate change is not offset by a change in the price levels of the countries. As a result, investors from different countries evaluate returns on the same asset differently. This violates the standard CAPM assumption that investors have homogenous expectations of returns (see paragraph 2.1.2).

As Williamson (1997) puts it: *"(…) these deviations should have a direct effect on firm value."* (Williamson 1997, p. 1).

Adler and Dumas (1984) state that all corporations are influenced by exchange rate movements, even the companies without foreign activities or assets. The question whether the exchange rate exposure should be included in pricing models like CAPM seems therefore justified.

This question received several answers, from researchers modeling and testing an International Capital Asset Pricing Model (ICAPM). Early versions of this model have been derived by Solnik (1974) and Adler and Dumas (1983). The ICAPM in general states that an investor that holds a well diversified portfolio of international assets, faces (i) market risk and (ii) exchange rate risk. As a reward for the bearing of these risks, both a market risk premium and an exchange rate risk premium should be awarded to the investor.

In more recent versions of the ICAPM, a clear consensus exists regarding the definition and measurement of the exchange rate exposure. These are both derived from Adler and Dumas (1984), who define this exposure based on the point of view of an investor:

"The amounts of foreign currencies which represent the sensitivity of the future, real domestic-currency (market) value of any physical or financial asset to random variations in the future domestic purchasing powers of these foreign currencies, at some specific future date." (Adler and Dumas 1984, p. 42).

Their quantification of this exposure follows from the following regression:

$$P = a + b.S + e \qquad (2.2)$$

where, P is the price of the asset in the home currency, S is the exchange rate, a is the regression constant e is the residual and b is the exposure. Adler and Dumas perform this regression in different states of nature, to obtain the exchange rate exposure.

2.2.3 Empirical testing

Jorion (1991) develops an asset pricing model based on the exchange rate exposure as identified by Adler and Dumas (1984). Jorion also analyses whether there are factors that affect both exchange rates and stock prices, in which case *"(…) stock returns may not exhibit a sensitivity to exchange innovations, after accounting for the original factors."* (Jorion 1991, p. 364).

Jorion develops a two factor model where both the market and the exchange rate are explaining variables. This model tests whether the CAPM is a good simulation of the reality in not pricing the exchange rate risk or whether the exchange rate risk is not diversifiable. Jorions model looks like:

$$E(\tilde{R}_i) = \delta_0 + \delta_1\beta_i^m + \delta_s\beta_i^s \qquad (2.3)$$

where $\tilde{R}_i$ is the nominal return of asset i in excess of the risk-free rate. This model depicts a linear relation between nominal returns and sensitivities regarding the market and exchange rate movements. If we look at this model for the market (so $_i = _m$), β_m^s must be equal to 0. This can be rewritten as:

$$E(\tilde{R}_i) = \delta_0 + [E(\tilde{R}_m - \delta_0]\beta_i^m + \delta_s\beta_i^s \qquad (2.4)$$

which is equal to the model derived by Black, Jensen and Scholes (1972) for testing the CAPM, in case δ_s =0 (and the exchange rate exposure is not priced).

Jorion adjusts this model to account for an expected rate of return (and an innovation part) and also tests a multi-factor model, where he extends an existing model with the same exchange rate exposure with coefficient δ_s.

Both models are tested for the United States for the period January 1971 (when the exchange rates ceased to be fixed) and December 1987. Within this period, Jorion finds no evidence that δ_s differs significantly from zero, meaning that the exchange rate risk does not seem to be priced in the market.

The implications of the findings of Jorion are remarkable. Since, according to Jorion, exchange rate exposure is not priced in the market, it would mean that companies that actively hedge such exposures, do not create shareholder value by doing so. This empirical result also opposes the financial theory as discussed before.

Dumas and Solnik (1995) on the other hand reach the conclusion that exchange rate risk is priced in the market. They find that international asset pricing models dominate the traditional pricing models that do not incorporate exchange rate risk. Dumas (1994) reaches the same conclusion.

2.3 Further research

Overall, results concerning the pricing of exchange rate exposure seem to be mixed. This discrepancy between theory and empirical research has since been the topic of debate and the motivation for an extensive search for variations on the asset pricing models that do show results that are in line with theory. Two variations that have resulted in important improvements and are applied in the research model of this paper are described below.

2.3.1 Open economies

Although most research regarding exchange rate exposure is centred around companies in the U.S., the American economy cannot be identified as the most open economy in the world, to say the least. When more open economies are investigated, exchange rate exposures seems to be higher. Nydahl (1999) investigates the relative small and open economy of Sweden to test the hypothesis that exchange rate exposure effects the firm value. He finds that more than a quarter of the investigated firms show a significant relation between exchange rate movements and stock returns. De Jong, Ligtering and Macrea (2006) perform an analysis for The Netherlands, and find that more than half of the companies they investigate show a significant exchange rate exposure.

2.3.2 Non-linear exposure

It has often been questioned whether the exchange rate exposure follows a linear pattern, as is assumed by the before mentioned research papers. Bartram (2004) has investigated both linear and non-linear exposure of a sample of German corporations. Again, the author points out that a study like this suits an open economy (like Germany) better than more closed economies (like the U.S.). Bartram finds a significant linear exposure for 8% of the sample firms, while the number of firms with a significant non-linear exposure is 12%. Kolari, Moorman and Sorescu (2008) find evidence of a priced non linear exchange rate exposure. The negative risk premium they find relating to this exposure is explained using Johnson (2004). He argues that increased volatility of the value of the firm decreases expected return. His reasoning is based on the option pricing models of Black and Scholes (1973), which state that higher volatility of the underlying asset decreases the rate of return of the call option. This is caused by the increase in the option price being larger than the increase in the expected pay-off.

Non-linearity of exchange rate exposures is part of the central hypothesis of this paper and will be further discussed in both chapter 3 and 5 with regard to the model being tested here. Special attention is given to the model of Kolari, Moorman and Sorescu, since their recent research provides impressive results with regard to the pricing of exchange rate exposure. Their model will be used as the basis of the test of the hypothesis of this paper and analyzed in-depth in chapter 3.

Table 2.2

International context				
Author(s)	Title	Describing	Outline	Period
Shapiro	*Exchange rate changes, inflation, and the value of the multinational corporation*	**International exposure**	Companies are exposed to exchange rates from import, export and international competition	1975
Jorion	*The pricing of exchange rate risk in the stock market*	**International pricing model**	By testing a factor covering international exposure, there appears to be no evidence for the pricing of exchange rate risk	1991
Adler & Dumas	*International portfolio choice and corporation finance: a synthesis*	**International CAPM**	A factor covering international exposure should be incorporated into the CAPM	1974-1998
Solnik	*An Equilibrium Model of the International Capital Market*			
De Santis & Gerard	*How big is the premium for currency risk*			
De Oliveira Andersson	*Exchange rate risk and its determinants: evidence from international stock markets*			

2.4 Euro

There are certain special events that perfectly suit the research of exchange rate exposure. Such events are linked to the introduction of fixed or floating currencies. The most important special events regarding exchange rate exposure are the introduction (1944) and dismissal (1973) of the Bretton Woods System (the introduction of fixed exchange rates) and the introduction of the Euro (1999).

Bartram and Karolyi (2006) investigate the influence of the introduction of the Euro on the foreign exchange rate risk exposures of 3220 non-financial firms from 18 European countries, Japan and the U.S. In their analysis, they make an important division between systematic risk and diversifiable risk. They conclude, based on their findings, that exchange risk forms an important part of systematic risk. Lowering that could have a large beneficial impact on the value of the business, since a lower beta (measure for systematic risk) implies reduced cost of capital.

The horizon they investigate is from January 1990 to August 2001. As date of the introduction of the Euro they take one year before the official introduction of the Euro, January 1 1999, because they assess that the markets have anticipated the introduction of the Euro. Evidence supporting this comes from Bris et al (2003), who point out that already in May 1998 was decided what countries would adopt the Euro and that around the middle of 1998 the forward rates in the countries who would adopt the Euro converged.

