Exact factor pricing in a European framework

John Crombez[†], Rudi Vander Vennet[††]
Ghent University

September 2000

The authors aknowledge helpful comments from Olivier Renault, Malcolm Baker, Jan Annaert, Maria Vassalou and participants at the EFMA 2000 Conference and the EFA 2000 Conference.

[†] Ghent University. Tel.++32.9.2643514, Fax.++32.9.2648995, e-mail: john.crombez@rug.ac.be (corresponding author)
[††] Ghent University

Exact factor pricing in a European framework

Abstract

The empirical verification of one-factor and multifactor asset pricing models attempts to identify the risk factors that should be used by investors to value risky cash flows and tries to distinguish models which are able to estimate expected returns without misspecification. In this paper we evaluate different model specifications for European stock market data for the period 1979-1998 and for three subperiods of different interest rate regimes. More specifically an exact factor pricing test is used to evaluate a one-factor model and several multifactor models on European country, sector and size portfolios. We find indications that European country portfolios are accurately described by a one-factor model while for the other portfolio groupings more factors are required. The factor based on the momentum variable seems to be a better extension of the market model than the factor based on book-to-market. The multivariate tests indicate that the evaluation of the models differs across the subperiods. The power of the tests is investigated for a risk-based and a non-risk-based alternative hypothesis. The risk-based alternative using a broader formulation of the wealth portfolio produces satisfactory power. For the non-risk-based alternative the power is somewhat lower for European stock portfolios.

JEL classification: C12, G12, G15

1. Introduction

The validation of asset pricing models has been widely studied over the past 30 years. An important step in the empirical testing of the CAPM was the Roll (1977) critique. He argued that the stock market index may not be an accurate description of the total wealth portfolio. A second landmark was the development of the testing design proposed by Fama and MacBeth (1973) who suggested a two-pass estimation method to avoid the errors-in-variable problem. Gibbons (1982) proposed a direct test of the CAPM to avoid this errors-in-variable problem using maximum likelihood estimation. All these tests are designed to validate the mean-variance efficiency of the market portfolio. In addition to the development of the arbitrage pricing theory (Ross, 1976), a broad set of extensions of the one-factor model has been investigated (Basu, 1977; Banz, 1981; Chen et al., 1986). As a consequence, the testing environment of asset pricing models has been extended to multifactor models (MacKinlay, 1987; Gibbons et al. 1989, henceforth GRS). In the debate following the empirical finding of market anomalies and the assessment of the power of the suggested tests, two sets of alternative theories have been forwarded, called risk-based and non-risk-based alternatives (Campbell et al., 1997). The first set of alternatives acknowledges that there may be omitted or unobservable risk factors (Roll, 1977). The non-risk-based alternatives try to capture market inefficiencies and mention the possibility of a data-snooping bias (Lo and MacKinlay, 1990).

In this study we focus on testing the exact factor pricing properties of one-factor and multifactor models for a dataset of European stocks using a multivariate test rather than some well-known univariate tests (as in Fama and MacBeth, 1973). Previous research has pointed out a number of important issues and caveats associated with this multivariate testing environment (GRS, 1989; MacKinlay, 1987; Affleck-Graves and McDonald, 1990). This paper tries to deal with some of these issues in the evaluation of exact factor pricing in a European setting. The identification of models implying exact factor pricing is important because of their use in the calculation of the firm's cost of equity as well as for asset allocation purposes. Using models yielding inexact factor pricing can lead to misspecification of expected returns, which could have a large impact both on the estimation of the cost of equity and the investment strategies derived from an optimization procedure using these expected returns as an input.

Roll (1977 and 1978) concluded that the test of the one-factor market model is possibly not a genuine test of the CAPM because proxies for the stock market portfolio may fail to capture the true market portfolio. Recent research indicates that the misspecification of total wealth may cause biases in the description of the cross-section of stock returns. Inclusion of labor income next to capital income improves the results for the U.S. data (Jagannathan and Wang, 1996). Second, individual stocks are often grouped in portfolios to reduce measurement errors. However, the regrouping of the sample may influence the power of the tests (Roll , 1977). Moreover, Lo and MacKinlay (1990) argue that portfolio formation based on a characteristic that arises from historical observations instead of theory could lead to data snooping. A survey of results on these issues is provided by Campbell et al. (1997) who show the exact factor pricing test results for different portfolio characteristics such as market value, dividend yield, and variance. It is, however, difficult to draw firm conclusions from these results. Fama and French (1998, henceforth FF98) present results for stock portfolios in fifteen countries, but they only report findings for portfolios based on specific characteristics such as book-to-market, which makes it difficult to assess what the possible size of the data snooping bias is. They find that a two factor model (market portfolio and book-to-market ratio) has the best performance in terms of exact factor pricing.

This paper deals with both the definition of the market portfolio and the data snooping bias. First, the CAPM test is performed using a market-capitalization-weighted portfolio of all stocks in the sample. All tests are also repeated for an equally weighted market portfolio. We investigate the value added of using an alternative wealth portfolio by including labor income and the return on real estate investments, next to stock market returns. Second, the use of a previously unused dataset should allow to investigate the possibly disturbing impact of data snooping biases (see Lo and MacKinlay, 1999). In order to consider the possible data snooping that may arise when characteristics are used that were previously found to have explanatory power, we group the 2427 European stocks in three different portfolios: country portfolios, sector portfolios and size portfolios. This particular choice is made because asset allocation, as it is practiced by institutional investors, has been and is still widely being conducted using a country-based or sector-based evaluation of the universe of investable stocks. We also analyze size portfolios because it gives the opportunity to compare our findings with previous studies. Moreover, we try to avoid a selection bias by including non-surviving stocks.

A third issue in exact factor pricing analyses is the power of the performed tests. MacKinlay (1987) acknowledges that little attention has been devoted to this issue. GRS (1989) and Affleck-Graves and McDonald (1990) point out different possibilities for the formulation of the alternative hypothesis. The evaluation of the tests using different alternatives turns out to differ substantially (MacKinlay, 1987, Campbell et al., 1997). Campbell et al. (1997) classify a wide range of alternative hypotheses in two groups: risk-based (omitted risk factors) and non-risk-based (market inefficiencies). MacKinlay (1987) reports that alternative assumptions about the risk-free return and the existence of a second factor next to the market return are not sufficient to explain the deviations from exact factor pricing. He also reports that non-risk-based alternative hypotheses seems to explain these deviations in a better way. A final issue we consider in this study is the stationarity assumption (MacKinlay, 1987; GRS, 1989; Affleck-Graves and McDonald, 1990). The GRS-test requires stationarity of the excess returns in order to use an estimate of the variance-covariance matrix, and thus limits the number of time periods. We look at the 20-year window of monthly observations and three subperiods of 5 years of monthly data associated with different interest rate regimes.

The rest of the paper is organized as follows. Section 2 describes the European dataset. Section 3 presents the asset pricing equations in an international framework, develops the mutivariate tests used to evaluate exact factor pricing and discusses the main results. Section 4 deals with the power of the suggested tests. Section 5 contains a number of conclusions and suggestions for future research.

2. The data : European stocks

The dataset consists of 2459 individual European stocks, aggregated into country portfolios, sector portfolios, and size portfolios (appendix 1 explains the construction of the portfolios). We collected a basic sample containing all European stocks representing at least 80% of the market capitalization in each of 17 European countries at the last trading day of December 1998. We augmented this sample with the stocks that were delisted prior to December 1998. Common reasons for delisting are merger, acquisition and failure. The 80% market capitalization threshold is also used for the dead stocks. From this initial list, preferred stocks were deleted for those companies with both listed ordinary and preferred shares, as well as stocks listed on a stock exchange outside their home country[1]. For the remaining 2427 stocks, we retrieved the monthly returns from January 1979 until December 1998 from Datastream. This dataset is composed of 2070 stocks listed in December 1998 and 357 dead stocks. The inclusion of a subsample of dead

[1] E.g. Nokia is listed in Finland and Germany; only the returns on the Finnish Stock Exchange are used.

stocks is intended to reduce the survivorship bias. Return series are calculated as the relative changes in the return index on a monthly basis. All return series are checked for deviations from normality using quantile-quantile plots. The monthly returns cover the period January 1979 to December 1998, but the number of stocks in the sample is different every month because a number of stocks were listed later than January 1979, while others were delisted prior to December 1998.

All returns are expressed both in Deutschmark (DEM) and in synthetic Euro. The synthetic Euro is calculated for the period before the start of the EMU as a GDP-weighted average of the constituent currencies. For the analysis in Euro, the risk-free rate is calculated in a similar way. The risk free rate used in the analysis based on returns expressed in DEM is the monthly return on three-month German treasury bills. The use of two currencies allows us to investigate whether the currency of denomination influences the results. In this paper, we use the DEM because it can be considered to have played the role of anchor currency for the countries that are now part of the Eurozone, but also, e.g., Switzerland. It moreover implies that the portfolios used to perform the tests are investable, not only for German investors, but also for the investors in the countries whose currencies were linked to the DEM in the setting of the European exchange rate mechanism (ERM)[2]. The implicit assumption underlying the analysis based on returns in synthetic Euro is that the portfolios are investable by investors from the Eurozone, which is probably less realistic because it would have required extensive use of hedging techniques in the early stages of the ERM. A final reason to perform the tests for both currencies is that if the test results are found to be comparable for the DEM and the synthetic Euro series, this would imply that the conclusions will probably be relevant for future investment decisions in European stocks, which, from 1999 onwards, are all expressed in Euro.

We present a number of descriptive statistics related to the return characteristics of the different regroupings of individual stocks. Table 1 shows the difference in relative weights (in %) for the three types of stock portfolios (country, sector and size). The full names of all portfolios are listed in appendix 1. The weights are reported at three points in time : 1979, 1988 and 1998. The number of country portfolios is 12 because there were fully available samples for 12 countries, while 5 out of the 17 countries only have a small number of stocks at the starting date of the sample and are therefore excluded for reasons of stability. The number of sectors is 14, based on an industry regrouping using Financial Times indices and STOXX regroupings of industries into

[2] The data cover the period January 1979 – December 1998, from the start of the ERM to the launch of EMU.

sectors. The actual regrouping used in the paper is explained in appendix 2. The number of size portfolios is chosen to be 13 in order to obtain comparable critical F-values (choice of degrees of freedom in the neighbourhood of the other tests) for the exact factor pricing tests. As table 1 indicates, by construction, there is a large difference in capitalization across the size portfolios, while this is less the case for country and sector portfolios. Within the country portfolios, the UK has the largest capitalization, followed by Germany and France. The largest sector portfolios are banking, insurance and cyclical services. Also by construction, the size portfolios contain an equal number of stocks, while this is not the case for country and sector portfolios. Table 1 reveals that among the country portfolios, the largest changes in market capitalization are observed for France, Italy (both upwards) and Germany (downwards). In the sector portfolios, the growing sectors in terms of market capitalization are pharmaceuticals, banks, insurance, utilities and especially telecom. A downward trend is observable, e.g., for resources and chemicals, and most pronounced for cyclical consumer goods. The weights of the size portfolios are more stable over time.

