Barra

EUE2 – A New Equity Model for Europe
Research Notes

Introduction

This research report details the estimation of Barra's new Europe Equity Model (EUE2) and highlights important improvements upon its predecessor, EUE1. Section 1 focuses on the construction of the risk indices, industry and country factors and estimation of the factor model. Section 2 discusses details of the covariance matrix, specific risk model, and currency model. Section 3 tests the performance of EUE2.

EUE2 is Barra's first European model to be estimated after the creation of the single European currency (the Euro). The Euro came into being on January 1st 1999 for the first wave of countries (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg[1], the Netherlands, Portugal and Spain). Greece joined on January 1st 2001. The remaining European Union (EU) Countries (Denmark, Sweden and the UK) may join in the future. The Europe Equity Model also covers Norway and Switzerland. Although they are not EU members[2], their economies and equity markets are very integrated with the EU.

1 – Descriptors, Risk Indices and Industries

Two factors drove our re-estimation process. First, now that more than two years have passed since the Euro transition, we can rely less on assumptions and more on observations. Second, we have collected a vastly expanded history of fundamental data for Western Europe. We also took the opportunity to improve the industry structure, in the light of the "new economy".

EUE2 is a multiple factor model with nine risk indices, 58 industries, and 16 country factors. Of the risk indices, five are carried over from EUE1 (Size, Momentum, Volatility, Value and Yield). The four new indices (Market Sensitivity, Growth, Leverage and Foreign Exposure) are mainly derived from our expanded fundamental dataset, and were chosen based on their power to explain common factor risk. The risk indices are shown in **Table 1** with their component descriptors.

The Blue Chip risk index from EUE1 has been dropped. This was a binary indicator variable giving unit exposure to the 100 largest companies (based on market capitalisation) and was initially included to capture globalisation and index effects. There are two reasons for its deletion. First, no index has, as yet, emerged as the benchmark European index (in the way that the FTSE 100 can be viewed as the

[1] Note that although Luxembourg assets are not officially covered in Barra models, the main stocks have parallel listings on the Dutch, French or Belgian markets, which are covered.
[2] Norway is a member of the EEA (European Economic Area), which facilitates free movement of trade and labour with the EU.

benchmark for the UK). Second, we are better able to handle globalisation effects through the new Foreign Exposure risk index.

All descriptors are filtered for extreme data points using the skipped Huber method; that is, values which are greater than 5.2 absolute median deviations from the median are truncated to this limit value. This method downplays the influence of extreme values and removes outlying errors. The risk index exposures are cross-sectionally standardised so that they have a capitalisation-weighted mean of zero and an equally weighted standard deviation of one each month.

EUE1 used the 19 (later reduced to 18) STOXX[3] sectors as an industry classification. EUE2 directly re-uses some of these sectors, and splits others into sub-sectors where empirical evidence indicated an improved model fit, to give a total of 29 industries. **Table 2** shows the EUE2 industry classification and its relationship with STOXX sectors. Note that it is possible to form a direct many-to-one mapping from the EUE2 industries into the STOXX sectors. This maintains a degree of backward compatibility with the old model, and ensures that users can report against STOXX sectors. **Table 3** shows the coverage of the industry classifications, both in terms of number of issues and percentage capitalisation. **Table 4** shows this information for the 16 countries included in the model, rather than industries.

The 29 industry classifications are factored separately over the UK, and the rest of Europe (continental Europe + Ireland), to give a total of 58 industry factors. This is due to the fact that industry factors estimated Europe-wide have a poor fit on the UK subset[4]. Note also from Table 4 that the UK market is by far the biggest in terms of capitalisation.

The industries have been chosen in order to minimise the possibility of low industry membership ('thin industries'). A thin industry correction is applied to a small number of industries early in the estimation period. This correction makes a Bayesian adjustment to the thin industry in the common factor regression, which forces the thin industry return towards the market return. In other words, our *a priori* belief is that thin industries should behave like the market. This adjustment reduces the influence of asset specific effects on the industry return.

Some of the industry changes are a result of the changing economy and equity markets' structure. For example, with the vast increase in technology listings in the past few years, we have split Technology into Technology Software and Technology Hardware. With a move away from manufacturing to a more service based economy, we have also split off Industrial Services from Industrial Goods and Services.