The main result of Bartram and Karolyi (2004) is that the introduction of the Euro had lead to a decline in the market risk exposure for firms in and outside Europe, implying that, as mentioned before, foreign exchange rate risk is a part of systematic risk.

Bris, Koskinen and Nilsson (2006) distinguish between companies from strong and weak euro-countries, when investigating the introduction of the Euro. This distinction is made based on whether the European country was faced with a exchange rate crisis (“weak”) or not (“strong”) before the introduction of the Euro. They find that companies from the weak euro countries benefit most from the introduction of the Euro, they see an increase in firm value. Net importing companies from strong euro countries also seem to benefit from the Euro, while the value of net exporting companies from strong countries do not react significantly to this event.

Faff, Marshall and Nygan (2007) investigate the effect on the introduction of the Euro on a sample of French firms. They come to the conclusion that the number of significantly exposed companies has dropped due to the Euro. In line with this finding, they also observe a drop in the number of firms that use derivatives to hedge exchange rate exposure. More on the topic of hedging in paragraph 2.5.

The period under investigation in this paper includes the introduction of the Euro. The tests of asset pricing models will therefore be conducted for the separate periods individually, to assess the influence of the introduction of a common currency for the home countries of the companies under investigation. More on this in chapters 3 and 4.

2.5 Hedging

When the firm's value is affected by factors that are uncontrollable, this often poses an unwanted risk. Companies that are aware of their exchange rate exposure, have an incentive to hedge this exposure. First of all, managers that are rewarded for their performance, will not be eager to be exposed to risks they cannot influence. By getting rid of all surrounding risks, they can focus and put their time and effort where it should be, their core business.

Besides this, it is often stated that hedging increases the value of the firm. Allayannis and Weston (2001) study a sample of 720 firms to find that for companies exposed to foreign exchange rate exposure, the use of foreign currency derivatives (FCD) increases the firm value with almost 5%. Allayannis and Ofek (1997) find a negative relation between the use of FCD's and the exchange rate exposure of a company, resulting in the conclusion that companies that use FCD's do so for hedging their exposure more than speculating.

Companies often claim to also use operational hedges to mitigate the exchange rate exposure. By spreading subsidiaries over a number of countries, they try to diminish the exposure. This form of diversification and its influence on the value of the firm has been a research topic with mixed results. Allayannis, Irhig and Weston (2001) find that operational hedging is not effective in increasing the firm value, unless it is combined with a form of financial hedging. As proxy for operational hedging activities, the dispersion of the company's subsidiaries over regions and countries is used.

Pantzalis, Simkins and Laux (2001) on the other hand find that operational hedging does significantly reduce exchange rate exposure. The interesting fact is that the proxy they use is almost identical to the one used by Allayannis, Irhig and Weston (2001).

The mixed conclusion could be due to the use of the proxy, that seems to have some flaws. Because although the spreading of activities over multiple countries could provide a hedge, hedging is not necessarily the objective of this dispersion. So, although spreading activities over multiple countries in the way companies tend to do it, provides no effective hedge, operational hedging could proof to be effective, if the dispersion is chosen based on exchange rate exposures (and not cost efficiency, for example).

Although the evidence on whether companies hedge exchange rate exposure and are successful in doing so, appears to be mixed, it does provide a warning to scholars investigating exchange rate exposure. Results of research regarding this exposure could be blurred by the hedging activities of a company. Where correcting results for financial hedges seems possible, incorporating operational hedges seems rather complicated. The mixed results regarding this topic as mentioned in this paragraph show how complicated.

In chapter 5, hedging will be discussed into more detail.

3. Methodology

In order to test the central hypothesis of this paper, two steps are required. First of all, the exchange rate exposure of companies has to be estimated. This will be done by regressing excess return on exchange rate movements. The process is described in paragraphs 3.1 and 3.2.

Step two consists of creating a net investment portfolio based on the exchange rate exposure estimations derived in step 1. Based on this net investment portfolio, a exchange rate exposure factor is created and added to two existing asset pricing models: CAPM (Sharpe) and the four factor model (Carhart), creating an ICAPM and five factor model, respectively. These models are tested in the period before and after the introduction of the Euro to test whether non linear exchange rate exposure is a priced factor. This step is described in paragraph 3.3.

3.1 Five factor model

As pointed out above, the first step consists of measuring exchange rate exposure. Adler and Dumas (1984) suggest that the exposure should be measured using a regression of the appropriate exchange rate on the value of the firm. Although intuitively correct, such a regression would not measure the isolated excess return caused by exchange rate fluctuations. To be able to do this, the return of the company's stock should be corrected for a market factor and for certain anomalies, as described in chapter 2. In order to do this, a five factor model will be derived (in line with Kolari, Moorman and Sorescu (2008)). This model will consist of the basic idea behind the CAPM and the models derived from the CAPM. Below is a step-by-step construction of this model.
First of all, the market risk will be incorporated in the model, by recreating the CAPM, following:

$$R_i = R_f + \beta_i(R_m - R_f) \qquad (3.1)$$

were R_f is the risk-free rate, β_i is the beta of the asset (a coefficient describing to what extent the return on the asset correlates with the market return) and R_m is the expected market return (see also chapter 2). Rewriting this, allowing for a constant and specifying it for period t, produces:

$$(R_i - R_f)_t = \alpha + \beta(R_m - R_f)_t \tag{3.2}$$

The limited power to explain results (as described in chapter 2), using this model, motivates to include more priced factors. It makes sense to include the factors Fama and French incorporate, when the added explanation power of the model of Fama and French is studied. These added factors contain the following anomalies:

- Size:
  Small firms tend to have lower earnings, relative to lager firms. To compensate this risk factor, larger returns are required. Therefore a net investment portfolio is created, with long positions is small firms and short positions in large firms. The return on this portfolio is used as the size factor SMB (Small firms Minus Big firms). Size is measured as the market value per share times the amount of shares outstanding, measured every year.
- Book to market value (B/M):
  In line with the size factor, companies are also divided based on their B/M value. This ratio consists of the book value (accounting view) of the company divided by the market value of the company. Fama and French (1992) show that a high B/M value implies relative low earnings for the next five years. These low earnings pose a risk factor (much as with the size factor) and should therefore be compensated. A net investment portfolio is constructed, with long positions in stocks of companies with high B/M values and short positions in stocks of companies with low B/M values. The return on this portfolio is used as the B/M factor HML (High B/M Minus Low B/M).

When these factors are incorporated, the model looks like this:

$$(R_i - R_f)_t = \alpha + \beta_1(R_m - R_f)_t + \beta_2 SMB_t + \beta_3 HML_t \qquad (3.3)$$

To obtain more accuracy, a fourth anomaly is included. This factor is derived from the model of Carhart (1997):

- Momentum
  As Jegadeesh and Titman (1993) show, stocks of companies that have performed poorly in the past half year, continue to do so in the next 3 to 12 months. The other way around, past winners continue to generate positive returns in the following period. As with the previous described factors, a net investment portfolio is constructed with long positions in stocks that have gained the highest returns in the past and short positions in stocks that have performed poorest in the past. The past is here defined as the period between t minus 12 months and t minus 2 months. The return of this portfolio in the year following the construction, is used as the momentum factor WML (past Winners Minus past Losers).

Including this factor results in the following four factor model:

$$(R_i - R_f)_t = \alpha + \beta_1(R_m - R_f)_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t \qquad (3.4)$$

For the net investment portfolios SMB, HML and WML, the total population of stocks is ranked based on the corresponding anomaly (i.e. size, B/M and momentum) and is then divided in a number of portfolios. In the base case scenario, a total of 3 portfolios is used. The return on the net-investment portfolios is therefore the return of portfolio 1 minus portfolio 3. To test whether the results are robust, the above described creation of the net-investment portfolios will be performed using various numbers of portfolios. When significant differences are obtained, this will be reported.