[Table 1]

Table 2 presents the first two moments of the time series (of 240 monthly returns) for all types of portfolios expressed in DEM and synthetic Euro. The magnitude of both the expected returns and the standard deviations for the different portfolios is comparable for the two currencies of denomination. From table 2 it is clear that the dispersion of the returns is more or less similar for the three types of portfolios of European stocks. The dispersion of risk is somewhat larger for country and sector portfolios than for size portfolios. This could indicate that the underlying characteristics of the country and sector portfolios are more diverse than those of the size portfolios. Of the country portfolios, Italy, Sweden and Norway are the most volatile ones. Also notable is that the country portfolios exhibit a size-related effect. For some countries, the marketcap weighted return is higher than the equally weighted return (e.g., Ireland, Switzerland) while for most other countries the reverse is true. Return volatilities are more comparable across sectors. Again, a mixed size effect can be observed for sector portfolios. Marketcap weighted returns are higher than equally wieghted returns for some sectors (resources, cyclical consumer goods, pharmaceuticals) and lower for others. The volatility of returns is comparable across size portfolios.

The incidence of the size effect (Banz, 1981) in European stock returns is ambiguous. If any effect can be detected in the lower panel of table 2, it seems to be restricted to the relatively small stocks. The post-formation returns of the size portfolios decrease from S1 to S8, where the lowest return is recorded for the market-capitalization weighted returns expressed in DEM. The portfolio of very large stocks (S13, which represents approximately 55% of the total market capitalization), however, exhibits a higher return than the 7 preceding size-ranked portfolios. Fama and French (1992) performed a two-way sorting of their sample of assets with size as the first sorting variable and the book-to-market ratio as the second. They find that the post-formation returns are not linear with respect to size and that the size effect can largely be explained by differences in market risk, the smallest size portfolios exhibiting the largest market beta and vice versa. Moreover, they conclude that the book-to-market effect dominates any size effect. The evidence in table 2 suggests that the size effect is disappearing in European stock markets, which would confirm US studies (see Jegadeesh and Titman, 1999). Looking at the stationarity of the book-to-market factor and the momentum factor (described below) and the small minus big size spread (as the difference between the small stock portfolio and the large cap portfolio, appendix 1) we observe that for the last 5 years of the data the size spread is insignificant (0.08 for DEM), again confirming the US findings. Consequently, we will not include the monthly size-related return spread (the 'small minus big' factor in FF) as an explanatory variable in the multifactor models. Instead, when we examine the ability of a multifactor model to describe the behavior of European stock returns we prefer to include momentum as an additional factor, next to the market and the book-to-market factors. The motivation is that Jegadeesh and Titman (1999) document that the empirical findings strongly support the existence of a momentum effect which persists in the 1990s in the US stock markets. The same is found by Rouwenhorst (1998) for European data.

[Table 2]

Hence, we use combinations of three possible factor portfolios in our empirical investigation. The first factor is a long position in the marketcap-weighted average of all stocks relative to a short position in a risk free investment. This factor is the CAPM market factor (M-F). Table 3 shows that the market portfolio expressed in synthetic Euro has a higher average return than the portfolio in DEM. The estimated market premium, however, is comparable for the two currencies. The second factor is the BTM factor made popular by Fama and French (1992, 1993, 1996). The book value of a company is defined as the value of equity capital plus reserves minus total intangibles[3]. The return differential consists of a long position in the 30% highest BTM stocks minus a short position in the 30% lowest BTM stocks (HML, as in Fama and French, 1996). All available stocks in December of the year t-1 are ranked according to their BTM value at the last trading day of December t-1. In most studies the subsequent return analysis covers the period July t to June t+1 in order to ensure that reported book values are known by investors. However, we prefer to perform the return analysis for the period January to December of year t because this treatment increases the number of stocks included in the estimations, especially in the beginning of the sample period. A value-weighted monthly HML return is calculated for the 12 months of year t[4]. Starting the first ranking in December 1978 and ending the ranking in December 1997 produces a time series of monthly returns from January 1979 until December 1998, both for the synthetic Euro and the DEM sample.

The third factor portfolio is based on the individual stock's momentum (Jegadeesh and Titman, 1993 and 1999). The factor LMOM is calculated as the return differential of a long position in the 25% stocks with the lowest six-month trailing return ('losers') minus a short position in the portfolio containing 25% of the stocks with the highest previous six-month performance ('winners')[5]. All stocks with data available from t-6 months to t-1 month are ranked at the end of t-1 (as in Jegadeesh and Titman, 1993, 1999 and Rouwenhorst, 1998). The parameter used to perform the ranking is the 6-month local momentum, which is the six-month cumulative stock return minus the six month home market return. The momentum portfolio rebalancing is performed on a monthly basis and the return differential is calculated as a difference between two equally weighted portfolios. Table 3 shows the averages and standard deviations for the three factors. The return premia associated with the factors is similar for DEM and Euro. Since the cross-correlations between the factors are relatively low, they are assumed not to cause any estimation problems.

[Table 3]

---

[3] Since we use book-to-market ratios of companies headquartered in different countries, differences in accounting standards could influence the rankings. For that reason, we re-rank all stocks after substracting the mean BTM ratio of their home country. We find that the average rank correlation between the original series and the deviations from the country mean is 0.9001 (with a low of .7779 and a high of .9636), indicating that difference in accounting standards should not have a large impact on the calculation of the BTM portfolios (see also Lewellen, 1999).

[4] We checked the robustness of the results for this treatment by comparing the estimation results for the common method of calculation (BTM ranking in December t-1 and returns from July t to June t+1) and our approach (BTM ranking in December t-1 and returns from January to December of year t). In the 39 DEM regressions for the two-factor model including HML, the alphas were indistinguishable and the average correlation of the residuals of the regressions is 0.9903. (tables are available at request). This supports the hypothesis that book values are well knows to stock analysts. Moreover, it is consistent with the finding by Fama and French (1995) that BTM ratios exhibit a high degree of persistence over time.

[5] As in Rouwenhorst (1998) we use quartile instead of decile portfolios in order to ensure that the portfolios contain a sufficient number of stocks, especially in the beginning of the sample period.

3. *The pricing framework*

The main focus of this paper is to test the relative efficiency of the following asset pricing kernels in a European setting : an international CAPM, a two-factor ICAPM and a three-factor ICAPM. Although there is some evidence that exchange rate risk is priced (Dumas and Solnik, 1995), it is a reasonable assumption that the exchange risk is negligible in stock returns across the Eurozone. Moreover, there is empirical evidence that factor loadings on international risk factors may vary through time (Ferson and Harvey, 1993). In order to restrict the dimensions of the pricing models, we assume the absence of time-variation in both the factor loadings and the risk premia. For the three types of portfolios the performance of the pricing models is evaluated by means of the Gibbons-Ross-Shanken (GRS 1989) multivariate test. A pricing model should be able to model the dynamics of any stock or portfolio return, but the overview in Campbell et al. (1997, p.241) indicates that this is not always the case. Hence, we test the accuracy of different pricing models on three kinds of portfolio regroupings.

3.1. The ICAPM

When testing the international CAPM, the stock returns are explained by their exposure to a global market portfolio. The global market portfolio used here is the market-capitalization weighted portfolio of all stocks in the sample listed at the beginning of the month as well as at the end of the month in which the return is calculated. We estimate the sensitivity of the excess portfolio return (R-F) to the excess return of the market index (M-F), as expressed by equation 3.1.1.

$$R ? F ? ? ? ? *(M ? F) ? ? \qquad 3.1.1$$

To test whether this pricing equation accurately describes the cross-section of the returns of the three types of portfolios, we test whether the vector of ?'s is multivariate zero. The multivariate test is described in appendix 3 The test statistic J (equation 3.1.2) has a central F-distribution with degrees of freedom N and T-N-k under the null hypothesis (see GRS, 1989 ; MacKinlay, 1987 ; Affleck-Graves and Mc Donald, 1990 and Campbell et al., 1997). The test statistic in 3.1.2 is a generalization for multifactor models. In this test, T is the number of periods of the time series (here 60 for 5 years of monthly data or 240 for 20 years), N is the number of portfolios and k is the number of independent factors. The test has an F-distribution with a non-centrality parameter (λ, equation 3.1.3) which equals zero under the null hypothesis (expression 3.1.4). By formulating an alternative hypothesis based on one of the components of the test statistic, we evaluate the power of the test. These components can be risk-based or non-risk-based which means that the power is either evaluated based on the risk factors used or based on the stability of the estimations, i.e. the alphas or the variance-covariance matrix of the residuals (see section 4).

$$J = \frac{T - N - k}{N} * \left[1 + \hat{\mu}_k' \hat{\Omega}_k^{-1} \hat{\mu}_k\right]^{-1} * \hat{\alpha}' \hat{\Sigma}^{-1} \hat{\alpha} \qquad 3.1.2$$

$$\lambda = T * \left[1 + \hat{\mu}_k' \hat{\Omega}_k^{-1} \hat{\mu}_k\right]^{-1} * \hat{\alpha}' \hat{\Sigma}^{-1} \hat{\alpha} \qquad 3.1.3$$

$$J \sim F_{N, T-N-k}(\lambda) \qquad 3.1.4$$

The components of the test-statistic derived from the pricing equations are : α the (N*1) vector of asset return intercepts, Σ the (N*N) variance-covariance matrix of disturbances, μ_k the (k*1) vector of means of the factor portfolios and Ω_k the variance-covariance matrix of factor portfolio returns. GRS (1989) provide a geometric interpretation of the test as expressed in equation 3.1.5. The interpretation is that the test statistic J evaluates exact factor pricing by comparing the squared Sharpe ratio of the portfolio of risk factors (sr_m) with that of the tangency portfolio (sr_t). The alternative hypothesis assumes that the portfolio of factors is not the tangency portfolio. In equation 3.1.5 we use the Sharpe ratio of the global market portfolio. It is important to note that J is an increasing function of the difference between the squared Sharpe ratios of the tangency portfolio and the portfolio of factors.

$$J = \frac{T - N - k}{N} \left(\frac{sr_t^2 - sr_m^2}{1 + sr_m^2} \right) \qquad 3.1.5$$

Tables 4a, 4b and 4c present the estimation results for the one-factor pricing model 3.1.1 (left panel of each table). In order to determine exact factor pricing, we are interested in the behavior of the vector of estimated constants in the regression. For the one-factor model applied to country portfolios, table 4a shows that the alphas are small and always insignificant. For sector portfolios (table 4b), the alphas are small, although significant for the basic materials and technology stocks. In the case of size portfolios (table 4c) we notice that there is a pattern both in the size and the significance of the estimated constants. The smallest size portfolios (S1, S2 and S3) exhibit a positive and significant alpha. The one but last portfolio (S12) has a significantly negative alpha. The pattern in the alphas coincides with the previously mentioned size effect (see table 2).

[Tables 4a,b,c]

Since the estimated alphas cannot be used to assess the exact factor pricing abilities of the tested pricing equations in a multivariate setting, we report the GRS J-statistics. All estimations and calculations are done for the entire period (20 years of monthly data) as well as for three subperiods. We selected three five-year subperiods corresponding with a different interest rate regime. Previous empirical work has documented that asset pricing models behave differently in varying monetary, and hence interest rate, regimes (Jensen et al, 1996). Consequently, we perform all tests for the entire sample period and (1) a period of stable risk-free rates (1983 :01 to 1987 :12), (2) a period of rising interest rates (1988 :01 to 1992 :12), and (3) a period of decreasing interest rates in the run-up to EMU (1994 :01 to 1998 :12) ; in each subperiod T=60 months. A graphical justification for the choice of these three subperiods is given in appendix 4 where both the short term interest rate for the DEM and the synthetic Euro are displayed.