The 58 industry factors, 16 country factors and nine risk indices of all estimation universe assets at time t constitute an 83 x n_t exposure matrix X_t where n_t is the number of assets in the estimation universe at time t. The factor model regressions are performed

[3] Official STOXX market sectors.
[4] See the EUE1 estimation report ("Regional Modelling of the Western European Market") for more details on this.

using returns (in excess of the risk free rate) in local currency for each security. This means that the factor returns are estimated from a fully-hedged perspective. We estimate the 83 factor returns by cross-sectional regression, subject to two linear constraints which are required to uniquely identify the regression[5]. The constraints ensure that the market factor return is reflected in the industry factors, unlike Barra's Global Equity Model, where the market factor return is captured by the country factors. The assets are weighted in the regression by the square root of their market capitalisation.

The estimation universe is a subset of all the assets in the model and is constructed as follows:

i. All assets in the broad STOXX index and FTSE All Share index are included.
ii. All Continental assets in the top 1000 by capitalisation are included.
iii. We try to ensure that each industry contains at least 20 assets, or all assets in the model if fewer than 20 exist. Additional assets are added in order of descending market capitalisation.
iv. We repeat the methodology in (iii) across countries to ensure that each has at least 20 assets.

Some minor exceptions to these rules include the exclusion of preference shares and foreign (non primary listing) shares.

Table 5 shows the adjusted R^2 for each monthly cross sectional regression, run over the period February 1991 to November 2000. It also shows the number of country, industry and risk index factors that are significant each month. The adjusted R^2 of the regression varies from 6.2% to 74.6% with a time series average of 35.9%. In a typical month 35.9% of the return to a typical stock comes from common factor return and the rest from asset specific return. By the nature of a risk model, the adjusted R^2 varies widely between a low value in very quiet months to a high value in months with large market-wide moves. The proportion of return due to common factors will be much higher for a broad-based portfolio than for a typical stock, due to the effect of diversification on asset specific return. Table 5 also shows the number of country, industry and risk index factors that are significant each month. Since these are risk factors, we do not expect them all to have a significant effect on the cross section of returns *each* month, but each will be significant for a substantial number of months.

Table 6 shows the percentage of months for which the t-statistic for each factor return from the cross sectional regression is significant. This metric indicates which factor returns have been most frequently important in explaining cross-sectional returns. All nine risk factors have good-to-excellent explanatory power by this measure (the same applies to industry and country factors). Table 6 also shows the market[6] betas of each of the factors. These have little relevance in determining whether a particular factor should be included or excluded in the model. The market betas measure the extent to which the different risk factors have market exposure, or are purely extra-market. By construction

[5] See the appendix for a detailed technical description of the constraints.
[6] Market is defined as the cap-weighted estimation universe.

of the linear constraint, the market return is forced into the industry factors, which is why the industry betas tend to be close to 1.

2 – Covariance Matrix, Currency Matrix and Specific Risk Model

The factor covariance matrix is calculated from the factor returns using exponential smoothing with a 48-month half-life. Thus observations from four years ago have half as much weight as the most recent observations in calculating variances and correlation.

All of Barra's multi-country models, fixed income and equity, utilize Barra's currency risk model. We use this currency risk model in EUE2 to construct the currency variance-covariance block and calibrate the non-currency factor and currency covariance blocks. We use the Deutschmark as a historical proxy for the Euro pre-1999. All Euro-zone currencies are assumed to have zero currency volatility with respect to the Euro historically. Therefore, from a Euro perspective, the eleven Euro countries have no historical currency returns. We form the off-diagonal currency factor / non-currency factor blocks by calculating the currency factor returns and the non-currency factor returns. The last block of the factor covariance matrix is the currency covariance matrix which we insert directly from Barra's currency risk model. To ensure consistency in the currency variances we calibrate the currency variances in the currency factor / non-currency factor blocks to match those in the currency covariance matrix. Correlations in these blocks are retained.

Finally, the matrix is scaled to reflect short-term changes in volatility using DEWIV (Daily Exponentially Weighted Index Volatility). We use high frequency market index volatility estimates to scale the factor covariance matrix to an exponentially weighted variance estimator with a short half-life (120 days). For EUE2, we use daily returns from the broad STOXX index as the market index in this technique.