The risk free rate (R_{ft}) is determined in line with Vaihekoski (2009). By following his price difference approach, we avoid the bias he describes that is a result of the compounding method of determining the risk free rate. The price difference approach uses equation 3.5 in determining the risk free rate:

$$R_t^d = \frac{R_t^{1m} d}{dpy + R_t^{1m}(dtm - d)} \qquad (3.5)$$

In this equation, d stands for the number of days over which the risk free rate is calculated, dtm corresponds to the days to maturity and dpy is the number of days per year. For this variables, the day counting convention related to the Euribor is used. R_t^{1m} is the one month rate of the corresponding (riskfree) asset (e.g. the one month T-bill rate or one month Euribor). The most important feature of this method is that the only compensation for investors of holding a riskfree asset is the passing of time.

3.2 Measuring exposure

To be able to measure the exchange rate factor, a variable containing the appropriate exchange rates will be included. The sensitivity of the different stocks towards the exchange rates is calculated through a regression on the factor as previous described:

$$(R_i - R_f)_t = \alpha + \beta_1 (R_m - R_f)_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t + \beta_5 X_t + e_{it} \qquad (3.6)$$

Where, $(R_i)_t$ is the return on stock i in period t, $(R_f)_t$ is the risk free rate in period t, α is a constant, $(R_i - R_f)_t$ is the excess return of the market portfolio over the risk free rate and accounts for the market premium (much like the CAPM). SMB is the factor accounting for size premium, HML is the factor accounting for the B/M premium and UMD is the factor accounting for the momentum premium. X is a factor based on the exchange rates company i faces. This is discussed into more detail in paragraph 4.3.

Equation 3.6 will be tested using weekly data and 2 year rolling periods. This regression is performed every half year. From this equation, every half year the β_5's will be estimated and used as a measure of the exchange rate exposure of the companies in the half year following the estimation period.

The number of companies that have a significant exposure towards exchange rates provides a result that can be compared to international research papers. As discussed before, the empirical evidence relating to the percentage of significantly exposed firms is mixed and usually shows percentages below 20%. Financial theory however would predict a more impressive percentage, as discussed in chapter 2. This result will therefore be analysed and compared to other findings in chapter 5.

3.3 Net investment portfolio

The hypothesis of this paper states that pricing of exchange rate exposure is non linear across firms when they are ranked based on their exposure. In other words, the most exposed companies, either negative or positive, should have expected returns that differ from the companies that have no significant exposure.

The next step therefore is to make a cross-sectional analysis of exchange rate exposure using a factor that incorporates this non-linear exposure. Such a factor differs from factors like SMB and HML, since these follow a linear pattern; e.g. smaller companies have a lower expected return, while larger companies have a higher expected return.

Although this exposure factor will also be constructed by creating a net-investment portfolio, the methodology of creating this portfolio differs from the net investment portfolios used to create the SMB and HML factors. To create a net-investment portfolio, all stocks first have to be ranked based on the variable determining the net-investment portfolio (e.g. size or B/M) and grouped in portfolios. The net-investment portfolios for linear factors consists of long positions in the top portfolios (e.g. portfolios with the smallest companies or portfolios with the highest B/M) and short positions in the lowest portfolios (e.g. portfolios with the largest companies or portfolios with the lowest B/M). For the non-linear exposure factor however, this method is not usable, since the top portfolios and the lowest portfolios both consist of companies with the highest exchange rate exposure (the top portfolios contains the highest *negative* exposure, the lowest contains the highest *positive* exposure). Because the main hypothesis states that companies with either high negative or high positive exposure have a lower expected return (compared to the low exposure companies), long positions should be taken in both the top and lowest portfolios, while shorting the other (middle) portfolios.

This net investment portfolio is based on the model of Kolari, Moorman and Sorescu (2008). It provides the solution to their finding that exposed companies have a lower return compared to unexposed companies. Since there is no ex-ante reason to expect otherwise in the sample used in this paper and the hypothesis states the same non-linearity, the same methodology will be followed (as described above).

The empirical evidence regarding this non-linearity is supported by option pricing models, stating that increased volatility of the underlying asset decreases the expected return of the option. In this case, the increased volatility of the cash flows of a company, caused by either a high negative or a high positive exchange rate exposure, would result in a lower expected return on the stock of the company. Note that this non-linear relation is already described as one of the solutions to the mixed evidence regarding exchange rate exposure in chapter 2.

As explained, the net investment portfolio will consist of long positions in stocks that have a significant exposure (positive or negative) and short positions in stocks that have no significant exposure. This net investment portfolio will be referred to as EMU (Exposed Minus Unexposed). To create the net investment portfolio , the companies are ranked bases on the β_5's resulting from equations 3.6. The stocks having a significant exchange rate exposure are grouped in portfolio E (Exposed), while the stocks with no significant exchange rate exposure are grouped in portfolio U (Unexposed).

The net investment portfolio will be held for 6 months. After these six months, the β_5's are remeasured and the portfolios are ranked again. Again long positions will be taken in the exposed stocks, short positions in the unexposed stocks. The EMU factor equals the return on this net investment portfolio over the years.

The EMU factor will be added to the CAPM and to the four factor model (Carhart, 1997) as described above, resulting in the following asset pricing models:
ICAPM:

$$(R_{it} - R_{ft})_t = \alpha + \beta_1(R_{mt} - R_{ft}) + \beta_5 EMU_t \qquad (3.7)$$

Five factor model:

$$(R_i - R_f)_t = \alpha + \beta_1(R_m - R_f)_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t + \beta_5 EMU_t \qquad (3.8)$$

Both models will be estimated using monthly data. The explanatory power of ICAPM will then be compared to the explanatory power of CAPM. The significance of the EMU factor will also be investigated. The same procedure will be followed for the five factor model (and its corresponding four factor model).

A distinctive feature of the research conducted in this paper is that the period under investigation includes the introduction of the Euro. As per the moment of introduction, the most important exchange rates that the companies in this sample face, became fixed. This event therefore provides a natural test of the exchange rate exposure factor as described above.

In the period before the Euro, the β_5's are expected to be positive in sign and significant (i.e. in line with the findings of Kolari, Moorman and Sorescu (2008)). A positive β_5 implies a negative foreign exchange rate risk premium, since it decreases the return demanded by the investor for firms with higher absolute exchange rate exposure. This result would be in line with the option pricing theory discussed previously.

After the introduction of the Euro, exchange rate exposure is expected to be smaller and addition of an exchange rate risk factor to asset pricing models should not significantly increase their explanatory power.

4. Data

4.1 Stocks

The stock prices and returns are retrieved from Bloomberg. The dataset consists of all stocks that were listed on January 1, 2000 on the main stock indices of the countries of the Eurozone (as per January 1, 2002), except for Greece. These eleven countries already virtually switched to the Euro as per January 1, 1999, following the Maastricht treaty. The countries are listed in table 4.1. The main stock market index and the number of stocks are also depicted in this table.

Table 4.1 Stocks

Euro countries	**Main stock index**	**Number of companies**
France	CAC40	40
Austria	ATX	24
Belgium	BEL20	20
Finland	OMXHelsinki	31
Germany	DAX30	30
Ireland	ISEQ	10
Italy	MIB30	30
Luxembourg	LuxX	12
Portugal	PSI20	20
Spain	IBEX35	35
The Netherlands	AEX	24
Total		276

4.2 Period

The period that is being researched is centred around the introduction of the Euro. The introduction of the physical Euro (coins and notes) was on January 1, 2002. For the countries of table 4.1 the virtual introduction took place on January 1, 1999, as mentioned above. In this research paper, the introduction of the Euro however is set on January 1, 1998, accounting for the fact that markets anticipated this introduction. This adjustment is in line with Bartram & Karolyi (2004) and Bris (2003).