Table 5 reports the results of the exact factor pricing tests for the country, sector and size portfolios and both currencies of denomination. The GRS-statistic ? is the estimated non-centrality parameter for the one-factor market model. The F-statistic and its associated p-value are calculated from equation 3.1.2. For country portfolios the ICAPM appears to provide an accurate description of the pricing dynamics. The non-centrality parameter for country portfolio is not statistically different from zero in the full sample and the three subperiods, irrespective of the currency of denomination. All p-values for the F-test are much larger than 5%. This implies that the null hypothesis of a multivariate zero alpha vector cannot be rejected and that a one-factor European market model captures the pricing of country stock portfolios. The calculated confidence interval of the estimated alphas for country portfolios ranges from -29 basis points to 39 basis points. By contrast, for sector portfolios the null hypothesis of a zero ? -vector is rejected for the full sample period (p -values for the F-test of 0.3% for the returns expressed in

DEM and 2.6% for the synthetic euro portfolios). This would imply a rejection of the ICAPM as a relevant model for the pricing of European sector portfolios. However, when the subperiods of different interest rate regimes are considered, the p-values are generally higher and do not allow strong inferences about exact factor pricing. The p-values are lowest in the period of rising interest rates (around 10%) and highest in the period of stable interest rates (maximum value of 31.5% for returns expressed in DEM). The strongest indication of non-acceptance of exact factor pricing based on the ICAPM is found for the size portfolios. The p-values are below 5% for the full sample period and for the subperiods of rising and decreasing interest rates. A rejection is not appropriate only for the subperiod characterized by a stable risk-free rate (p-values of 13.3% for the DEM and 18.2% for the synthetic euro). For both the sector and size portfolio, the confidence interval for the ? -vector ranges from -50 to 50 basis points.

[Table 5]

3.2. *Multifactor models*

The ICAPM can be augmented by assuming that the fraction of the portfolio returns which is not captured by the global market portfolio is priced by additional global multifactor minimum-variance (MMV) portfolios (Fama and French, 1996). Similarly, the generalized CAPM initiated by Merton (1973) suggests that investors are concerned about state variable risk next to the mean and variance of their portfolio returns. Following Fama and French (1996 and 1998) the return differentials on two MMV portfolios are added to equation 3.1.1 in order to explain the expected portfolio returns. The construction of the long-short strategy of return differences for the two additional factors (book-to-market and local momentum) was described in section 2. All assets in the European sample are ranked according to the relevant parameter (BTM and LMOM). As in Fama and French (1996) we assume that the low BTM, the high BTM, the local losers and the local winners portfolios are MMV. A combination of the one-factor market model and the two additional mimicking factor portfolios leads to the construction of the models described in equations 3.2.1, 3.2.2 and 3.2.3. The testable hypothesis is that the vectors of estimated intercepts is zero. The correlations between the three factor portfolios (table 3) is relatively low, hence we expect that their combination causes no particular estimation problems.

$$R\ ?\ F\ ?\ ?\ ?\ ?\ *\ (M\ ?\ F\ )\ ?\ ?\ *\ HML\ ?\ ? \qquad 3.2.1$$

$$R\ ?\ F\ ?\ ?\ ?\ ?\ *\ (M\ ?\ F\ )\ ?\ ?\ *\ LMOM\ ?\ ? \qquad 3.2.2$$

$$R\ ?\ F\ ?\ ?\ ?\ ?\ *\ (M\ ?\ F\ )\ ?\ ?\ *\ HML\ ?\ ?\ *\ LMOM\ ?\ ? \qquad 3.2.3$$

The right hand panels of tables 4a, 4b and 4c show the estimation results for the three augmented equations. For country portfolios (table 4a), the findings for the vector of alphas is very similar to those based on equation 3.1.1 (left panel). None of the estimated country alphas is significant at conventional levels. An interesting observation is that the HML factor is univariate significant for almost all countries (except for Austria and the UK), while the momentum factor is generally insignificant. For sector portfolios (table 4b), adding the non-market factors does not change the univariate interpretation of the alphas; they are only significant for the basic materials and technology stocks. Again we observe that the HML factor explains some of the variance of the individual portfolio returns (except for cyclical consumer goods, cyclical services and telecom). For size portfolios, the inclusion of the two additional factors has an ambiguous effect on the univariate significance of the alphas. When only the HML factor is included, next to the market portfolio, only the ? of S1 and some of the large-size portfolios are significant. When the LMOM factor is added, on the other hand, the pattern of significance observed in the results for the market model (left panel) is preserved (? is significant for the smallest size portfolios and S12). Interestingly, the local momentum variable seems to explain more of the variance of size portfolio returns than for the other portfolio regroupings. However, one has to bear in mind that the univariate interpretation of the test statistics does not provide information about of the changes in the estimated variance-covariance matrix of residuals when factors are added. This shortcoming is remedied by using the multivariate test statistics described in 3.1.

The results of the exact factor pricing tests for the extended models are reported in table 6 (DEM) and table 7 (synthetic euro). Comparing table 6 with table 5, it is clear that the inclusion of extra factors based on BTM and momentum does not improve the explanation of the returns of country portfolios over the full sample period. The p-values for the estimation of the two and three-factor models for the country portfolio returns expressed in DEM range from 0.08 to 0.51 (left panels A, B and C of table 6) compared to 0.47 for the one-factor model (left panel A of table 5). For the results over the whole sample period expressed in synthetic Euro, the p-values are even more elevated (between 0.84 and 0.94). The non-centrality parameter ? moves further away from zero when the HML factors is included in the DEM specification, it remains unaltered when LMOM is added, while the ? found for the single-factor model is unchanged for all multifactor models expressed in synthetic Euro (table 7 versus panel B of table 5). Moreover, the confidence interval for the estimated country alphas increases to [-40, 40] basis points. These findings indicate that the addition of extra factors does not improve the pricing of country portfolios based on a simple one-factor market model. These results hold for the three subperiods covering varying interest rate regimes.

The picture is partially different for the sector and size portfolios. For the entire period 1979-1998 and returns expressed in DEM as well as in Euro, the two and three-factor models which include the book-to-market factor can be rejected based on the p-values. In most cases, the non-centrality parameter ? does not move closer to zero, indicating the absence of exact factor pricing. The only exception is the case of the two-factor specification for sector portfolios in Euro including the momentum effect, where the augmented model cannot be rejected at conventional levels (p-value 0.12). However, the explanation of the cross-sectional returns of the sector and size portfolios varies across the different interest rate regimes. Table 6 shows that the p-values for the multifactor models applied to the sector portfolios over the three subperiods are on average higher than the corresponding p-values in panel A of table 5. The most pronounced effect is the two-factor sector model with momentum as the additional factor, which yields a p-value of 0.25 compared with 0.08 for the single-factor model. For the sector portfolios, the two and three-factor models which contain the book-to-market variable add little or no value to the single-factor model. In the subperiod 1998-1992, the two-factor model including the book-to-market factor can even be rejected at better than the 5% level. In the subperiods of both stable and decreasing interest rates, the multifactor models for the sector returns cannot be rejected. The results based on the synthetic Euro specification confirm the DEM findings. For the size portfolios, the performance of the multifactor models is reasonable in the period 1983-1987 (stable interest rates), with p-values in table 6 being consistently higher than in table 5 for the single-factor model. However, the augmented models perform badly in the subperiod of declining interest rates (1994-1998), since all models can be rejected at the 10% level. Hence, our empirical exercise reveals that looking at the univariate test statistics does not always yield sufficient information to assess the degree of misspecification of the model in a cross-sectional framework. For example, for sector portfolios, the HML factor seems to provide additional explanatory power for the return series (based on univariate t-statistics and R^2 in table 4b), but it turns out to be the local momentum factor which reduces the level of cross-sectional misspecification.

[Table 6 and 7]

Based on the reported findings, we conclude that the returns on European country portfolios are fairly accurately described by their sensitivity to a broad market portfolio. Additional factors add little or no value. A somewhat surprising indication is that the widely used BTM factor does not seem to improve the exact factor pricing of the return structure of European portfolios in general. The inclusion of additional MMV factors causes an upward shift in the p-values away from rejection only in some cases for sector or size portfolios. Moreover, we find that the momentum factor seems to be more important for exact factor pricing in general than the book-to-market factor, which is usually found to add explanatory power based on the univariate tests. The results do not allow us to conclude that the pricing dynamics of European stock portfolios systematically differs across the different short-term interest rate regimes. However, the finding that in the overall period the null hypothesis of an overall zero alpha vector can be strongly rejected for some specifications, while that is not the case in various subperiods, could indicate that the factor loadings and the pricing dynamics shift over time. Under this interpretation, factor loadings or risk premia could be time-varying. We proceed with an analysis of the power of the reported tests.

4. The power of the exact factor pricing tests

In testing the correct specification of a model, the test can be very dependent on assumptions and data. That is why, next to the test itself, it is important to carefully consider the alternative hypothesis in order to evaluate the power of the test. MacKinlay (1987) provides an overview of some of the relevant issues associated with the specifiction of the alternative hypothesis. As previously mentioned, the regrouping of individual stocks into portfolios could alleviate potential estimation errors and may be necessary in some cases to lower the number of parameters to be estimated. Affleck-Graves and McDonald (1990) argue that the disaggregation of the portfolios into individual assets adds little to the efficiency of the test. However, they note that a lot of the characteristics of the individual assets are lost when regrouping and possible deviations from the null could be left unnoticed. Their first argument conflicts with the GRS (1989) finding that a low ratio of N/T yields little power. In addition to the finding that the number of assets or portfolios is not very important, MacKinlay finds evidence that the power increases with the length of the time period used to perform the test (MacKinlay, 1987). The reason is that, at a given significance level, the accuracy of the estimation of the residual covariance matrix increases. Moreover, Affleck-Graves and McDonald (1990) argue that the power of a diagonal statistic (i.e., under the assumption that the residual covariance matrix is diagonal) is higher than a multivariate statistic.

4.1. A risk-based evaluation

These are, among others, important considerations when testing the exact factor pricing of a given theoretical model. One possible alternative hypothesis we consider is that the market portfolio is unobservable or incorrect (see Roll, 1977). In most of the asset pricing literature an equally weighted or market-capitalization weighted sum of returns of all shares is used as the market proxy. However, Jagannathan and Wang (1996) argue that stocks are only a minor, although growing, part of the national wealth and, hence, stock index returns would only proxy for total wealth if the correlation with the total wealth portfolio were perfect. Consequently, in a first test of the power of exact factor pricing, we use a different specification for the market proxy as the alternative hypothesis. We refer to this test as a risk-based test. Although we do not add an additional factor to the model, we use a time-varying linear combination of different wealth components to assess the power. In other words, we use a different specification of the market risk factor. Assuming that total wealth is not perfectly correlated with the global market portfolio of stocks, we calculate a weighted return portfolio which is intended to be a better proxy for the true wealth portfolio. The constructed portfolio contains both capital income and labor income. For each of the countries in the sample the percentages of labor and capital income in total income are calculated from the national accounts data in order to construct the average yearly weights for both types of wealth. The weight of capital income varies from 31.9% in 1979 to 37.9% in 1998. We further divide the capital income portfolio in two components, 75% is assumed to be related to stock dividends and 25% consists of real estate returns calculated from the Datastream real estate price index for the European Union. The labor income portfolio is specified as in Jagannathan and Wang (1996).