The specific risk model uses the standard Barra methodology, although a separate model is estimated for UK and Continental stocks. Let ε_{it} denote the asset specific return to security i in month t from the factor model regressions. Let π_{it} denote the relative absolute specific return of asset i in month t:

$$\pi_{it} = (|\varepsilon_{it}| - S_t)/S_t$$

where S_t is the square-root-cap-weighted average of $|\varepsilon_{it}|$, i=1,…,n_t, in month t.

As explanatory variables for π_{it} we use a set of descriptors which includes all the industry and country dummies, and others mainly based on stock volatility. Let Z_{it-1} denote the vector of descriptors for asset i at time t-1. We concatenate the time-series / cross-sectional sample of π_{it} and regress them against Z_{it-1}:

$$\pi_{it} = b'Z_{it-1} + u_{it}$$

where $i=1,..n_t$ $t=1,\ldots,T$ and b are the estimated regression coefficients and u_{it} are the regression residuals. S_t is forecast using an equally-weighted moving average of the past six months' realised S_t. The product of the one-month-ahead forecasts for π_{it} and S_t are the forecast absolute specific returns. The standard Barra technology is to scale these forecasts to make them specific risk forecasts by multiplying them by the empirical ratio of mean absolute specific return to standard deviation of specific return. We found that this ratio differs by capitalisation class, larger stocks possessing a lower empirical ration than smaller stocks.

3 – Model Performance

The first comparison that we carried out between EUE1 and EUE2 was an examination of portfolio R^2, run from February 1997 to November 2000 (**Table 7**). This is a measure of how well the common factor model 'fits' the portfolio. This is shown for the broad STOXX index, the STOXX Technology portfolio, and the STOXX Industrial Goods and Services portfolio. Due to the extra risk indices, change in industry structure, and change in estimation universe from EUE1 to EUE2, we can see a general, overall improvement for EUE2. On the broad index, the average increase is 6.5%. The higher increases for the sector portfolios are due to the more refined industry structure of EUE2, and support the premise that this refinement improved the model.

A major performance measure of an equity risk model is the bias test. We calculate this by generating risk forecasts for a variety of portfolios and then observing whether the magnitude of realised returns on the portfolios are consistent with the risk forecasts. A standardised outcome is defined as the realised return on a portfolio divided by its ex-ante predicted risk. If the risk forecast is accurate, then the time series of standardised outcomes should have a sample standard deviation close to 1.0. Bias tests using total risk were run from January 1997 to December 2000 for both EUE1 and EUE2. The results can be seen in **Table 8**. Here, portfolios of the form EUR*** are the capitalisation-weighted portfolios of all assets covered by Barra in that country, and UNIV is all assets in all countries. We can see a general improvement in EUE2 compared with EUE1.

Summary

The original Europe Equity Model was estimated just before the dawn of the single currency, when European markets were undergoing great transition. Some of these trends are still continuing, but we are now able to operate with much more hindsight, and need to make less use of a 'crystal ball'. We have introduced an improved set of risk factors, and new industry definitions that reflect the changing European economy, as well as dynamic methods for capturing risk trends promptly (DEWIV was not originally included in EUE1). We have also improved the specific risk model to better reflect the difference in behaviour of the UK and Continental markets.

Table 1
The Risk Indices and Their Underlying Descriptors

All descriptors listed below contribute *positively* to the risk index value. That is, the more positive is the descriptor value, the more positive is the risk index value.

Size

The size index is based on market capitalisation. It differentiates large stocks from small stocks. The size index has been a major determinant of performance in many markets worldwide, and is an important source of risk as well.

Descriptors:
- Log of Capitalisation
- Total Assets

Momentum

The momentum index identifies stocks that have been recently successful based on price behaviour in the market, measured by twelve-month cumulative excess returns.

- Log rate of excess return over the last twelve months
- Historic Alpha

Market Sensitivity

The market sensitivity index records the historical exposure of a stock's return to movements in the overall market, based on a 5-year historical beta regression.

- Historic Beta
- Historic Beta * Historic Sigma

Volatility

This risk index is a predictor of the volatility of a stock based on its historical price behaviour.

- Historic Sigma
- Cumulative Range
- Previous Months Squared Return
- Squared Return from 2 months ago
- Squared Return from 3 months ago

Growth

This index measures the historic growth in a company's fundamentals.