Because of the unique period that is being researched, the effect of the introduction of the Euro can be studied. Therefore all important results will be presented for the different sub periods, identified in table 4.2.

Table 4.2 Sub periods

From	**Until**	**Subperiod**
January 1, 1993	December 31, 1997	Pre-Euro period
January 1, 1998	June 30, 2001	Euro period

For the cross-sectional analysis, monhtly returns are used. On these returns, winsorising is performed in such a way that all returns fall within 95% of the symmetric confidence interval. When using winsorising, a normal distribution of the stock returns is assumed. This assumption is also one of the main assumptions underlying the CAPM.

The risk free rate is calculated using the 1 month Euribor (Euro Interbank Offered Rate, which exists as long as the Euro does, so per January 1, 1999) or the 1 month Fibor (Frankfurt Interbank Offered Rate, for the period before the Euro). This one month rate is converted into weekly rates (when applicable) using the method described in chapter 3.

The market index used is the MSCI World Index, consisting of 1,500 stocks worldwide. This index is often used as a proxy for the market index, which theoretically would have to consist of all risky assets, including (for example) real estate and human capital. The fact that these categories and a lot others are not included, was the basis of Roll's critique (1977), who claimed that because the theoretical market portfolio is not observable, the CAPM cannot be tested. Stambaugh (1982) tested whether the addition of categories (such as real estate and consumer goods) significantly altered the results and found no significant proof that it did.

4.3 Exchange rates

The main coefficient of equation 3.6, β_5, is linked to variable X. This variable is determined per country, based on the important trade flows from the specific country. X is defined as the return on a basket of currencies against the home currency. If X is positive, it means that the home currency can buy more units of the foreign currencies basket, i.e. the home currency becomes stronger. Importers usually benefit from a stronger home currency, which can lead to an increase in the value of the company. Therefore, the firm value of a (net) importer will usually have a positive exposure towards X. For exporters, it is exactly the other way around, meaning that the relation between the value of the firm and X will likely be negative.

The currency basket consists of 57 currencies (including 16 Eurozone currencies). The weighing of these currencies is different for each home country, based on information regarding bilateral import- and export data between the home country and the specific basket country. The exchange rates are deflated using Consumer Price Indices (CPI). More information regarding the countries included in this basket is gathered in table 4.3 (see Appendix). This information is retrieved from the Statistical Data Warehouse of the European Central Bank.

5. Results

As discussed in chapter 3, first the sensitivity of the excess returns (using the extended four factor model) towards the exchange rate movements is measured, using equation 3.6.

5.1 Exchange rate exposure

From table 5.1 (the lower row, depicting the average significance percentages) it becomes clear that about 9% of all stocks show a significant exchange rate exposure.

Table 5.1 Portfolios ranked on exchange rate sensitivity

Portfolio	Overall period		Pre-Euro period		Euro period	
	Significant	Return	Significant	Return	Significant	Return
1	44.8%	7.2%	56.9%	10.8%	27.5%	2.0%
2	20.4%	10.5%	28.5%	13.0%	8.8%	6.9%
3	5.3%	9.0%	8.1%	10.8%	1.2%	6.3%
4	3.6%	11.0%	6.1%	12.7%	0.0%	8.6%
5	0.3%	10.3%	0.5%	11.6%	0.0%	8.5%
6	1.0%	12.3%	1.7%	12.9%	0.0%	11.4%
7	0.0%	11.3%	0.0%	11.8%	0.0%	10.5%
8	0.0%	12.8%	0.0%	13.1%	0.0%	12.4%
9	1.0%	11.1%	1.6%	11.9%	0.0%	9.9%
10	16.8%	11.6%	16.9%	11.9%	16.8%	11.2%
Average	9.1%		12.4%		5.4%	

Over the total period (January 1, 1993 to June 30, 2001), every half year all stocks are ranked on their exchange rate sensitivity (β_5), using

$$(R_i - R_f)_t = \alpha + \beta_1 (R_m - R_f)_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t + \beta_5 X_t + e_{it}$$

where Ri is the individual security return. Rm is the return on the market portfolio MSCI World, Rf is the one-month Euribor/Fibor, SMB is the return on a portfolio of small stocks minus the return on a portfolio of big stocks, HML is the return on a portfolio stocks with a high book-to-market value, minus stocks with al low book-to-market value, WML is the return on a portfolio of past winners minus a portfolio of past losers and X is the return of a basket of currencies on the home currency of company i. The stocks are then gathered in 10 portfolios which are held for the following half year, after which they are sorted again. The returns of these portfolios and the percentage of significantly exposed companies per portfolio are depicted (using a 10% significance level).

The difference between the pre-Euro and the Euro period is striking: before 1998 12% of the firms show a significant exposure, after 1997 this percentage drops to 5%. In the appendix, table 5.2 is included using the ICAPM to assess the relation between excess return and exchange rates. Circa 13% of all stocks show significant exposure, using this method over the entire period.

These percentages are quite low and don't seem to be in line with financial theory (as discussed in chapter 2), predicting significant influence of exchange rate fluctuations on the value of the company. However, this result does fit a more or less consistent outcome of previous studies of exchange rate exposure. In table 5.3 a summary is provided of earlier research regarding the portion of companies that have a significant exposure regarding exchange rates. Per research paper, the author, investigated period and the home country/countries of the researched companies is shown.

A distinction is made between the results regarding countries that are investigated in this paper (the countries that switched to the Euro per 1999), here denoted as "Euro" and the results regarding the other countries ("non-Euro").

Although the percentages differ somewhat over time and in the different countries, it becomes clear that for most research papers, the percentage of significantly exposed companies is comparable to the percentage found here. For the "Euro"-area, the average percentage of exposed companies amounts to c. 9%, compared to c. 7% in this paper (using the ICAPM, comparable to the methods used in the described papers[2]). The difference could be explained by the introduction of the Euro, during the sample period. The effect of the Euro will be discussed later.

[2] Using a significance level of 5%, for both the research papers in table 5.3 and this paper.

Table 5.3 Results from previous research papers

Author	Year	Period	Area (non-Euro)	Exposure		Area (Euro)	Exposure	
Jorion	1990	1981-1987	U.S.	15%	*			
Jorion	1991	1981-1987	U.S.	20%/35%	*			
Bodnar & Gentry	1993	1973-1988	U.S.	23%	*			
			Canada	21%	*			
		1983-1988	Japan	25%	*			
Prasad & Rajan	1995	1981-1989	U.S.	15%	*	Germany	17%	**
			Japan	4%	*			
			U.K.	6%	*			
Choi & Prasad	1995	1987-1989	U.S.	10%/15%	**			
He & Ng	2002	1979-1993	Japan	25%	*			
Dominguez & Tesar	2004	1980-1999	Chile	4%	*	Netherlands	15%	*
			Japan	22%	*	France	8%	*
			Thailand	15%	*	Germany	11%	*
			U.K.	13%	*	Italy	7%	*
Doidge, Griffin & Williamson	2005	1975-1999	Australia	7%	*	Netherlands	6%	*
			Canada	7%	*	Belgium	12%	*
			U.K.	9%	*	France	6%	*
			U.S.	8%	*	Spain	11%	*
			Japan	9%	*	Germany	6%	*
			Hong Kong	10%	*	Italy	9%	*
			Malaysia	4%	*			
			New Zealand	7%	*			
			Denmark	9%	*			
			Norway	12%	*			
			Singapore	10%	*			
			Switzerland	5%	*			

With regard to the relatively low percentages denoted in table 5.3, Bartram and Bodnar (2005) speak of the "The Exchange Rate Exposure Puzzle". They state that the findings of most researchers do not concur with the predicted level of exposed firms, but that nonetheless the exchange rate exposure is *"real, statistically significant and consistent with the predictions of financial theory for some firms, just not for as large a percentage of firms as suggested by the researchers' priors."* (p. 2).