4.2. A non-risk-based evaluation

The distribution of the non-risk-based alternatives is specified by the elements of 3.1. We use the variance-covariance matrix from equations 1 to 4 as well as the squared Sharpe ratios from equation 1 to 4. Several other studies (as mentioned in Campbell et al., 1997) assume the latter to be zero. In the case of multifactor models we find it more appropriate to use the estimated value of $?'_{k}?_{k}^{-1}?_{k}$. In the non-risk-based test we specify values for the intercepts. The assumption that the vector ? is normally distributed remains. We take the value for the standard deviation to be 0.002 which seems a reasonable number for European data. A value of 20 basis points is higher than the 10 basis points suggested by Campbell et al. (1997) but they acknowledge that their assumption is somewhat conservative. Moreover, 95% of the deviations will be situated between -.004 and +.004 which is close to the estimated values reported in table 4. For each evaluation of the power under the assumption of a non-risk-based alternative, we randomly draw 100 vectors of N alphas from the specified distribution and use the mean of the power under the non-central F-distributions as the power for this test. The mean and standard deviation of the estimated non-centrality parameters are also reported.

4.3. The results

In table 8, the power of the tests for the various pricing models applied to country portfolios is presented. For the whole sample period 1979-1998, the power of the test is relatively high both for the risk-based and the non-risk-based alternative hypotheses, ranging from approximately 40% (the risk-based alternative in DEM) to more than 80% (the risk-based alternative for the Euro sample). Overall, the conclusions of the power evaluation are comparable for the two currencies, especially for the non-risk-based analysis. In the subperiods, the power of the multivariate test varies across the different interest rate regimes. The risk-based alternative (probabilities between 0.261 and 0.701) turns out to yield more power than the non-risk-based alternatives (from 0.161 to 0.811). Overall, the power of the tests seems reasonable and indicates that accepting the null hypothesis of exact factor pricing for country portfolios is plausible in most cases.

[Table 8]

For size and sector portfolios, the story is somewhat different. The power of rejecting the null, given the alternative hypothesis is relatively high. The p-values for the entire period are above 90% for both portfolio groupings and for the different factor models and are even close to 1 for the risk-based alternative for size portfolios. Overall, the number of factors in the model does not seem to have much influence on the power of the test in a given period. Somewhat lower power (p-values from +/-0.350) is found for multivariate tests with sector portfolios in the subperiods, while this is not the case for size portfolios. The high power of the tests for size portfolios indicates that the rejection of exact factor pricing of size portfolios is fairly robust. At the same time, the non-rejection of exact factor pricing in specific subperiods for the corresponding portfolio types raises the question what factors cause these differences. It is very well possible that the assumption of constant loadings and risk premia is weaker for these types of portfolios than for country portfolios, which are geometrically closer to the global market portfolio. This again illustrates that the portfolios which are close to the market portfolio (here country portfolios) are generally found to be fairly priced in terms of squared Sharpe ratios, but it is often more difficult to distinguish them from the alternative hypothesis.

[Table 9 and 10]

Overall these results indicate that the multivariate tests possess a relatively high degree of power. Our findings differ from what other research pointed out in the past (MacKinlay, 1987, Affleck-Graves and McDonald, 1990), especially for the risk-based alternative. But the most important conclusion remains that the pricing is different for different portfolio types and, hence, that the portfolio formation characteristics may influence the results.

5. Conclusions

This paper attempts to evaluate the exact factor pricing proporties of single-factor and multifactor asset pricing models for a large European sample of stocks in a multivariate setting. The analysis is explicitly designed to avoid to a maximum degree the possibly disturbing influences of data snooping, survival bias and model misspecification. The data set is hitherto unexplored. Particular attention is devoted to the testing framework, the specification of the alternative hypothesis and the power of the tests. For country portfolios, the results indicate that the cross-section of returns is accurately described by the one-factor market model. Sector and size portfolios seem to be priced by more than one factor. The results of this paper indicate that the factor portfolio based on the momentum effect performs better as an additional risk factor for European stock data than the factor portfolio based on the book-to-market effect.. Since the results are similar for the specifications in DEM and in synthetic Euro, European investors can rely on previous insights to guide their investment decisions in the Eurozone.

The ability of the pre-specified risk factors to price stock portfolios varies across different interest rate regimes. For some portfolio types, the cross-section of returns is well described in a stable interest rate environment, while the same model does not yield an accurate pricing in other subperiods. This could indicate that risk premia may be time-varying for some types of portfolios (e.g., here size portfolios) and much less for others (here, country portfolios). This finding also stresses the need to use a sufficiently long time period to investigate the pricing performance of various models. In this paper the results based on the full 20-year period exhibit the highest degree of stability. Power evaluations are important in the assessment of exact factor pricing. Previous research has generally shown weaker power for the risk-based alternative. In this paper, a different specification of the market portfolio, including both labor income and capital income, was found to be a good alternative. The non-risk-based alternative hypothesis produces somewhat weaker power.

APPENDIX 1 : Identification of the portfolio types.

Country portfolios included

AUS = Austria
BEL = Belgium
FRA = France
GER = Germany
IRE = Ireland
ITA = Italy
NET = Netherlands
DEN = Denmark
NOR = Norway
SWE = Sweden
SWI = Switzerland
UK = United Kingdom

Countries for which no country portfolio could be constructed

POR = Portugal
SPA = Spain
LUX = Luxemburg
GRE = Greece
FIN = Finland

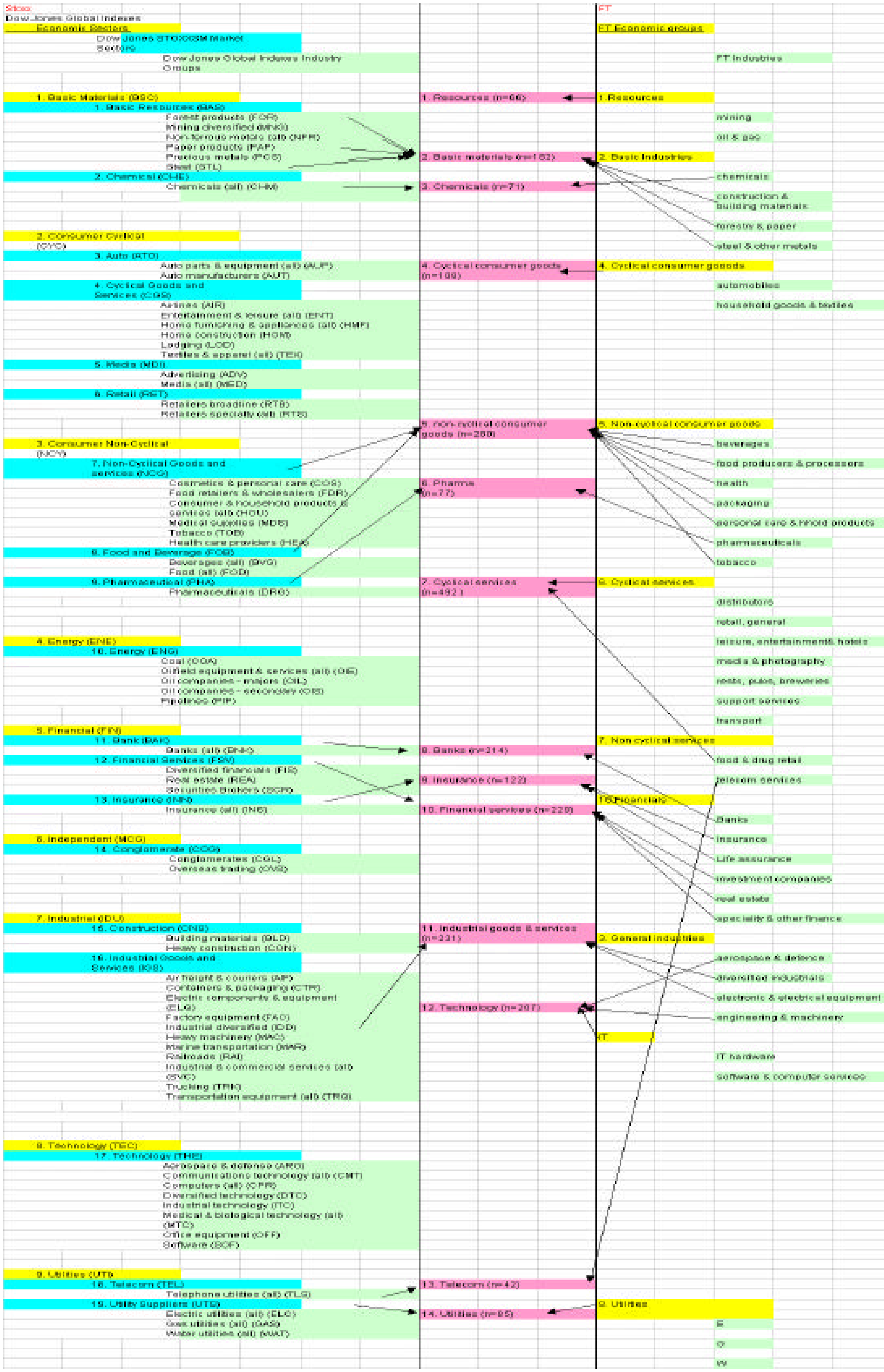
Sector portfolios

Reso = resources
Bmat = basic materials
Chem = chemicals
Cycc = cyclical consumer goods
Ncyc = non-cyclical consumer goods
Phar = pharma
Cycs = cyclical services
Bank = banks
Insu = insurances
Fina = financial services
Indu = industrials
Tech = technology
Tele =telecom
Util = utilities

Size portfolios

S1 = small size, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13= large size

APPENDIX 2. Construction of the sector portfolios based on the Financial Times and STOXX industries.



APPENDIX 3 The GRS test

From a general factor model:
With i = the number of factors in the model.

$$R ? F ? ? ? \underset{i}{?} ?_i F_i ? ?$$

If a portfolio is mean-variance efficient, the following first-order condition must hold:

$$E(R ? F) ? \underset{i}{?} ?_i E(F_i)$$

From this follows a null hypothesis that contains the parameter restriction:

$$H_0 : ? ? 0$$

Where ? is the cross-sectional vector of intercepts for N portfolios or assets.

APPENDIX 4: Short term interest rates in DEM and synthetic EURO for the period 01-1979 : 12-1998.

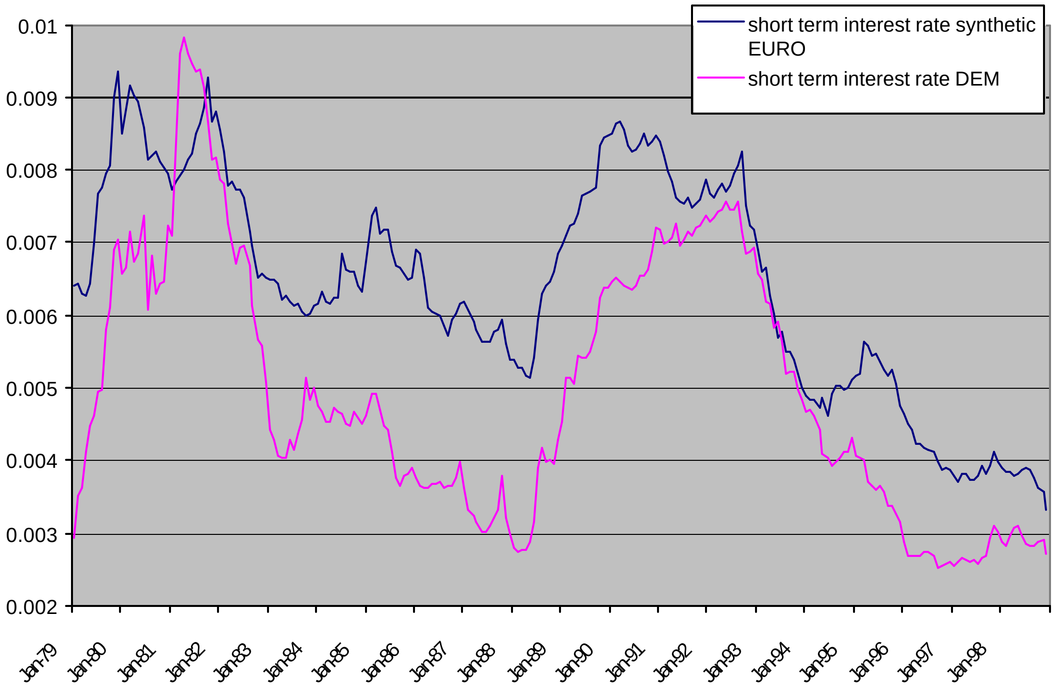


Table 1.