- Earnings Growth
- Asset Growth
- Sales Growth

- Dividend Growth

Leverage

Leverage is a measure of the company's debt exposure.

- Debt to Assets
- Debt to Price

Value

This index captures the extent to which a company's ongoing business is inexpensively priced in the marketplace by looking at earnings to price, book to price and sales to price. It is an important source of performance and also one of the most important sources of common factor risk.

- Book to Price Ratio
- Earnings to Price Ratio
- Sales to Price Ratio

Foreign Exposure

This gives an indication of how 'international' a company is, and looks at the proportion of a company's business that is conducted outside of the home country.

- Foreign Earnings
- Foreign Sales
- Foreign Assets

Yield

This risk index measures the company's current dividend yield.

- Current Yield

Table 2
EUE2 Industry Classifications and their Relationship to EUE1 STOXX Industries

EUE1 STOXX Sector	EUE2 Industries
Basic Resources	Basic Resources
Chemicals	Chemicals
Automobiles	Automobiles
Cyclical Goods & Services	Entertainment and Leisure
	Textiles (& Furnishings)
	Travel
Media	Media
Retail	Retail
Food & Beverage	Food
	Distillers & Brewers
Non-Cyclical Goods & Services	Non Cyclical Goods & Services
	Tobacco
Energy	Energy
Banks	Banks
Financial Services	Financial Services
	Real Estate
	Investment Trusts
Insurance	Insurance
Healthcare	Healthcare (includes Pharmaceuticals)
Construction	Construction
Industrial	Aerospace (& Defence)
	Industrial Services
	Industrial Diversified
	Industrial Equipment
	Transportation
Technology	Technology Hardware
	Technology Software
Telecom	Telecommunications
Utilities	Utilities

Table 3
Industry Distribution

	Market Percentage by Number of Share Issues	Market Percentage by Capitalisation
Aerospace (& Defence)	0.4	0.5
Automobiles	1.7	2.1
Banks	4.3	12.5
Basic Resources	4.5	2.6
Chemicals	2.3	2.7
Construction	6.5	2.1
Distillers & Brewers	1.7	1.2
Energy	1.4	7.3
Entertainment and Leisure	3.4	1.8
Food	3.8	2.7
Financial Services	7.7	4.0
Technology Hardware	3.3	6.2
Healthcare	3.3	7.5
Industrial Diversified	5.1	2.5
Industrial Equipment	8.7	2.6
Insurance	2.4	6.5
Investment Trusts	5.8	0.9
Media	3.1	3.0
Non Cyclical Goods & Services	1.8	2.2
Real Estate	4.9	1.1
Retail	3.2	3.1
Technology Software	1.1	1.3
Industrial Services	7.9	3.0
Telecommunications	1.4	12.5
Textiles	3.1	1.0
Tobacco	0.7	1.3
Transportation	3.8	1.1
Travel	0.5	0.5
Utilities	2.1	4.4

Table 4
Country Distribution

Country	Market Percentage by Number of Share Issues	Market Percentage by Capitalisation
Austria	1.5	0.3
Belgium	2.4	2.4
Denmark	5.7	1.4
Finland	2.5	3.0
France	5.2	13.7
Germany	11.8	13.3
Greece	4.7	2.1
Ireland	1.0	0.7
Italy	5.4	6.6
Netherlands	3.1	6.9
Norway	3.1	0.8
Portugal	1.9	0.7
Spain	5.7	4.2
Sweden	7.0	4.1
Switzerland	5.1	7.5
United Kingdom	33.8	32.2