So even although the percentage of companies that have a significant exchange rate exposure is fairly low, it may be worthwhile to investigate this group to some more detail. The issue of the small percentage of exposed firms is discussed in paragraph 5.5, where possible explanations are discussed.

5.2 Firm characteristics

From table 5.1, it is clear that the number of stocks with a negative exchange rate exposure is significant larger than the number of stocks with a positive exchange rate exposure. At first glance, it would appear that in our sample more (net)exporters than (net)importers are included. This observations is in line with the trade surplus common in Europe. A word of caution is in place however regarding this observation, since it could very well be the case that (net)importers engage more actively in hedging activities than their exporting counterparts. More on the influence of hedging on these results in paragraph 5.5.

5.2.1 Countries

In figure 5.1 (see Appendix), information regarding the home counties of the significantly exposed companies is depicted. Italy, Portugal, Germany and the Benelux countries (Belgium, Netherlands and Luxembourg) have the highest percentages exposed countries. When the total period is split in a pre-Euro period and an Euro-period, the effect of the introduction of the Euro in the different countries can be seen. This effect can be observed by comparing the second and third graph bar for each country. The most drastic drop in significantly exposed countries (relatively) can be found in Portugal. Although this country had the highest percentage in the pre-Euro period, it dropped to the last position in the Euro-period, giving an indication that Portugal is one of the countries that has benefited significantly from the introduction of the Euro. For Austria, France and Finland, we see almost no difference between the pre-Euro period and the Euro period. Their relatively low percentage of exposed companies was consistent in both sub-periods.

5.2.2 Size and book-to-market value

In order to shed some light on the influence of size and book-to-market (B/M) value on the exchange rate exposure of the company, nine sub portfolios are created. These portfolios are constructed by splitting the total population in three sub-groups based on size. Every one of these subgroups is then split into three subgroups based on B/M. This way, nine portfolios are constructed. In table 5.4 in the appendix, the information regarding the average of these portfolios over the sub periods is shown.

In the period before the introduction of the Euro, there seems to be a positive relation between the size of the company and the absolute value of the exchange rate exposure. On the other hand, the influence of the book-to-market value on the exposure seems unclear. For the Euro-period, the exposure has no clear dependence on either of the variables size and book-to-market value.

5.3 Portfolio ranking

As discussed in the chapter 3, all stocks are ranked based on the estimated foreign exchange rate exposure and then grouped into 10 portfolios. These portfolios are created every half year, so every half year the stocks with the lowest (i.e. most negative) exposure are grouped in portfolio 1 and the stocks with the highest (i.e. most positive) exposure are grouped in portfolio 10.

In table 5.1, the average returns of these portfolios can be seen. Furthermore information is gathered concerning the coefficient of the exchange rate exposure of the stocks in the 10 portfolios. In columns 2,4 and 6 of the table, the percentage of significantly exposed companies per portfolio is depicted, e.g. portfolio 1 contains 44.8% significantly exposed companies over the total period.

The returns on the portfolios are shown in columns 3, 5 and 7. For the total period, there seem to be no clear and significant differences between the returns on the different portfolios, although the return on portfolio 10, being the portfolio with the highest (i.e. most positive) exposure is slightly higher than the return on portfolio 1 (most negative exposure), 12% versus 7%.

In columns 4 to 7 of table 5.5, a distinction is made between the pre-Euro period and the Euro-period. When the total examined period is split in a pre-Euro period and an Euro-period, a possible effect of the introduction of the Euro can be observed. The difference between the two periods is clear and in line with the expectations. The introduction of the Euro has clearly lowered the percentage of companies significantly exposed to exchange rates. In the pre-Euro period, 12% shows a significant exposure relating to exchange rate changes, in the Euro-period this percentage has dropped to 5%.

The returns on the portfolios for these periods provide an interesting picture. The returns on the portfolios in the Euro period seem to show an upward sloping line. The difference between portfolio 10 and portfolio 1 is over 9 basis points. Contrary to what would be expected, it seems that the exposure of a firm to exchange rate fluctuations influences the value (and therefore returns) of the firm after the introduction of the Euro following a linear pattern. A warning is in place however, since in the Euro-period, the percentage of significantly exposed companies is especially small and this suggested relation could proof to be insignificant.

In the pre-Euro period, the differences between the portfolios appear to be small. Where Kolari, Moorman and Sorescu (2008) find that the most exposed portfolios (in absolute terms, so the first and the last portfolio) have a return that is almost half the return of the unexposed portfolios, the differences here are significant smaller. The average return on the exposed portfolios is however still smaller than the average return on the unexposed companies. This holds for the total period as well as both sub periods. With the smaller differences, the creation of an EMU portfolio could proof to be less effective. The convincing evidence Kolari, Moorman and Sorescu (2008) report however still provides a firm motivation to test the main hypothesis of this paper.

5.4 EMU portfolio

To test the hypothesized non-linear cross sectional relation between exposure and return, the return on the net investment portfolio (based on exchange rate exposure) is added as an independent variable to the CAPM and the four factor model.

5.4.1 ICAPM

The performance of this factor is measured by looking at the significance of this factor in the models (and the potentially added explanatory power). To measure this, the ICAPM and CAPM are estimated using 9 size / book-to-market portfolios (which are created in line with the method described in paragraph 5.2.2). To create the natural test described in paragraph 3.3, the model is tested for the pre-Euro period and the Euro period separately. Table 5.6 reports the coefficients of β_5, with their corresponding t-statistic. From the 9 portfolios in the pre-Euro period, 4 have a significant β_5 coefficient. Furthermore, the coefficients are all positive, as is expected: there appears to be a negative risk premium relating to exchange rate exposure. All R-squares (although low) are increased by adding the EMU-factor (see table 5.8 in the appendix).

The difference between these results and the results in the Euro-period are striking. No portfolio has a significant β_5 and the increases in R-squares by adding the EMU-factor are small or zero. This comes as no surprise, since the percentage of significantly exposed firms was lower and the non-linear relation between return and exposure implied by the EMU-factor seemed to be absent in this period. The R-squares are however higher than in the pre-Euro period, which seems somewhat surprising.

5.4.2 Five factor model

Although the ICAPM already shows improvements, the limited explanatory power of CAPM in earlier research motivates to test how the EMU-factor performs in an extended four factor model, as described in chapter 3.

This five factor model is again tested on the 9 size / book-to-market portfolios. Table 5.7 shows the results. From the 9 portfolios, 7 appear to have a significant coefficient in the pre-Euro period. Again all coefficients are positive. The R-squares increase even more than with the ICAPM (see table 5.9 in the appendix). The difference with the Euro period is again clear, only 1 portfolio shows a significant β_5.

Although the EMU-factor does not seem to add a lot explanatory power in the Euro-period (in line with the ICAPM), the R-squares for this period are higher than for the pre-Euro period. The higher explanatory power is mainly caused by the momentum factor (WML), which performs significantly better than in the pre-Euro period. A possible explanation of the increased significance of the WML-factor could be the dot-com bubble building up and bursting in that period. Until March 2000, most stocks seemed to keep winning (which is partially what the momentum anomaly predicts, winners will continue to do so) and after March 2000, stocks kept on losing in a downfall of stock markets that didn't end until after the end of the sample period of this paper (consistent with the momentum anomaly that predicts that losers continue to lose).

Both the five factor model and the ICAPM are also estimated using the 10 exposure portfolios from table 5.1. The results are depicted in table 5.10 and 5.11 in the appendix and are in line with the above described results.

The addition of the EMU-factor to existing asset pricing models appears to significantly enhance the explanatory power of both investigated asset pricing models. Exchange rate exposure is a priced factor in the pre-Euro period for the sample under investigation. Furthermore, the natural test of the introduction of the Euro provides the results that were expected (see paragraph 3.3), addition of an exchange rate risk factor does not increase the explanatory power of asset pricing models.