Relative weights in the country, sector and size portfolios

The weights for the three types of portfolios are calculated as the percentage of capitalization represented by the portfolio relative to the total sampe capitalization. Weights are reported at three different time periods : the first year of the sample (December 1979), at the middle of the sample (December 1988) and at the end of the sample (December 1998). In panel A country portfolio weights are reported, sector portfolio weights appear in panel B and size portfolio weights in panel C.

Panel A

		AUS	BEL	FRA	GER	IRE	ITA	NET	DEN	NOR	SWE	SWI	UK		
Country	12-1979	1.0	2.8	7.7	20.4	0.5	2.0	9.1	0.9	0.7	7.4	9.4	38.2		
	12-1988	2.2	3.2	8.3	13.2	0.5	7.3	6.9	1.0	0.6	2.4	6.5	41.6		
	12-1998	0.5	3.1	12.5	14.9	0.9	6.6	8.5	1.2	0.7	3.7	10.1	29.3		
Panel B															
		Reso	Bmat	Chem	Cycc	Ncyc	Phar	Cycs	Bank	Insu	Fina	Indu	Tech	Tele	Util
Sector	12-1979	10.9	4.0	6.4	13.4	9.3	5.2	9.6	11.9	6.1	4.9	9.4	6.0	0.3	2.6
	12-1988	8.8	3.9	5.3	4.2	11.6	5.7	14.3	12.2	9.2	5.0	7.8	5.5	3.7	2.8
	12-1998	6.6	2.6	2.8	3.7	8.7	8.4	11.8	15.8	11.0	3.2	7.7	5.0	8.5	4.4
PanelC															
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	
Size	12-1979	0.1	0.2	0.4	0.7	1.1	1.6	2.1	2.9	4.2	5.8	8.8	15.3	56.7	
	12-1988	0.1	0.4	0.6	0.9	1.3	1.7	2.3	3.2	4.4	6.2	9.2	16.9	52.8	
	12-1998	0.1	0.4	0.5	0.8	1.0	1.3	1.8	2.3	3.2	4.6	7.8	15.0	61.1	

Note : the country portfolio weights do not sum to one because all weights are relative to the total sample market capitalization and there are 17 countries in the sample and only 12 reported here because of missing values in the remaining 5 coun tries.

Table 2

Average return and risk for European stock portfolios from January 1979 to December 1998.

All average returns and standard deviations are reported in % for the country, sector and size portfolios. The standard deviations are the numbers in italic below the returns. All numbers are calculated for market-capitalization (MCAP) and equally (EW) weighted portfolios. The values are reported for the synthetic Euro (EURO) and the Deutschmark (DEM) as the currency of denomination.

		AUS	*BEL*	*FRA*	*GER*	*IRE*	*ITA*	*NET*	*DEN*	*NOR*	*SWE*	*SWI*	*UK*
EURO	MCAP	0.78	1.21	1.14	0.96	1.27	1.16	1.42	1.18	1.19	1.64	1.19	1.30
		4.82	*5.17*	*6.01*	*5.01*	*6.27*	*7.17*	*4.63*	*4.93*	*8.41*	*7.60*	*4.86*	*5.63*
	EW	1.05	1.39	1.28	0.89	1.19	1.31	1.37	1.30	1.31	1.63	0.78	1.41
		4.75	*4.96*	*5.98*	*4.52*	*5.71*	*7.41*	*4.62*	*4.89*	*8.01*	*7.54*	*4.22*	*5.77*
DEM	MCAP	0.68	1.04	0.97	0.78	1.10	1.03	1.27	0.99	1.01	1.47	1.02	1.14
		4.91	*5.23*	*6.09*	*5.02*	*6.41*	*7.46*	*4.67*	*5.09*	*8.50*	*7.78*	*4.89*	*5.83*
	EW	0.87	1.20	1.11	0.73	1.02	1.13	1.19	1.09	1.09	1.45	0.61	1.24
		4.73	*5.01*	*6.07*	*4.56*	*5.85*	*7.61*	*4.64*	*4.92*	*8.04*	*7.71*	*4.23*	*5.96*

		Reso	*Bmat*	*Chem*	*Cycc*	*Ncyc*	*Phar*	*Cycs*	*Bank*	*Insu*	*Fina*	*Indu*	*Tech*	*Tele*	*Util*
EURO	MCAP	1.39	0.70	1.07	1.18	1.35	1.53	1.10	1.04	1.36	1.11	0.99	0.84	1.22	1.17
		6.04	*5.15*	*4.83*	*6.29*	*4.58*	*5.10*	*5.18*	*5.08*	*5.21*	*4.70*	*4.96*	*5.27*	*6.04*	*3.73*
	EW	1.19	1.02	1.20	1.01	1.30	1.38	1.33	1.19	1.44	1.33	1.06	1.04	1.38	1.27
		6.06	*5.27*	*4.86*	*4.81*	*4.03*	*4.37*	*4.65*	*4.03*	*4.71*	*4.98*	*4.48*	*5.06*	*5.55*	*3.25*
DEM	MCAP	1.22	0.53	0.89	1.01	1.19	1.36	0.94	0.88	1.18	0.94	0.80	0.67	1.07	1.00
		6.14	*5.33*	*4.99*	*6.48*	*4.78*	*5.21*	*5.35*	*5.21*	*5.32*	*4.86*	*5.09*	*5.43*	*6.21*	*3.85*
	EW	1.00	0.83	1.02	0.84	1.12	1.18	1.16	1.01	1.26	1.16	0.87	0.88	1.20	1.11
		6.17	*5.43*	*5.04*	*4.99*	*4.19*	*4.45*	*4.81*	*4.13*	*4.89*	*5.17*	*4.63*	*5.21*	*5.65*	*3.43*

		S1	*S2*	*S3*	*S4*	*S5*	*S6*	*S7*	*S8*	*S9*	*S10*	*S11*	*S12*	*S13*
EURO	MCAP	1.62	1.44	1.43	1.29	1.22	1.08	0.60	1.01	1.01	1.07	1.07	0.97	1.25
		4.23	*4.22*	*4.29*	*4.17*	*4.54*	*4.41*	*4.39*	*4.52*	*4.33*	*4.41*	*4.45*	*4.56*	*4.57*
	EW	1.65	1.45	1.43	1.30	1.22	1.08	1.05	1.01	1.01	1.07	1.06	0.98	1.18
		4.31	*4.18*	*4.28*	*4.17*	*4.53*	*4.42*	*4.47*	*4.52*	*4.33*	*4.42*	*4.53*	*4.57*	*4.58*
DEM	MCAP	1.43	1.30	1.25	1.12	1.04	0.90	0.89	0.82	0.84	0.90	0.92	0.81	1.08
		4.42	*4.37*	*4.50*	*4.35*	*4.09*	*4.59*	*4.63*	*4.69*	*4.47*	*4.56*	*4.70*	*4.74*	*4.73*
	EW	1.45	1.31	1.25	1.13	1.03	0.91	0.89	0.83	0.85	0.90	0.90	0.82	1.01
		4.50	*4.33*	*4.49*	*4.35*	*4.68*	*4.59*	*4.63*	*4.69*	*4.47*	*4.56*	*4.73*	*4.74*	*4.72*

Table 3

Average return and standard deviation of the factor portfolios

Average returns and standard deviations of the factor portfolios are presented in % in panel A. All factor portfolio statistics are reported in synthetic Euro (EURO) and Deutschmark (DEM). The global market portfolio is a market-capitalization weighted average of all available stocks. The equity premium is the difference between the average return on the global market portfolio andthe risk-free rate. HML is the factor portfolio based on the return differential between the high book-to-market multifactor minimum variance portfolio and the low book-to-market MMV portfolio. LMOM is the factor portfolio based on the return differential between the local losers MMV portfolio and the local winners MMV portfolio. Panel B reports the correlations between the factors for the two currencies of denomination.

Panel A	**Average return (%)**	**? (%)**
Global market portfolio in EURO	1.304	4.92
Global market portfolio in DEM	1.133	5.10
Equity premium in EURO	0.662	5.12
Equity Premium in DEM	0.637	4.92
HMLin EURO	0.193	2.73
HML in DEM	0.197	2.73
LMOM in EURO	-0.617	2.12
LMOM in DEM	-0.642	2.08

Panel B: Correlations

EURO	**M-F**	**HML**	**LMOM**
M-F	1		
HML	-.106	1	
LMOM	-.004	.116	1

DEM	**M-F**	**HML**	**LMOM**
M-F	1		
HML	-.102	1	
LMOM	-.030	.136	1

Table 4a *Estimation results for the single-factor and multifactor pricing equations : country portfolios.*

The R² and the factor loadings are reported for the 4 estimated pricing equations in DEM. The t-values of the factor loading are in parentheses. The left panel shows the results for the one-factor model, the second panel reports the estimation results for the two-factor model including the high minus low BTM factor, the third panel shows the results for two-factor model including the local momentum factor, the last panel shows the three-factor model. ? is the estimated constant, ? is the factor loading on the excess return of the global market portfolio, ? is the factor loading on the HML factor and ? is the factor loading on the local momentum factor.