Table 5
R^2 Statistics and Numbers of Significant Factors

Date	Adjusted R^2	No. of Sig. Country Factors (Out of 16)	No. of Sig. Industry Factors (Out of 58)	No. of Sig. Risk Index Factors (Out of 9)
Feb-91	59.2	5	51	2
Mar-91	36.8	9	13	2
Apr-91	19.8	4	6	1
May-91	32.1	9	6	2
Jun-91	38.3	4	30	2
Jul-91	29.5	4	7	4
Aug-91	28.4	6	11	1
Sep-91	30.1	6	30	1
Oct-91	33.1	8	27	3
Nov-91	40.7	7	26	2
Dec-91	25.5	4	8	7
Jan-92	33.7	6	38	4
Feb-92	28.0	8	9	3
Mar-92	39.2	7	10	1
Apr-92	48.6	6	8	5
May-92	24.6	5	9	6
Jun-92	58.9	5	41	4
Jul-92	54.0	3	33	3
Aug-92	31.8	8	32	3
Sep-92	42.9	8	11	4
Oct-92	38.1	9	9	2
Nov-92	33.2	5	10	0
Dec-92	35.3	4	9	1
Jan-93	34.0	6	11	3
Feb-93	35.8	8	31	1
Mar-93	30.5	7	15	1
Apr-93	29.1	8	7	2
May-93	24.3	5	13	2
Jun-93	30.3	6	24	3
Jul-93	29.5	4	33	2
Aug-93	47.4	5	34	0
Sep-93	20.0	4	26	2
Oct-93	39.7	6	38	2
Nov-93	23.9	5	4	2
Dec-93	48.0	3	42	2
Jan-94	47.7	5	31	3
Feb-94	32.7	2	32	3
Mar-94	47.6	5	26	2
Apr-94	32.7	9	15	3

Date	Adjusted R^2	No. of Sig. Country Factors (Out of 16)	No. of Sig. Industry Factors (Out of 58)	No. of Sig. Risk Index Factors (Out of 9)
May-94	39.3	8	45	1
Jun-94	40.4	3	40	2
Jul-94	37.6	4	43	4
Aug-94	39.5	8	17	4
Sep-94	6.2	5	29	2
Oct-94	25.0	5	10	2
Nov-94	22.6	4	14	2
Dec-94	15.0	4	9	3
Jan-95	34.4	7	24	3
Feb-95	18.6	4	10	0
Mar-95	37.8	9	12	3
Apr-95	35.7	10	36	4
May-95	28.1	2	14	2
Jun-95	26.7	7	11	3
Jul-95	35.6	5	31	1
Aug-95	23.2	4	8	5
Sep-95	26.3	6	8	1
Oct-95	28.1	4	12	1
Nov-95	30.0	6	16	0
Dec-95	21.4	2	6	0
Jan-96	31.3	4	28	4
Feb-96	24.3	5	9	4
Mar-96	19.8	1	7	3
Apr-96	39.3	6	12	1
May-96	21.5	3	6	1
Jun-96	22.4	2	11	4
Jul-96	40.9	3	20	4
Aug-96	28.8	5	24	3
Sep-96	27.1	2	25	3
Oct-96	20.5	3	7	3
Nov-96	33.5	6	36	2
Dec-96	26.6	6	16	5
Jan-97	43.9	4	29	2
Feb-97	45.0	7	27	3
Mar-97	24.1	3	12	2
Apr-97	32.4	9	20	4
May-97	38.1	6	33	1
Jun-97	51.3	7	46	1
Jul-97	52.3	7	47	2
Aug-97	55.1	9	51	4
Sep-97	56.9	8	47	4
Oct-97	60.7	4	43	7

Date	Adjusted R^2	No. of Sig. Country Factors (Out of 16)	No. of Sig. Industry Factors (Out of 58)	No. of Sig. Risk Index Factors (Out of 9)
Nov-97	35.3	9	20	2
Dec-97	38.2	3	18	2
Jan-98	46.9	12	32	1
Feb-98	50.6	8	44	2
Mar-98	62.0	11	54	3
Apr-98	33.7	8	12	2
May-98	34.4	8	9	3
Jun-98	46.3	9	22	5
Jul-98	36.4	5	16	2
Aug-98	74.6	10	58	2
Sep-98	51.3	6	36	5
Oct-98	48.6	7	35	5
Nov-98	49.6	9	27	3
Dec-98	26.3	8	27	3
Jan-99	31.4	7	14	4
Feb-99	31.7	6	15	3
Mar-99	38.3	7	14	4
Apr-99	54.4	5	31	2
May-99	35.5	5	21	3
Jun-99	25.5	1	11	2
Jul-99	28.1	6	16	1
Aug-99	36.2	5	18	1
Sep-99	30.8	5	23	5
Oct-99	30.3	3	15	3
Nov-99	45.8	6	25	4
Dec-99	49.3	7	30	3
Jan-00	39.3	8	34	4
Feb-00	44.1	6	20	5
Mar-00	37.4	7	15	4
Apr-00	37.0	5	13	5
May-00	29.7	6	10	4
Jun-00	28.2	8	17	2
Jul-00	19.3	6	14	4
Aug-00	33.7	7	18	3
Sep-00	45.0	6	20	3
Oct-00	32.2	5	12	5
Nov-00	55.5	3	30	4
Average	**35.9**	**5.8**	**22.1**	**2.7**