Since the results regarding the addition of the EMU-factor are in line with the results found by Sorescu, Kolari and Moorman (2008), their suggested explanation for the observed negative risk premium (corresponding to the positive β_5 coefficients), derived from option pricing theory, could also provide an explanation for the results from this paper. Option pricing theory states that an increase in volatility of the underlying asset, ceteris paribus increases the price of the call option. Since the expected pay-offs do not increase to the same extent, the expected return actually decreases. It is not uncommon in financial theory to view the equity of a company as a call option on the company's assets. If the same reasoning regarding the influence of increased volatility is followed, the expected rate of return on a company's stock would be lower when volatility of the cash flows is increased. This reasoning perfectly fits the idea that companies with either high negative or high positive exchange rate exposure are awarded a negative risk premium.

Table 5.6 **Panel A:** Coefficients of EMU for 9 size / book-to-market portfolios, from Jan 1, 1993 to Dec 31, 1997

$$(R_{it} - R_{ft})_t = \alpha + \beta_1(R_{mt} - R_{ft}) + \beta_5 EMU_t$$

	Book-to-market		
Size	Low	Medium	High
Small	*0.269*	*0.260*	0.291
	(t = 1.43)	(t = 1.58)	(t = 1.67)
Medium	0.406	*0.244*	0.397
	(t = 1.91)	(t = 1.38)	(t = 2.50)
Big	*0.022*	*0.285*	0.367
	(t = 0.11)	(t = 1.58)	(t = 2.54)

Panel B: Coefficients of EMU for 9 size / book-to-market portfolios, from Jan 1, 1998 to June 30, 2001

	Book-to-market		
Size	Low	Medium	High
Small	*0.236*	*0.234*	*-0.103*
	(t = 1.08)	(t = 1.41)	(t = - 0.53)
Medium	*0.037*	*-0.081*	*-0.126*
	(t = 0.21)	(t = - 0.52)	(t = - 0.53)
Big	*-0.176*	*-0.142*	*-0.165*
	(t = - 0.89)	(t = - 0.99)	(t = - 0.84)

Italic: not significant at the 10% level

Every year, portfolios are formed based on their size and book-to-market value. Ri is the individual security return. Rm is the return on the market portfolio MSCI World, Rf is the one-month Euribor/Fibor, EMU is the return on a portfolio of stocks with a significant foreign exchange rate exposure minus the return on a portfolio of stocks without a significant exchange rate exposure. Between brackets are the t-statistics for the corresponding coefficient.

Table 5.7 **Panel A:** Coefficients of EMU for 9 size / book-to-market portfolios, from Jan 1, 1993 to Dec 31, 1997

$$(R_i - R_f)_t = \alpha + \beta_1(R_m - R_f)_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t + \beta_5 EMU_t$$

	Book-to-market		
Size	Low	Medium	High
Small	0.310	0.283	*0.267*
	(t = 1.80)	(t = 1.73)	(t = 1.51)
Medium	0.531	0.319	0.426
	(t = 2.78)	(t = 1.86)	(t = 2.64)
Big	*0.142*	0.391	0.407
	(t = 0.73)	(t = 2.43)	(t = 2.91)

Panel B: Coefficients of EMU for 9 size / book-to-market portfolios, from Jan 1, 1998 to June 30, 2001

	Book-to-market		
Size	Low	Medium	High
Small	*-0.225*	*-0.008*	-0.413
	(t = - 1.10)	(t = - 0.04)	(t = - 2.47)
Medium	*-0.054*	*-0.137*	*-0.306*
	(t = - 0.27)	(t = - 0.80)	(t = - 1.54)
Big	*-0.124*	*-0.162*	*-0.167*
	(t = - 0.58)	(t = - 1.04)	(t = - 0.91)

Italic: not significant at the 10% level

Every year, portfolios are formed based on their size and book-to-market value. Ri is the individual security return. Rm is the return on the market portfolio MSCI World, Rf is the one-month Euribor/Fibor, SMB is the return on a portfolio of small stocks minus the return on a portfolio of big stocks, HML is the return on a portfolio stocks with a high book-to-market value, minus stocks with al low book-to-market value, WML is the return on a portfolio of past winners minus a portfolio of past losers, EMU is the return on a portfolio of stocks with a significant foreign exchange rate exposure minus the return on a portfolio of stocks without a significant exchange rate exposure. Between brackets are the t-statistics for the corresponding coefficient.

5.5 Alternative methodologies

Although the evidence on the pricing of non-linear exchange rate exposure from paragraph 5.4 is quite firm, the often weak empirical evidence concerning the significantly exposed companies could be caused by more than one factor. The lack of empirical proof so far will therefore be discussed in this paragraph.

Bartram and Bodnar (2005) investigate possible reasons for the unconvincing existence of exchange rate exposure of most firms. They come up with several possible flaws in the methodologies used in previous research. A summary of these possible methodology issues is shown in table 5.12.

Although some alterations in the research methodology compared to the 'traditional' approach as used by Adler and Dumas (1984), show better results, most of them do not appear to give a reliable explanation for the sometimes weak evidence. They conclude that the exchange rate exposure puzzle is not caused by flaws in the methodologies used in the different studies.

Bodnar and Wong (2003), Bartram and Bodnar (2005) and Bartram (2005) come up with a different solution to the puzzle. They indicate that the use of the stock return as a proxy for cash flows is, although inevitable, not without flaws and biases. One of the most important implications of the use of stock market data is that the possible hedging operations companies undertake, cannot be identified. It could therefore very well be that the lack of significant results as shown in table 5.3, is partly caused by hedging.

Bartram (2005) shows some guidelines regarding the effect of hedging, based on a single case study where internal data (regarding cash flows) of a multinational firm is used. He finds significant exposures of the operational cash flows (which are not offset by operational hedging), but no significant exposure of the total cash flow. It follows that the cash flows from financial activities within the investigated firm are opposite in sign of the cash flows from operational activities. This firm pursues an active hedging strategy to such an extent, that the influence of exchange rates on the total cash flow is not significant. Although this is a single case study, the lessons learned can be used in a broader context. Bartram therefore concludes *"(…) that managers of corporations exposed to foreign exchange rate risk are successful at reducing the exposure of their operations to such an extent that the remaining net exposures are hard to identify empirically."* (Bartram 2005, p. 19).

The influence of hedging activities seem to be a factor that cannot be ignored when studying exchange rate exposure. So although recent studies (performed after the paper of Bartram and Bodnar (2005)) and the results from this paper show that a methodology incorporating non-linear exchange rate exposure could increase the performance of asset pricing models, the influence of hedging activities could proof to be another piece of the puzzle.

Table 5.12 Alternative methodologies

Issue	Author	Problem	Presented solution	Influence of significance
Trade weighted mulitalteral exchange rate	Khoo (1994), Miller and Reuer (1998), Batram (2004)	Not representative for individual firms, leads to diversification and reducing of significance	The impact of the use of bilateral exchange rates is investigated	Not significant higher
Control variables	Booth and Rotenberg (1990), Kiymaz (2003)	The use of control variables could reduces the exposure to a "residual exposure"	Regressions with only exchange rate exposure as explanatory variable	Higher, but overestimated
Mispriced exchange rate effects	Amihud (1994), Bartov and Bodnar (1994), Bodnar (1995), Donnelly and Sheehy (1996), Walsh (1994)	Effect of exchange rate fluctuations could be lagged	Lagged exchange rates are used in the regressions	Most studies find only weak significance
Time variation of the exposure	Allayannis (1997), Allayannis abd Ihrig (2001)	Due to variation over subperiods, the exposure over the total period does not seem significant	Investigate the conditional exposure as function of economic factors	Not significantly higher
Time horizon	Bodnar and Wong (2003). Chow et al. (1997)	The significance seems to increase with longer horizons	Different time horizons are investigated	Higher, but longer horizons are not "always a feasible option"
Non-linear exchange rate exposure	Batram (2004), Koutmos and Martin (2003), Miller and Reuer (1998)	The (potentially false) assumption that exchange rate exposure is linear could explain low significance	Investigating non-linear exchange rate exposures	Higher, not impressive

6. Conclusions

Of a sample of 276 European companies, only 9% show a significant exchange rate exposure in the period between January 1, 1993 and June 30, 2001. Although this figure is quite low compared to the expectations from financial literature, it is consistent with previous empirical research. A possible explanation for this discrepancy could be the fact that most companies have a good insight in their exposure and use financial or operational hedges to reduce it to insignificant levels.