DEM	R-F=? +?*(M -F)			R-F=? +?*(M-F)+ ?*HML				R-F=? +?*(M-F)+ ?*LMOM				R-F=? +?*(M-F) +?*HML +?*LMOM				
	R^2	?	?	R^2	?	?	?	R^2	?	?	?	R^2	?	?	?	?
AUS	0.36	-.002	0.580	0.37	-.002	0.587	0.145	0.36	-.001	0.58	0.082	0.37	-.002	0.588	0.140	0.058
		(-0.74)	(11.62)		(-0.87)	(11.76)	(1.55)		(-0.51)	(11.63)	(0.67)		(-0.69)	(11.74)	(1.48)	(0.47)
BEL	0.41	.001	0.656	0.45	.000	0.677	0.383	0.41	.003	0.66	0.203	0.45	.001	0.677	0.369	0.139
		(0.47)	(12.77)		(0.14)	(13.53)	(4.09)		(0.92)	(12.85)	(1.61)		(0.47)	(13.55)	(3.90)	(1.12)
FRA	0.47	-.001	0.818	0.48	-.001	0.83	0.224	0.47	.000	0.82	0.060	0.48	-.001	0.831	0.221	0.022
		(-0.16)	(14.51)		(-0.34)	(14.76)	(2.12)		(-0.03)	(14.49)	(0.43)		(-0.28)	(14.73)	(2.08)	(0.16)
GER	0.44	-.001	0.648	0.46	-.002	0.663	0.274	0.44	-.001	0.65	-.009	0.46	-.002	0.663	0.280	-0.057
		(-0.51)	(13.53)		(-0.78)	(14.02)	(3.09)		(-0.51)	(13.50)	(-0.07)		-0.89)	(13.99)	(3.12)	(-0.49)
IRE	0.47	.001	0.866	0.49	-.000	0.881	0.278	0.47	.001	0.866	0.025	0.49	.000	0.881	0.280	-0.024
		(0.16)	(14.61)		(-.05)	(14.95)	(2.52)		(0.20)	(14.58)	(0.17)		(-0.10)	(14.92)	(2.51)	(-0.16)
ITA	0.31	.000	0.816	0.37	-.002	0.853	0.674	0.31	-.001	0.815	-0.104	0.38	-.003	0.851	0.697	-0.226
		(0.02)	(10.40)		(-0.38)	(11.29)	(4.76)		(-0.13)	(10.36)	(-0.54)		(-0.73)	(11.28)	(4.89)	(-1.21)
NET	0.68	.003	0.755	0.72	.002	0.775	0.371	0.68	.002	0.753	-0.130	0.73	.001	0.774	0.391	-0.198
		(1.69)	(22.38)		(1.29)	(24.65)	(6.30)		(1.17)	(22.39)	(-1.56)		(0.47)	(24.90)	(6.66)	(-2.57)
DEN	0.32	.001	0.562	0.36	.001	0.582	0.371	0.32	.001	0.561	-0.061	0.36	.000	0.581	0.384	-0.128
		(0.51)	(10.51)		(0.20)	(11.13)	(3.79)		(0.35)	(10.47)	(-0.46)		(-0.11)	(11.11)	(3.89)	(-0.99)
NOR	0.35	-.001	0.985	0.41	-.003	1.027	0.774	0.35	.001	0.988	0.284	0.41	-.002	1.028	0.758	0.151
		(-0.24)	(11.31)		(-0.67)	(12.30)	(4.95)		(0.15)	(11.36)	(1.33)		(-0.42)	(12.30)	(4.80)	(0.73)
SWE	0.42	.004	0.982	0.44	.004	0.960	-0.408	0.42	.005	0.985	0.225	0.44	.006	0.962	-0.439	0.302
		(0.89)	(13.03)		(1.15)	(12.86)	(-2.92)		(1.20)	(13.07)	(1.22)		(1.59)	(12.93)	(-3.12)	(1.64)
SWI	0.50	.001	0.681	0.51	.001	0.690	0.163	0.50	.001	0.680	-0.037	0.51	.000	0.689	0.170	-0.067
		(0.39)	(15.54)		(0.23)	(15.76)	(1.99)		(0.28)	(15.49)	(-0.34)		(0.03)	(15.72)	(2.05)	(-0.62)
UK	0.89	-.000	1.074	0.89	-.001	1.075	.012	0.89	-.001	1.074	-0.045	0.89	-.001	1.075	0.017	-0.048
		(-0.33)	(43.03)		(-0.35)	(42.75)	(0.25)		(-0.53)	(42.95)	(-0.73)		(-0.56)	(42.69)	(0.35)	(-0.77)

Table 4b. *Estimation results for the single-factor and multifactor pricing equations: sector portfolios.*

The R² and the factor loadings are reported for the 4 estimated pricing equations in DEM. The t-values of the factor loading are in parentheses. The left panel shows the results for the one-factor model, the second panel reports the estimation results for the two-factor model including the high minus low BTM factor, the third panel shows the results for two-factor model including the local momentum factor. The last panel shows the three-factor model. ? is the estimated constant, ? is the factor loading on the excess return of the global market portfolio, ? is the factor loading on the HML factor and ? is the factor loading on the local momentum factor.

DEM	R-F=? +?*(M-F)			R-F=? +?*(M-F)+?*HML				R-F=? +?*(M-F)+?*LMOM				R-F=? +?*(M-F) +?*HML +?*LMOM				
	R^2	?	?	R^2	?	?	?	R^2	?	?	?	R^2	?	?	?	?
Reso	0.60	.001	0.930	0.62	.001	0.947	0.326	0.60	.000	0.928	-0.134	0.62	-.001	0.946	0.346	-0.194
		(0.53)	(18.71)		(0.24)	(19.43)	(3.57)		(0.19)	(18.68)	(-1.10)		(-0.26)	(19.47)	(3.77)	(-1.62)
Bmat	0.77	-.005	0.915	0.80	-.006	0.934	0.357	0.78	-.004	0.918	0.273	0.81	-.005	0.936	0.335	0.214
		(-3.25)	(27.96)		(-4.02)	(30.59)	(6.24)		(-2.18)	(28.69)	(3.46)		(-3.02)	(31.10)	(5.90)	(2.88)
Chem	0.75	-.001	0.848	0.77	-.002	0.862	0.257	0.75	-.001	0.849	0.017	0.77	-.002	0.862	0.259	-0.028
		(-0.89)	(26.85)		(-1.30)	28.22)	(4.48)		(-0.79)	(26.79)	(0.22)		(-1.35)	(28.15)	(4.48)	(-0.37)
Cycc	0.54	-.001	0.927	0.54	.000	0.918	-0.168	0.54	.001	0.930	0.269	0.55	.002	0.920	-0.199	0.303
		(-0.28)	(16.57)		(-0.14)	(16.37)	(-1.60)		(0.30)	(16.72)	(1.96)		(0.53)	(16.54)	(-1.89)	(2.21)
Ncyc	0.88	.001	0.877	0.88	.001	0.881	0.082	0.88	.001	0.877	0.004	0.88	.001	0.881	0.083	-0.010
		(1.26)	(40.76)		(1.10)	(41.03)	(2.05)		(1.23)	(40.66)	(0.08)		(0.98)	(40.94)	(2.05)	(-0.19)
Phar	0.66	.003	0.826	0.66	.004	0.816	-0.181	0.66	.002	0.823	-0.222	0.67	.003	0.815	-0.162	-0.194
		(1.70)	(21.26)		(1.92)	(21.13)	(-2.51)		(0.96)	(21.38)	(-2.34)		(1.23)	(21.24)	(-2.23)	(-2.05)
Cycs	0.88	-.002	0.982	0.88	-.002	0.984	0.032	0.88	-.002	0.982	0.021	0.88	-.002	0.984	0.030	0.015
		(-1.53)	(41.42)		(-1.58)	(41.24)	(0.71)		(-1.36)	(41.34)	(0.35)		(-1.43)	(41.15)	(0.67)	(0.26)
Bank	0.70	-.002	0.856	0.74	-.003	0.876	0.369	0.70	-.002	0.856	-0.004	0.74	-.003	0.876	0.376	-0.069
		(-0.89)	(23.70)		(-1.43)	(25.72)	(5.78)		(-0.86)	(23.64)	(-0.04)		(-1.61)	(25.68)	(5.83)	(-0.82)
Insu	0.71	.001	0.877	0.73	.001	0.895	0.325	0.71	.001	0.878	0.028	0.73	.000	0.985	0.328	-0.030
		(0.66)	(23.91)		(0.28)	(25.43)	(4.93)		(0.72)	(23.86)	(0.30)		(0.16)	(25.37)	(4.92)	(-0.34)
Fina	0.89	-.001	0.901	0.90	-.002	0.912	0.207	0.89	-.001	0.901	0.019	0.90	-.002	0.912	0.209	-0.017
		(-1.27)	(43.93)		(-1.83)	(47.09)	(5.71)		(-1.10)	(43.84)	(0.38)		(-1.85)	(46.99)	(5.70)	(-0.35)
Indu	0.79	-.003	0.886	0.79	-.003	0.892	0.108	0.79	-.003	0.886	-0.036	0.79	-.003	0.892	0.114	-0.056
		(-1.69)	(29.82)		(-1.86)	(30.03)	(1.94)		(-1.76)	(29.74)	(-0.49)		(-2.00)	(29.99)	(2.02)	(-0.76)
Tech	0.79	-.004	0.948	0.83	-.005	0.968	0.369	0.79	-.004	0.949	0.072	0.83	-.005	0.968	0.368	0.008
		(-2.63)	(30.13)		(-3.43)	(33.39)	(6.80)		(-2.24)	(30.14)	(0.93)		(-3.23)	(33.32)	(6.71)	(0.11)
Tele	0.46	.000	0.829	0.46	.000	0.832	0.057	0.47	.000	0.828	-0.098	0.47	.000	0.832	0.069	-0.110
		(0.14)	(14.35)		(0.09)	(14.30)	(0.53)		(-0.07)	(14.30)	(-0.69)		(-0.14)	(14.28)	(0.62)	(-0.76)
Util	0.53	.002	0.553	0.56	.001	0.565	0.235	0.53	.001	0.552	-0.034	0.56	.000	0.565	0.243	-0.076
		(0.88)	(16.45)		(0.58)	(17.21)	(3.82)		(0.73)	(16.40)	(-0.41)		(0.27)	(17.19)	(3.91)	(-0.94)

Table 4c. *Estimation results for the single-factor and multifactor pricing equations : size portfolios.*

The R² and the factor loadings are reported for the 4 estimated pricing equations in DEM. The t-values of the factor loading are in parentheses. The left panel shows the results for the one-factor model, the second panel reports the estimation results for the two-factor model including the high minus low BTM factor, the third panel shows the results for two-factor model including the local momentum factor. The last panel shows the three-factor model. ? is the estimated constant, ? is the factor loading on the excess return of the global market portfolio, ? is the factor loading on the HML factor and ? is the factor loading on the local momentum factor.

DEM	R-F=? +? *(M -F)			R-F=? +? *(M-F)+ ?* HML				R-F=? +? *(M-F)+ ?*LMOM				R-F=? +? *(M-F) +?*HML +?*LMOM				
	R²	?	?	R²	?	?	?	R²	?	?	?	R²	?	?	?	?
S1	0.62	.005	0.687	0.67	.004	0.705	0.343	0.63	.006	0.689	0.207	0.67	.005	0.706	0.328	0.150
		(2.75)	(19.75)		(2.43)	(21.42)	(5.56)		(3.37)	(20.02)	(2.45)		(2.89)	(21.55)	(5.29)	(1.86)
S2	0.68	.004	0.711	0.72	.003	0.728	0.307	0.69	.004	0.713	0..112	0.72	.003	0.728	0.301	0.059
		(2.18)	(22.68)		(1.84)	(24.47)	(5.50)		(2.51)	(22.76)	(1.45)		(2.00)	(24.46)	(5.34)	(0.81)
S3	0.74	.003	0.762	0.79	.002	0.782	0.370	0.75	.004	0.764	0.174	0.79	.003	0.783	0.359	0.111
		(1.81)	(26.10)		(1.37)	(29.57)	(7.48)		(2.46)	(26.44)	(2.45)		(1.83)	(29.72)	(7.22)	(1.71)
S4	0.75	.002	0.739	0.80	.001	0.758	0.356	0.76	.003	0.742	0.237	0.80	.002	0.759	0.338	0.178
		(1.08)	(26.59)		(0.56)	(30.18)	(7.57)		(2.09)	(27.32)	(3.54)		(1.42)	(30.70)	(7.23)	(2.91)
S5	0.82	.000	0.833	0.85	-.001	0.849	0.297	0.82	.001	0.835	0.168	0.85	.000	0.850	0.285	0.118
		(0.06)	(32.80)		(-0.50)	(36.26)	(6.76)		(0.85)	(33.31)	(2.72)		(0.14)	(36.53)	(6.47)	(2.06)
S6	0.82	-.001	0.816	0.85	-.002	0.832	0.281	0.83	.000	0.818	0.174	0.85	-.001	0.832	0.268	0.127
		(-0.88)	(33.14)		(-1.51)	(36.43)	(6.57)		(-0.01)	(33.72)	(2.91)		(-0.77)	(36.78)	(6.26)	(2.27)
S7	0.83	-.001	0.829	0.87	-.002	0.847	0.318	0.84	.000	0.831	0.179	0.87	-.001	0.848	0.305	0.126
		(-1.10)	(34.33)		(-1.89)	(39.03)	(7.83)		(-0.18)	(35.01)	(3.06)		(-1.10)	(39.44)	(7.52)	(2.37)
S8	0.84	-.002	0.842	0.88	-.003	0.861	0.346	0.85	-.001	0.845	0.231	0.88	-.002	0.862	0.328	0.174
		(-1.69)	(34.85)		(-2.67)	(40.64)	(8.72)		(-0.50)	(36.04)	(4.01)		(-1.57)	(41.58)	(8.38)	(3.40)
S9	0.85	-.002	0.809	0.88	-.002	0.826	0.305	0.85	-.001	0.811	0.143	0.89	-.002	0.826	0.296	0.091
		(-1.50)	(36.66)		(-2.40)	(42.25)	(8.34)		(-0.69)	(37.19)	(2.66)		(-1.73)	(42.51)	(8.06)	(1.90)
S10	0.86	-.001	0.827	0.88	-.002	0.842	0.262	0.86	-.001	0.829	0.107	0.88	-.001	0.842	0.255	0.062
		(-1.05)	(37.58)		(-1.73)	(41.59)	(6.90)		(-0.43)	(37.86)	(1.98)		(-1.27)	(41.65)	(6.68)	(1.25)
S11	0.90	-.001	0.874	0.92	-.002	0.889	0.267	0.90	-.001	0.876	0.123	0.92	-.001	0.889	0.259	0.078
		(-1.35)	(45.71)		(-2.24)	(52.63)	(8.45)		(-0.54)	(46.34)	(2.65)		(-1.58)	(52.93)	(8.17)	(1.88)
S12	0.91	-.002	0.889	0.93	-.003	0.902	0.232	0.91	-.002	0.890	0.084	0.93	-.003	0.902	0.228	0.044
		(-2.72)	(49.88)		(-3.68)	(56.17)	(7.72)		(-2.06)	(50.19)	(1.92)		(-3.17)	(56.21)	(7.50)	(1.11)
S13	0.94	.000	0.902	0.94	.000	0.902	0.005	0.94	.000	0.901	-0.020	0.94	.000	0.902	0.007	-0.021
		(0.15)	(63.02)		(0.13)	(62.58)	(0.18)		(-0.02)	(62.88)	(-0.57)		(-0.05)	(62.48)	(0.26)	(-0.59)