Table 6
Factor Significance and Factor Betas

Factor	Percentage of Months Significant	Beta of Factor Returns Against Market
Size	50.8	0.06
Momentum	48.3	-0.05
Market Sensitivity	39.0	0.17
Variability	30.5	0.08
Growth	18.6	0.04
Leverage	22.9	-0.01
Value	23.7	0.02
Foreign Exposure	26.3	0.03
Yield Risk Index	14.4	-0.01
Continental Chemicals	38.1	0.98
Continental Basic Resources	50.0	1.05
Continental Automobiles	44.9	1.10
Continental Entertainment	30.5	0.99
Continental Travel	28.8	0.97
Continental Textiles	25.4	0.93
Continental Retail	45.8	0.78
Continental Media	31.4	0.93
Continental Energy	49.2	0.89
Continental Banking	50.8	1.12
Continental Insurance	50.0	0.95
Continental Financial Services	50.0	1.11
Continental Real Estate	29.7	0.72
Continental Investment Trusts	15.3	0.85
Continental Healthcare	43.2	0.79
Continental Construction	46.6	1.03
Continental Industrial Equipment	55.1	1.03
Continental Industrial Services	51.7	1.06
Continental Industrial Diversified	38.1	1.00
Continental Transportation	38.1	1.03
Continental Aerospace & Defence	28.8	0.97
Continental Food	39.0	0.79
Continental Distillers & Brewers	22.0	0.75
Continental Tobacco	13.6	0.64
Continental Non-Cyclical Goods	36.4	1.02
Continental Technology Hardware	45.8	1.26
Continental Technology Software	21.2	1.29
Continental Telecom	59.3	1.18
Continental Utility	43.2	0.74
UK Chemicals	32.2	0.96
UK Basic Resources	37.3	0.97

Factor	Percentage of Months Significant	Beta of Factor Returns Against Market
UK Automobiles	32.2	1.08
UK Entertainment	31.4	1.12
UK Travel	42.4	1.02
UK Textiles	16.9	0.86
UK Retail	37.3	0.78
UK Media	39.0	0.98
UK Energy	49.2	0.80
UK Banking	64.4	1.04
UK Insurance	36.4	0.89
UK Financial Services	39.8	1.20
UK Real Estate	36.4	0.80
UK Investment Trusts	45.8	1.24
UK Healthcare	51.7	0.71
UK Construction	44.1	1.10
UK Industrial Equipment	38.1	1.12
UK Industrial Services	39.8	0.94
UK Industrial Diversified	30.5	1.06
UK Transportation	24.6	0.97
UK Aerospace & Defence	43.2	1.13
UK Food	33.1	0.86
UK Distillers & Brewers	32.2	0.84
UK Tobacco	35.6	0.76
UK Non-Cyclical Goods	16.9	0.99
UK Technology Hardware	29.7	1.20
UK Technology Software	22.9	1.17
UK Telecom	62.7	1.15
UK Utility	46.6	0.71
Austria	22.0	0.06
Belgium	21.2	-0.10
Finland	27.1	-0.17
France	44.1	0.22
Germany	41.5	-0.01
Ireland	37.3	-0.05
Italy	49.2	-0.10
Netherlands	13.6	-0.04
Portugal	58.5	0.14
Spain	33.9	0.01
Denmark	29.7	0.11
Greece	30.5	-0.02
Norway	39.8	0.16
Sweden	42.4	-0.10
Switzerland	33.9	-0.02
United Kingdom	58.5	-0.04