Since recent empirical evidence suggests that exchange rate exposure follows a non-linear pattern, the central hypothesis of this paper is revolves around this non-linearity. To test whether non-linear exchange rate exposure is priced, a net investment portfolio is formed with long positions in significantly exposed stocks and short positions in stocks without significant exchange rate exposure. When the return on this portfolio is added as explanatory variable (EMU) to the CAPM and to the four factor model of Carhart (1997), both models show increased explanatory power. With regard to the four factor model, the added EMU factor proofs to be significant for 7 out of 9 size / book-to-market portfolios, showing its robustness across size and book-to-market.

Because the period under investigation includes the introduction of the Euro, this unique event provides a natural test with regard to exchange rate exposure. The percentage of significantly exposed companies in the Euro-period is less than half the percentage in the pre-Euro period.

As a result of this decreased significance, the addition of the EMU factor shows almost no improvement for both investigated asset pricing models during the Euro period. This finding corresponds with the expectation that the introduction of the Euro significantly decreased exchange rate exposure for European companies.

The findings of this paper suggest that a methodology that incorporates non-linear exchange rate exposure significantly improves asset pricing models for companies that trade in an environment of (mainly) floating exchange rates.

To fully solve the discrepancy between theory and practice, more research is required however. First of all, non-linearity of exchange rate exposure should be tested over different periods and areas to further test its robustness. It is important to find out how this non-linearity develops over different periods of the macro-economic cycle.

Future research could also shed more light on the exposures of exporting and importing companies. To be able to use option pricing theory as a valid explanation for the found negative risk premium, it has to be clear that (net) importers and (net) exporters contribute equally to the lower expected return. If they do not, option pricing theory could proof to be incapable of explaining the empirical results.

Finally, more research is required regarding the influence of hedging and especially operational hedging of exchange rate exposure. More clarity regarding this topic will help to create more detailed pricing models that will be better capable of identifying the exposures companies face.

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Appendix

Table 4.3 Basket currencies

Euro countries	**Exchange rate fixed on**	**Non-euro European countries**	**Other trade partners**	
France	December 31, 1998	Bulgaria	Algeria	Mexico
Austria	December 31, 1998	Czech Republic	Argentina	Morocco
Belgium	December 31, 1998	Denmark	Australia	New Zealand
Finland	December 31, 1998	Estonia	Brazil	Norway
Germany	December 31, 1998	Hungary	Canada	Russia
Ireland	December 31, 1998	Latvia	Chile	Singapore
Italy	December 31, 1998	Lithuania	China	South Africa
Luxembourg	December 31, 1998	Poland	Croatia	South Korea
Portugal	December 31, 1998	Romania	Hong Kong	Switzerland
Spain	December 31, 1998	Sweden	Iceland	Taiwan
The Netherlands	December 31, 1998	United Kingdom	India	Thailand
			Indonesia	The Philippines
Greece	June 19, 2000		Israel	Turkey
Slovenia	July 11, 2006		Japan	United States
Malta	July 10, 2007		Malaysia	Venezuela
Cyprus	July 10, 2007			
Slovakia	July 8, 2008			

Figure 5.1 Percentage of significantly exposed firms per country.

Blue bars represent the overall period, white bars the pre-Euro period, black bars the Euro period

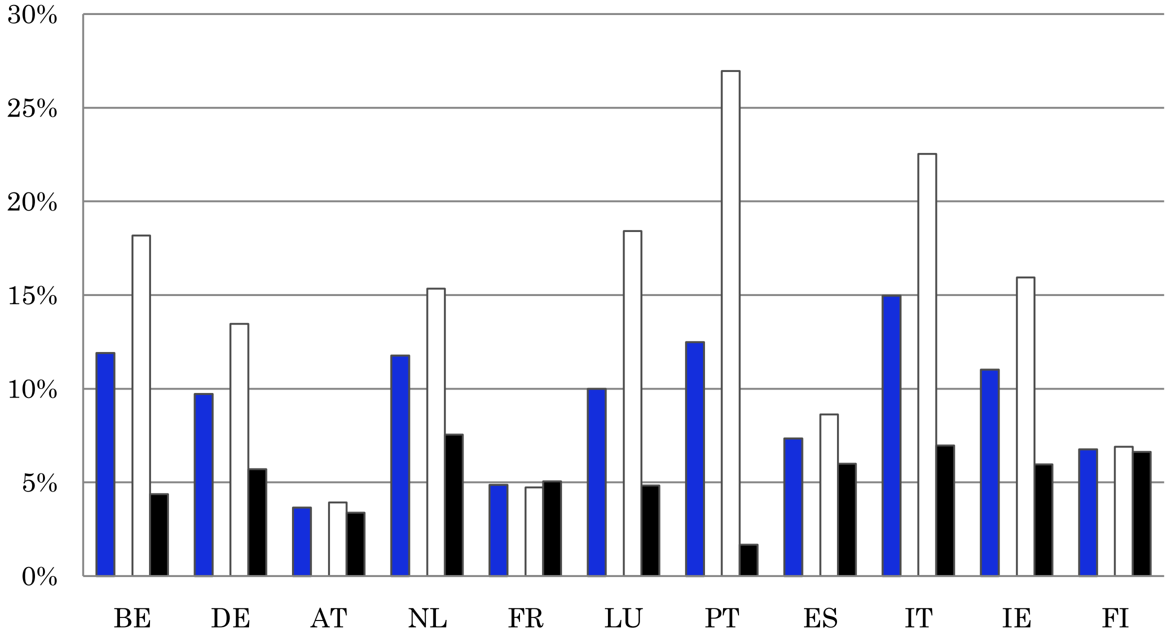

Table 5.2 Portfolios ranked on exchange rate sensitivity

Portfolio	Overall period		Pre-Euro period		Euro period	
	Significant	Return	Significant	Return	Significant	Return
1	66.1%	9.7%	67.6%	12.1%	63.8%	6.2%
2	31.7%	10.6%	37.8%	10.8%	23.1%	10.3%
3	8.3%	13.5%	12.7%	14.5%	2.1%	12.1%
4	3.0%	9.1%	5.2%	11.5%	0.0%	5.7%
5	0.6%	11.5%	1.0%	13.0%	0.0%	9.4%
6	0.4%	11.0%	0.6%	12.4%	0.0%	8.9%
7	0.0%	10.2%	0.0%	12.3%	0.0%	7.2%
8	0.0%	10.3%	0.0%	10.3%	0.0%	10.3%
9	1.3%	10.7%	2.3%	12.0%	0.0%	8.8%
10	21.9%	10.4%	25.8%	11.6%	16.3%	8.7%
Average	13.3%		15.6%		10.8%	

Over the total period (January 1, 1993 to June 30, 2001), every half year all stocks are ranked on their exchange rate sensitivity (β_5), using

$$\left(R_i - R_f\right)_t = \alpha + \beta_1\left(R_m - R_f\right)_t + \beta_5 X_t + e_{it}$$

where Ri is the individual security return. Rm is the return on the market portfolio MSCI World, Rf is the one-month Euribor/Fibor and X is the return of a basket of currencies on the home currency of company i.

The stocks are then gathered in 10 portfolios which are held for the following half year, after which they are sorted again. The returns of these portfolios and the percentage of significantly exposed companies per portfolio are depicted (using a 10% significance level).