Table 5. Results for the multivariate GRS test of exact factor pricing using a one-factor model

For the four dfferent time periods and the two currencies of denomination (panel A and B), the test values are reported. The first period is the full sample period from January 1979 until December 1998. The second period is a period of stable interest rates, from January 1983 until December 1987. The third period is a period of rising interest rates, from January 1988 until December 1992. The last period is a period of declining interest rates, from January 1994 until December 1998. ? is the estimated non-centrality parameter from the one-factor model. The F-statistic (F-stat) is the GRS statistic (equation 3.1) and the p-value is the associated probability of the F-test. N is the number of portfolios in the study and T is the number of observations in the time series.

Panel A: DEM, R-F=a+b(M-F)*												
	79:01 - 98:12			83:01 – 87:12			88:01 – 92:12			94:01 – 98:12		
	Country	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*
?	12.351	36.553	56.561	3.740	21.495	25.542	17.152	31.151	32.938	14.160	29.292	38.462
F-stat	0.982	2.468	4.132	0.253	1.191	1.558	1.158	1.726	2.010	0.956	1.623	2.347
p-value	0.467	0.003	0.000	0.994	0.315	0.133	0.340	0.084	0.042	0.502	0.110	0.017
Panel B: Synthetic Euro, R-F=a+b(M-F)*												
	79:01 - 98:12			83:01 – 87:12			88:01 – 92:12			94:01 – 98:12		
	Country	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*
?	6.852	28.431	53.885	3.687	20.939	23.476	12.224	29.651	34.632	16.332	26.987	39.420
F-stat	0.545	1.920	3.936	0.249	1.160	1.432	0.826	1.643	2.113	1.103	1.496	2.405
p-value	0.884	0.026	0.000	0.994	0.337	0.182	0.624	0.104	0.032	0.380	0.152	0.015
N	12	14	13	12	14	13	12	14	13	12	14	13
T	240	240	240	60	60	60	60	60	60	60	60	60

Table 6. Test results for the multivariate GRS test of exact factor pricing using the DEM as the currency of denomination.

For the four different time periods the test values are reported for three multifactor models. The first period is the full sample period, from January 1979 until December 1998. The second period is a period of stable interest rates, from January 1983 until December 1987. The third period is a period of rising interest rates, from January 1988 until December 1992. The last period is a period of declining interest rates, from January 1994 until December 1998. ? is the estimated non-centrality parameter from the multifactor models. The F-statistic (F-stat) is the GRS statistic (equation 3.1) and the p-value is the associated probability of the F-test. N is the number of portfolios in the study and T is the number of observations in the time series.

	79:01 - 98:12			83:01 – 87:12			88:01 – 92:12			94:01 – 98:12		
Panel A: DEM, R-F=a+b(M-F)+g*HML*												
	Country	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*
?	16.895	54.077	65.876	9.115	22.760	19.495	17.273	40.125	32.443	14.072	27.154	38.601
F-stat	1.337	3.635	4.791	0.602	1.233	1.164	1.142	2.174	1.936	0.930	1.471	2.304
p-value	0.199	0.000	0.000	0.829	0.287	0.336	0.352	0.025	0.051	0.526	0.163	0.019
Panel B: DEM, R-F=a+b(M-F)+d*LMOM*												
	79:01 - 98:12			83:01 – 87:12			88:01 – 92:12			94:01 – 98:12		
	Country	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*
?	11.863	30.160	48.581	4.968	22.188	22.975	14.948	23.788	26.403	9.215	21.084	29.729
F-stat	0.939	2.028	3.533	0.328	1.202	1.371	0.988	1.289	1.576	0.609	1.142	1.774
p-value	0.509	0.017	0.000	0.980	0.308	0.211	0.475	0.253	0.129	0.823	0.351	0.078
Panel C: DEM, R-F=a+b(M-F)+g*HML+d*LMOM*												
	79:01 - 98:12			83:01 – 87:12			88:01 – 92:12			94:01 – 98:12		
	Country	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*
?	20.747	49.531	54.558	9.047	22.502	18.876	15.025	32.379	24.105	9.112	19.577	30.022
F-stat	1.635	3.315	3.950	0.585	1.192	1.102	0.971	1.715	1.407	0.589	1.037	1.752
p-value	0.083	0.000	0.000	0.843	0.316	0.383	0.489	0.088	0.195	0.839	0.438	0.083
N	12	14	13	12	14	13	12	14	13	12	14	13
T	240	240	240	60	60	60	60	60	60	60	60	60

Table 7. Test results for the multivariate GRS test of exact factor pricing using a synthetic Euro as the currency of denomination.

For the four time periods the test values are reported for three multifactor models. The first period is the full sample period, from January 1979 until December 1998. The second period is a period of stable interest rates, from January 1983 until December 1987. The third period is a period of rising interest rates, from January 1988 until December 1992. The last period is a period of declining interest rates, from January 1994 until December 1998. ? is the estimated non-centrality parameter from the multifactor models. The F-statistic (F-stat) is the GRS statistic (equation 3.1) and the p-value is the associated probability of the F-test. N is the number of portfolios in the study and T is the number of observations in the time series.

Panel A: Synthetic Euro, R-F=a+b(M-F)+g*HML*												
	79:01 - 98:12			83:01 – 87:12			88:01 – 92:12			94:01 – 98:12		
	Country	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*
?	6.747	37.827	57.599	9.471	23.274	17.765	13.285	38.696	33.933	17.656	25.071	38.414
F-stat	0.534	2.543	4.189	0.626	1.261	1.060	0.878	2.097	2.025	1.167	1.358	2.293
p-value	0.891	0.002	0.000	0.809	0.269	0.416	0.574	0.031	0.041	0.334	0.214	0.020
Panel B: Synthetic Euro, R-F=a+b(M-F)+d*LMOM*												
	79:01 - 98:12			83:01 – 87:12			88:01 – 92:12			94:01 – 98:12		
	Country	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*
?	5.831	21.951	45.060	5.045	20.624	21.054	9.808	22.060	27.382	11.471	18.990	29.827
F-stat	0.461	1.475	3.277	0.334	1.118	1.257	0.648	1.195	1.634	0.758	1.029	1.780
p-value	0.935	0.121	0.000	0.979	0.370	0.274	0.790	0.313	0.111	0.688	0.444	0.077
Panel C: Synthetic Euro, R-F=a+b(M-F)+g*HML+d*LMOM*												
	79:01 - 98:12			83:01 – 87:12			88:01 – 92:12			94:01 – 98:12		
	Country	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*	*Country*	*Sector*	*Size*
?	7.652	33.164	46.847	9.357	22.245	17.127	11.425	31.280	24.389	12.488	17.910	29.465
F-stat	0.603	2.220	3.392	0.605	1.178	1.000	0.739	1.657	1.423	0.807	0.949	1.720
p-value	0.839	0.008	0.000	0.826	0.326	0.468	0.707	0.088	0.187	0.641	0.518	0.090
N	12	14	13	12	14	13	12	14	13	12	14	13
T	240	240	240	60	60	60	60	60	60	60	60	60

Table 8. Power statistics for a risk-based and a non-risk-based alternative hypothesis for the multivariate exact factor pricing test for country portfolios

For the four time periods, the power statistics are given for all tested models. For the risk-based alternative, the non-centrality parameter ? is reported as well as the power of the test that the specified null hypothesis is accepted given the alternative. For the non-risk-based alternative, the mean non-centrality parameter ? is given for hundred simulations of the alpha vector from the normal distribution with mean zero and deviation .002. The standard deviation of the non-centrality parameters is std ?. ?$_1$ and ?$_2$ are the degrees of freedom of the F-test under the null hypothesis. M-F is the excess return on the global market portfolio, HML is the difference in return between the high book-to-market portfolio and the low book-to-market portfolio. LMOM is the difference in return between the portfolio of loser stocks and the portfolio of winner stocks.