Table 7
Portfolio R^2 Statistics

	STOXX		STOXX Technology		STOXX Industrial	
Date	EUE1	EUE2	EUE1	EUE2	EUE1	EUE2
Feb-97	48.0%	56.4%	26.2%	66.0%	5.4%	30.6%
Mar-97	33.1%	42.0%	33.6%	74.4%	-14.8%	7.5%
Apr-97	37.8%	45.9%	27.6%	50.2%	-1.2%	10.0%
May-97	42.4%	48.0%	42.0%	51.0%	36.6%	52.4%
Jun-97	60.0%	68.6%	53.7%	79.6%	46.0%	52.5%
Jul-97	62.8%	69.3%	83.0%	82.1%	33.1%	48.6%
Aug-97	72.7%	75.6%	87.4%	85.3%	31.2%	42.7%
Sep-97	67.0%	70.8%	79.4%	81.2%	44.1%	69.1%
Oct-97	69.3%	74.5%	48.4%	67.1%	78.5%	81.8%
Nov-97	38.3%	50.1%	-11.8%	29.6%	32.4%	43.9%
Dec-97	58.6%	60.6%	1.5%	61.2%	27.5%	57.4%
Jan-98	52.4%	56.9%	60.7%	77.4%	2.4%	7.4%
Feb-98	58.3%	64.0%	66.9%	70.4%	47.8%	49.2%
Mar-98	63.1%	69.8%	48.3%	61.9%	67.4%	77.4%
Apr-98	26.6%	36.6%	27.1%	44.7%	14.2%	20.3%
May-98	39.2%	44.7%	62.1%	65.7%	44.9%	51.3%
Jun-98	37.8%	49.6%	31.7%	66.8%	32.3%	61.5%
Jul-98	40.7%	48.4%	17.9%	32.8%	11.4%	7.6%
Aug-98	80.1%	83.6%	86.6%	86.0%	67.4%	65.8%
Sep-98	56.4%	63.6%	61.6%	70.3%	37.8%	48.7%
Oct-98	50.1%	63.2%	34.1%	54.3%	37.6%	36.9%
Nov-98	61.5%	65.3%	78.5%	79.7%	39.6%	46.2%
Dec-98	33.6%	40.2%	33.8%	47.9%	5.7%	10.3%
Jan-99	36.9%	45.0%	34.0%	46.6%	1.1%	31.2%
Feb-99	37.4%	41.4%	25.5%	4.5%	27.5%	47.2%
Mar-99	45.0%	59.2%	23.1%	70.2%	10.2%	37.7%
Apr-99	59.4%	67.1%	60.2%	70.0%	49.9%	67.6%
May-99	43.9%	48.4%	24.9%	28.8%	19.1%	22.4%
Jun-99	37.2%	40.4%	67.5%	65.9%	38.7%	39.2%
Jul-99	37.3%	44.0%	15.6%	20.0%	-4.5%	21.0%
Aug-99	27.8%	34.2%	21.2%	44.4%	28.5%	40.8%
Sep-99	28.6%	32.5%	-14.4%	13.1%	14.2%	17.6%
Oct-99	42.4%	42.4%	58.0%	64.4%	-20.7%	-96.6%
Nov-99	63.3%	67.5%	77.8%	81.3%	19.9%	46.3%
Dec-99	62.4%	64.1%	76.5%	79.6%	63.2%	51.8%
Jan-00	51.8%	54.9%	25.4%	29.7%	37.9%	27.4%
Feb-00	52.5%	57.4%	68.2%	70.7%	26.8%	67.5%
Mar-00	54.3%	54.3%	47.4%	50.2%	27.0%	41.8%

	STOXX		STOXX Technology		STOXX Industrial	
Date	EUE1	EUE2	EUE1	EUE2	EUE1	EUE2
Apr-00	38.5%	52.5%	2.8%	55.6%	9.6%	13.5%
May-00	38.0%	41.3%	66.3%	75.5%	21.0%	43.8%
Jun-00	29.3%	37.8%	9.3%	25.3%	15.8%	26.7%
Jul-00	20.3%	28.7%	15.9%	36.4%	14.8%	29.2%
Aug-00	40.0%	43.7%	60.8%	64.0%	-3.1%	15.6%
Sep-00	53.5%	65.4%	71.1%	84.0%	31.0%	56.7%
Oct-00	27.9%	41.7%	8.8%	45.4%	14.7%	11.5%
Nov-00	61.2%	68.1%	69.9%	85.0%	42.8%	40.4%
Average	**47.4%**	**53.9%**	**43.4%**	**58.6%**	**26.4%**	**36.5%**
Difference		**6.5%**		**15.2%**		**10.1%**