Table 5.4 **Panel A:** Average β_5 coefficients for stocks grouped in 9 size / book-to-market portfolios from Jan 1, 1993 to Dec 31, 1997

$$(R_i - R_f)_t = \alpha + \beta_1(R_m - R_f)_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t + \beta_5 X_t + e_{it}$$

	Book-to-market		
Size	Low	Medium	High
Small	-0.684	-1.099	-0.759
Medium	-0.711	-0.979	-0.921
Big	-1.534	-1.451	-1.322

Panel B: Average β_5 coefficients for stocks grouped in 9 size / book-to-market portfolios from Jan 1, 1998 to June 30, 2001

	Book-to-market		
Size	Low	Medium	High
Small	-0.649	-0.832	-0.099
Medium	-0.575	-0.525	-0.181
Big	-1.381	-0.358	-1.295

Every year, portfolios are formed based on their size and book-to-market value. Ri is the individual security return. Rm is the return on the market portfolio MSCI World, Rf is the one-month Euribor/Fibor, SMB is the return on a portfolio of small stocks minus the return on a portfolio of big stocks, HML is the return on a portfolio stocks with a high book-to-market value, minus stocks with al low book-to-market value, WML is the return on a portfolio of past winners minus a portfolio of past losers, X is the return of a basket of currencies compared to the home currency of company i.

Table 5.9 **Panel A:** R^2 increases for 9 size / book-to-market portfolios, from Jan 1, 1993 to Dec 31, 1997, by adding EMU factor **Panel B** R^2 increases for 9 size / book-to-market portfolios, from Jan 1, 1998 to June 30, 2001, by adding EMU factor

$$(R_i - R_f)_t = \alpha + \beta_1(R_m - R_f)_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t + \beta_5 EMU_t$$

vs

$$(R_i - R_f)_t = \alpha + \beta_1(R_m - R_f)_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t$$

Panel A:

	Book-to-market		
Size	Low	Medium	High
Small	3.2%	3.4%	2.7%
Medium	8.0%	3.6%	7.0%
Big	0.6%	4.8%	6.6%

Panel B:

	Book-to-market		
Size	Low	Medium	High
Small	1.1%	0.0%	3.8%
Medium	0.1%	0.6%	1.9%
Big	0.4%	0.8%	0.6%

Every year, portfolios are formed based on their size and book-to-market value. Ri is the individual security return. Rm is the return on the market portfolio MSCI World, Rf is the one-month Euribor/Fibor, SMB is the return on a portfolio of small stocks minus the return on a portfolio of big stocks, HML is the return on a portfolio stocks with a high book-to-market value, minus stocks with al low book-to-market value, WML is the return on a portfolio of past winners minus a portfolio of past losers, EMU is the return on a portfolio of stocks with a significant foreign exchange rate exposure minus the return on a portfolio of stocks without a significant exchange rate exposure. The R improvements are measured by subtracting the R^2 of the initial four factor model from the R^2 of the five factor model (including the EMU factor).

Table 5.10 **Panel A:** R^2 increases for 9 size / book-to-market portfolios, from Jan 1, 1993 to Dec 31, 1997, by adding EMU factor

Panel B R^2 increases for 9 size / book-to-market portfolios, from Jan 1, 1998 to June 30, 2001, by adding EMU factor

$$(R_{it} - R_{ft})_t = \alpha + \beta_1(R_{mt} - R_{ft}) + \beta_5 EMU_t$$

vs

$$(R_{it} - R_{ft})_t = \alpha + \beta_1(R_{mt} - R_{ft})$$

Panel A

	Book-to-market		
Size	Low	Medium	High
Small	2.5%	2.9%	3.3%
Medium	4.8%	2.2%	6.2%
Big	0.0%	2.6%	5.6%

Panel B

	Book-to-market		
Size	Low	Medium	High
Small	1.6%	2.7%	0.3%
Medium	0.1%	0.3%	0.4%
Big	1.0%	0.8%	0.8%

Every year, portfolios are formed based on their size and book-to-market value. Ri is the individual security return. Rm is the return on the market portfolio MSCI World, Rf is the one-month Euribor/Fibor, EMU is the return on a portfolio of stocks with a significant foreign exchange rate exposure minus the return on a portfolio of stocks without a significant exchange rate exposure. The R^2 improvements are measured by subtracting the R^2 of the initial CAPM from the R of the international CAPM (including the EMU factor).

Table 5.10 Coefficients of EMU for 10 exposure portfolios, from Jan 1, 1993 to Dec 31, 1997

$$(R_{it} - R_{ft})_t = \alpha + \beta_1(R_{mt} - R_{ft}) + \beta_5 EMU_t$$

Portfolio	Jan 1, 1993 to Dec 31, 1997	Jan 1, 1998 to June 30, 2001
1	0.704 (t = 2.99)	*0.518* (t = 1.27)
2	0.574 (t = 3.0)	*0.115* (t = 0.64)
3	0.329 (t = 1.78)	*-0.077* (t = - 0.41)
4	*0.250* (t = 1.51)	*-0.163* (t = - 0.98)
5	*0.211* (t = 1.24)	*-0.201* (t = - 1.30)
6	*0.155* (t = 0.89)	*0.052* (t = 0.35)
7	*0.072* (t = 0.37)	-0.269 (t = - 1.68)
8	0.299 (t = 1.93)	*-0.176* (t = - 1.07)
9	*0.041* *(t = 0.22)*	*-0.292* (t = - 1.49)
10	0.375 (t = 1.97)	*0.088* (t = 0.44)

Italic: not significant at the 10% level

Every year, portfolios are formed based on their size and book-to-market value. Ri is the individual security return. Rm is the return on the market portfolio MSCI World, Rf is the one-month Euribor/Fibor, EMU is the return on a portfolio of stocks with a significant foreign exchange rate exposure minus the return on a portfolio of stocks without a significant exchange rate exposure. Between brackets are the t-statistics for the corresponding coefficient.

Table 5.11 Coefficients of EMU for 10 exposure portfolios, from Jan 1, 1993 to Dec 31, 1997

$$(R_i - R_f)_t = \alpha + \beta_1(R_m - R_f)_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 WML_t + \beta_5 EMU_t$$

Portfolio	Jan 1, 1993 to Dec 31, 1997	Jan 1, 1998 to June 30, 2001
1	0.735 (t = 3.05)	*-0.023* (t = - 0.06)
2	0.630 (t = 3.29)	*-0.076* (t = - 0.38)
3	0.393 (t = 2.17)	*-0.134* (t = - 0.61)
4	0.298 (t = 1.81)	*-0.153* (t = - 0.85)
5	*0.250* (t = 1.48)	*-0.170* (t = - 1.02)
6	*0.205* (t = 1.19)	*-0.019* (t = - 0.12)
7	*0.148* (t = 0.77)	-0.443 (t = - 2.70)
8	0.341 (t = 2.19)	*-0.248* (t = - 1.45)
9	*0.122* *(t = 0.70)*	-0.395 (t = - 1.85)
10	0.464 (t = 2.83)	*-0.251* (t = - 1.43)

Italic: not significant at the 10% level

Every year, portfolios are formed based on their size and book-to-market value. Ri is the individual security return. Rm is the return on the market portfolio MSCI World, Rf is the one-month Euribor/Fibor, SMB is the return on a portfolio of small stocks minus the return on a portfolio of big stocks, HML is the return on a portfolio stocks with a high book-to-market value, minus stocks with al low book-to-market value, WML is the return on a portfolio of past winners minus a portfolio of past losers, EMU is the return on a portfolio of stocks with a significant foreign exchange rate exposure minus the return on a portfolio of stocks without a significant exchange rate exposure. Between brackets are the t-statistics for the corresponding coefficient.

Figure Returns on the anomaly net investment portfolios and excess market return (monthly returns)