Country portfolios		**Risk-based**				**Non-risk-based**						?$_2$
		DEM		EURO		DEM			EURO			
?$_1$= 12		?	power	?	power	?	? (?)	Power	?	? (?)	power	
1-79/12-98	*M-F*	8.75	0.420	21.97	0.885	15.83	10.47	0.729	14.31	10.90	0.673	227
	M-F,HML	8.61	0.414	21.12	0.870	16.15	10.66	0.739	12.73	7.48	0.608	226
	M-F,LMOM	8.34	0.400	20.25	0.852	14.82	10.43	0.693	12.92	9.05	0.617	226
	M-F,HML,LMOM	8.68	0.417	19.92	0.844	16.86	11.61	0.762	11.62	6.10	0.559	225
1-83/12-87	*M-F*	6.49	0.261	4.65	0.189	3.92	2.80	0.162	4.05	2.82	0.167	47
	M-F,HML	15.04	0.612	8.97	0.364	4.10	2.68	0.169	3.81	2.77	0.158	46
	M-F,LMOM	10.89	0.448	5.06	0.203	4.29	3.46	0.176	4.05	3.12	0.166	46
	M-F,HML,LMOM	14.91	0.602	8.31	0.334	3.96	2.61	0.161	3.90	2.69	0.160	45
1-88/12-92	*M-F*	15.72	0.636	27.22	0.904	8.87	7.51	0.361	11.37	12.00	0.467	47
	M-F,HML	15.31	0.621	26.55	0.894	9.69	9.17	0.396	11.57	8.18	0.474	46
	M-F,LMOM	16.76	0.671	27.37	0.904	9.70	8.06	0.397	9.37	12.93	0.381	46
	M-F,HML,LMOM	14.84	0.600	25.97	0.883	6.69	8.96	0.392	9.12	7.94	0.368	45
1-94/12-98	*M-F*	17.70	0.701	26.06	0.732	17.66	19.93	0.700	13.52	14.45	0.554	47
	M-F,HML	17.03	0.680	19.80	0.866	16.97	15.88	0.678	16.29	12.98	0.653	46
	M-F,LMOM	13.67	0.560	24.76	0.759	21.87	26.13	0.811	13.44	17.46	0.549	46
	M-F,HML,LMOM	11.78	0.480	18.90	0.888	15.23	12.64	0.614	12.50	11.35	0.509	45

Table 9. Power statistics for a risk-based and a non-risk-based alternative hypothesis for the multivariate exact factor pricing test for sector portfolios

For the four time periods, the power statistics are given for all tested models. For the risk-based alternative, the non-centrality parameter ? is reported as well as the power of the test that the specified null hypothesis is accepted given the alternative. For the non-risk-based alternative, the mean non-centrality parameter ? is given for hundred simulations of the alpha vector from the normal distribution with mean zero and deviation .002. The standard deviation of the non-centrality parameters is std ?. $?_1$ and $?_2$ are the degrees of freedom of the F-test under the null hypothesis. M-F is the excess return on the global market portfolio, HML is the difference in return between the high book-to-market portfolio and the low book-to-market portfolio. LMOM is the difference in return between the portfolio of loser stocks and the portfolio of winner stocks.

Sector portfolios		**Risk-based**				**Non-risk-based**						$?_2$
		DEM		EURO		DEM			EURO			
$?_1$= 14		?	power	?	power	?	? (?)	Power	?	? (?)	power	
1-79/12-98	*M-F*	28.76	0.951	41.00	0.995	34.96	17.57	0.983	34.03	15.43	0.980	225
	M-F,HML	34.63	0.982	44.32	0.997	37.34	17.83	0.989	34.62	16.76	0.982	224
	M-F,LMOM	23.35	0.886	33.81	0.979	34.56	17.74	0.982	35.27	16.19	0.984	224
	M-F,HML,LMOM	27.33	0.938	37.23	0.989	36.91	18.62	0.983	34.04	16.31	0.980	223
1-83/12-87	*M-F*	22.09	0.757	23.43	0.802	9.46	4.57	0.348	10.27	5.38	0.380	45
	M-F,HML	27.14	0.868	21.66	0.760	10.49	5.13	0.386	10.16	5.612	0.374	44
	M-F,LMOM	25.01	0.831	19.73	0.708	10.11	4.71	0.372	10.37	5.35	0.382	44
	M-F,HML,LMOM	25.11	0.831	20.30	0.721	10.01	4.96	0.366	10.06	4.96	0.368	43
1-88/12-92	*M-F*	37.07	0.964	39.53	0.974	24.39	13.63	0.821	19.66	11.65	0.709	45
	M-F,HML	43.74	0.986	44.94	0.988	25.61	13.32	0.842	20.42	10.56	0.727	44
	M-F,LMOM	35.86	0.956	38.60	0.970	24.69	14.72	0.825	19.23	10.42	0.694	44
	M-F,HML,LMOM	41.60	0.980	46.46	0.990	23.90	14.29	0.807	19.94	9.61	0.711	43
1-94/12-98	*M-F*	33.17	0.939	36.38	0.960	23.18	13.96	0.797	14.86	7.39	0.555	45
	M-F,HML	32.11	0.928	35.07	0.951	26.10	18.53	0.851	15.68	8.19	0.581	44
	M-F,LMOM	26.61	0.859	25.82	0.846	25.67	16.11	0.843	14.29	8.32	0.531	44
	M-F,HML,LMOM	23.50	0.799	25.38	0.836	19.75	10.80	0.706	15.92	9.07	0.586	43

Table 10. Power statistics for a risk-based and a non-risk-based alternative hypothesis for the multivariate exact factor pricing test for size portfolios

For the four time periods, the power statistics are given for all tested models. For the risk-based alternative, the non-centrality parameter ? is reported as well as the power of the test that the specified null hypothesis is accepted given the alternative. For the non-risk-based alternative, the mean non-centrality parameter ? is given for hundred simulations of the alpha vector from the normal distribution with mean zero and deviation .002. The standard deviation of the non-centrality parameters is std ?. $?_1$ and $?_2$ are the degrees of freedom of the F-test under the null hypothesis. M-F is the excess return on the global market portfolio, HML is the difference in return between the high book-to-market portfolio and the low book-to-market portfolio. LMOM is the difference in return between the portfolio of loser stocks and the portfolio of winner stocks.

Size portfolios		**Risk-based**				**Non-risk-based**						$?_2$
		DEM		EURO		DEM			EURO			
$?_1$= 13		?	power	?	power	?	? (?)	Power	?	? (?)	Power	
1-79/12-98	*M-F*	45.51	0.998	60.33	1.000	136.93	66.96	1.000	127.77	61.64	1.000	226
	M-F,HML	47.17	0.999	61.10	1.000	139.46	69.26	1.000	127.49	66.60	1.000	225
	M-F,LMOM	43.68	0.998	51.63	0.999	143.16	60.74	1.000	120.19	58.14	1.000	225
	M-F,HML,LMOM	39.70	0.994	50.68	0.999	122.56	58.74	1.000	143.09	63.78	1.000	224
1-83/12-87	*M-F*	30.23	0.924	22.95	0.813	39.10	18.64	0.978	36.11	16.84	0.966	46
	M-F,HML	28.56	0.904	16.80	0.644	35.71	16.00	0.964	31.35	14.63	0.933	45
	M-F,LMOM	31.12	0.931	19.21	0.718	37.48	17.30	0.972	32.30	17.77	0.941	45
	M-F,HML,LMOM	27.76	0.892	15.61	0.601	36.46	17.38	0.966	35.83	16.57	0.963	44
1-88/12-92	*M-F*	38.46	0.976	44.36	0.991	67.10	31.60	1.000	47.31	21.78	0.944	46
	M-F,HML	37.79	0.973	43.43	0.989	65.83	31.13	1.000	57.29	27.60	1.000	45
	M-F,LMOM	37.82	0.973	43.37	0.989	69.00	35.43	1.000	53.46	25.92	0.998	45
	M-F,HML,LMOM	32.58	0.942	39.59	0.979	61.34	33.88	1.000	54.73	27.18	1.000	44
1-94/12-98	*M-F*	39.89	0.981	42.23	0.3987	71.12	37.44	1.000	66.03	35.73	1.000	46
	M-F,HML	42.80	0.987	41.02	0.983	68.10	33.32	1.000	60.78	28.74	1.000	45
	M-F,LMOM	32.82	0.945	30.57	0.926	75.57	37.84	1.000	55.50	28.42	1.000	45
	M-F,HML,LMOM	32.62	0.942	30.26	0.921	66.98	32.76	1.000	53.31	24.29	1.000	44

References

Affleck-Graves, John, and McDonald, Bill, 1990, Multivariate tests of asset pricing: the comparative power of alternative statistics, Journal of Financial and Quantitative Analysis 25, 163-185.

Banz, Rolf W., 1981, The relationship between return and market value of common stocks, Journal of Financial Economics 9, 3-18.

Basu, S., 1977, Investment performance of common stocks in relation to their price-earnings ratios: a test of the efficient market hypothesis, Journal of Finance 32, 663-682.

Campbell, John, Lo, Andrew and MacKinlay, A. Craig, 1997, The econometrics of financial markets, Princeton University Press.

Chen, Nai-Fu, Roll, Richard, and Ross, Stephen A, 1986, Economic forces and the stock market, Journal of Business 59, 383-403.

Davis, James. L ., 1994, The cross-section of realized stock returns : the pre-compustat evidence, Journal of Finance 49, 1579-1593.

Dumas, Bernard and Solnik, Bruno, 1995, The world price of foreign exchange risk, Journal of Finance 50, 445-479.

Fama, Eugene F. and French, Kenneth R., 1992, The cross-section of expected stock returns, Journal of Finance 47, 427-465.

Fama, Eugene F. and French, Kenneth R., 1993, Common risk factors in the returns on stock and bonds, Journal of Financial Economics 33, 3-56.

Fama, Eugene F. and French, Kenneth R., 1995, Size and book-to-market factors in earnings and returns, Journal of Finance 50, 131-155.

Fama, Eugene F. and French, Kenneth R., 1996, Multifactor explanations of asset pricing anomalies, Journal of Finance 51, 55-84.

Fama, Eugene F. and French, Kenneth R., 1998, Value versus growth: the international evidence, Journal of Finance 53, 1975-1999.

Fama, Eugene F. and MacBeth, James D., 1973, Risk, return and equilibrium: empirical tests, Journal of Political Economy 81, 607-636.

Ferson, Wayne E. and Harvey, Campbell R, 1993, The risk and predictability of international equity returns, Review of Financial Studies 6, 527-566.

Gibbons, Michael R., 1982, Multivariate tests of financial models: a new approach, Journal of Financial Economics 10, 3-27.

Gibbons, Michael R., Ross, Stephen A. and Shanken, Jay, 1989, A test of the efficiency of a given portfolio, Econometrica 57, 1121-1152.

Jagannathan, Ravi and Wang, Zhenyu, 1996, The conditional CAPM and the cross-section of expected returns, Journal of Finance 51, 3-53.

Jegadeesh, Narasimhan and Titman, Sheridan, 1993, Returns to buying winners and selling losers: implications for stock market efficiency, Journal of Finance 48, 65-91.

Jegadeesh, Narasimhan and Titman, Sheridan, 1999, Profitability of momentum strategies: an evaluation of alternative explanations, NBER working paper, 7159.

Jensen, Gerald R., Mercer, Jeffrey M. and Johnson, Robert R., 1996, Business conditions, monetary policy and expected security returns, Journal of Financial Economics 40, 213-237.

Lewellen, Jonathan, 1999, The time-series relations among expected returns, risk and book-to-market, Journal of Financial Economics 54, 5-43.

Lintner, J., 1965, The valuation of risk assets and the selection of risky investment in stock portfolios and capital budgets, Review of Economics and Statistics 47, 13-37.

Lo, Andrew W. and MacKinlay, A. Craig, 1999, A non-random walk down Wall Street; Princeton University Press.

Lo, Andrew W. and MacKinlay, A. Craig, 1990, Data-snooping biases in tests of financial asset pricing models, Review of Financial Studies 3, 431-467.

MacKinlay, A. Craig, 1987, On multivariate tests of the CAPM, Journal of Financial Economics 18, 341-71.

Merton, Robert C., 1973, An intertemporal capital asset pricing model, Econometrica 41, 867-887.

Roll, Richard, 1977, A critique of the asset pricing theory's tests: part I: on past and potential testability of the theory, Journal of Financial Economics 4, 129-176.

Roll, Richard, 1978, Ambiguity when performance is measured by the securities market line, Journal of Finance 33, 1051-1069.

Ross, Stephen A., 1976, The Arbitrage Theory of Capital Asset Pricing, Journal of Economic Theory 13, 341-360.

Rouwenhorst, Geert, 1998, International momentum strategies, Journal of Finance 53, 267-284.

Sharpe, W., 1964, Capital asset prices : a theory of market equilibrium under conditions of risk, Journal of Finance 19, 425-442.