Table 8
Bias Tests

Portfolio	EUE2	EUE1
AEX	1.03	1.10
BEL20	1.00	1.08
CAC40	1.12	1.18
DAX	1.17	1.25
EURAUT	0.79	0.88
EURBEL	1.35	0.66
EURDEN	0.81	0.75
EURFIN	0.96	0.81
EURFRA	0.83	0.74
EURGER	0.98	1.04
EURIRE	0.79	0.58
EURITA	0.95	0.80
EURNET	0.92	0.80
EURNOR	0.67	0.76
EUROTOP	1.09	1.14
EURSPA	0.77	0.73
EURSWE	0.87	0.70
EURSWI	0.65	0.41
EURUKI	0.85	0.72
FT100	0.99	1.00
FTALL	1.00	1.01
FTAUT	0.96	1.20
FTBEL	1.03	1.10
FTDEN	1.04	1.18

Portfolio	EUE2	EUE1
FTFIN	1.18	1.18
FTFRA	1.07	1.16
FTGER	1.09	1.17
FTIRE	1.03	1.07
FTITA	1.00	1.01
FTNET	0.97	1.03
FTNOR	1.12	1.14
FTSPA	1.11	1.16
FTSWE	1.09	1.09
FTSWI	1.08	1.11
FTUKI	1.00	1.01
MIB30	1.04	1.04
OMX	1.03	1.03
SMI	1.12	1.16
STX	1.10	1.14
STX50	1.12	1.15
STXAUTO	1.03	1.14
STXBANK	1.24	1.30
STXBASI	1.32	1.35
STXCCYC	1.28	1.39
STXCHEM	1.25	1.34
STXCNON	0.94	1.02
STXCONS	1.12	1.20
STXE	1.12	1.18
STXE50	1.10	1.15
STXENRG	1.22	1.22
STXFDBV	1.11	1.16
STXFINS	1.35	1.40
STXINDU	1.26	1.31
STXINSU	1.17	1.20
STXMEDI	1.51	1.49
STXPHRM	1.01	1.01
STXRETL	0.98	1.02
STXTECH	1.40	1.50
STXTELE	1.40	1.32
STXUTIL	0.96	1.00
UNIV	0.81	0.66

Appendix
The Linear Constraints on Country and Industry Factors

The factor model includes 16 country dummies and 58 industry dummies. Each asset has a unit exposure to one country dummy and one industry dummy, and this creates a singularity in the matrix of independent variables. To see the problem intuitively, consider adding 10% (or any arbitrary amount) to each of the 16 country factor returns, and subtracting the same 10% amount from each of the 58 industry factor returns. Since every asset has unit exposure to exactly one industry factor and one country factor, every asset has 10% added and 10% subtracted from its explained return – leaving every asset's explained return unchanged. So we can make these changes without affecting the fit of the model – that is the nature of an indeterminacy. We need to put a constraint on the factor returns to "identify" them, that is, to properly separate the country factor returns from the industry factor returns.

We resolve the indeterminacy by placing a linear constraint on the country factor returns. The weighted average country factor return is constrained to equal zero. We use the square root of equity capitalisation of each security as weights. The linear constraint is therefore:

$$\sum_{j=1}^{16}\sum_{i=1}^{n}(CAP_i)^{1/2} d_{ij}^{c} f_j^{c} = 0 \qquad \text{(A1)}$$

where CAP_i is the market capitalisation of security i, δ_{ij}^{c} equals 1 if security i is in country j and zero otherwise, f_j^{c} is country factor return j, and n is the number of securities in the model.

If the model had only one set of industry factors then (A1) would fully resolve the indeterminacy. However the presence of two full sets of industry factors, one for the UK and one for all other countries, means that (A1) alone is not enough. We need to ensure that the UK and continental industry factor returns capture the same overall market move, so that the constraint (A1) is binding. To do this, we constrain the weighted sum of the differences between the UK and continental industry factors to equal zero:

$$\sum_{h=1}^{19}\sum_{i=1}^{n}(CAP_i)^{1/2}(d_{ih}^{UK} + d_{ih}^{Con})(f_h^{UK} - f_h^{Con}) = 0 \qquad \text{(A2)}$$

where δ_{ih}^{UK} equals 1 if security i is in UK industry h and zero otherwise, f_h^{UK} is UK industry factor return h, and δ_{ih}^{Con}, f_h^{Con} are defined similarly for continental industries.