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Analysis of European Stock Returns: Evidence of a New Risk Factor

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Abstract

Due to the increasing importance of industry diversification, we analyse the sector risk structure of European stock markets. The presence of a new factor correlated to the *new economy* statistically explains returns variability in recent years.

1. INTRODUCTION

Historically country effects have been dominant in explaining variations in international stock returns with the consequence that investors diversify their portfolios according to this evidence. Nevertheless increasing integration of international stock markets, in Europe especially due to Euro introduction, makes country diversification less relevant. In addition the impact of industrial sector effects is becoming roughly equals to that of country ones. Table 1 shows movements in stock indexes correlation from 1993-1996 period to 1997-2000 respectively at country and sector levels. While country correlation has widely increased between the two subperiods, correlation among industrial sector of EMU countries decreased although if it still remains at high level with respect to the benchmark industrial correlation of United States, that in the last period was lower than 0.5. Moreover, both in USA and EMU countries financial market volatility has widely increased in recent years (Fig.1).

The purpose of the paper is to go deepen in to the new correlation structure of equity market with the aim of evaluating features of the industrial structure for performing new portfolio strategies. We study annualized returns of industrial sector from the beginning of 1997 to the end of October 2000 (252 weekly observations). All data are derived by seasonally unadjusted close prices, on each Wednesday of the period. The sector classification of industries proposed by Datastream was adopted principal industries composing each sector are summarized in the appendix.

The paper develops as follows. In the first section the general valuation model is presented. Then its statistical counterpart, the latent factor analysis, is carried out to identify number and features of risk factors of

Table 1: Average Monthly Index Returns Correlations

	EMU		USA
	country	*sector*	*sector*
1993-1996	0.475	0.703	0.418
1997-2000	0.678	0.621	0.470

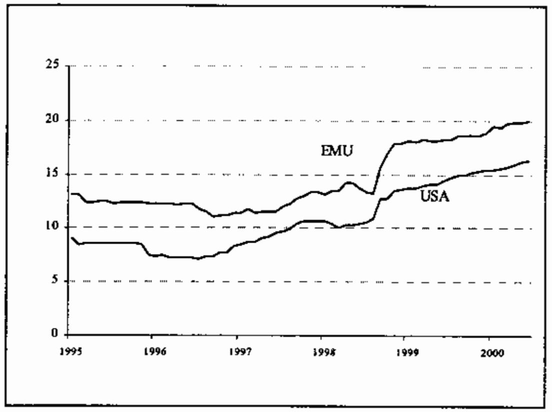

Figure 1: Equity Market Indexes Volatilities

European stock market and an interpretation of latent factors is provided. Finally explanatory power of identified risk factors is tested by means of an extended CAPM model.

2. THE ARBITRAGE PRICING MODEL

The most general approach to explain asset pricing in terms of risk factors is the well known Arbitrage Pricing Theory (APT) obtained through arbitrage motivations (Ross 1976). Following APT, equities prices are drawn by a returns generator process which linearly composes K different risk factors plus an idiosyncratic residual component. Letting for time t, $\mathbf{R}_t$ be the equities returns vector, $\mathbf{f}_t$ the K unknown factors' vector and $\mathbf{e}_t$ the residual risk components, the model could be stated as:

$$\mathbf{R}_t = \boldsymbol{\mu} + B\mathbf{f}_t + \mathbf{e}_t$$

with

$$\begin{aligned} E(\mathbf{R}_t) &= \boldsymbol{\mu} \qquad E(\mathbf{R}_t\mathbf{R}_t') = \Sigma \\ E(\mathbf{f}_t) &= \mathbf{0} \qquad E\left(\mathbf{f}_t'\mathbf{e}_t\right) = 0 \\ E(\mathbf{e}_t) &= \mathbf{0} \qquad E\left(\mathbf{e}_t\mathbf{e}_t'\right) = diag\{\psi_i\} = \Psi \end{aligned} \tag{1}$$

In the model, the vector $\boldsymbol{\mu}$ contains the idiosyncratic returns' components, the $n \times K$ matrix B is the coefficients' matrix which indicates both the exposition of each equity on systematic risk factors and, contemporaneously, systematic risk factor's contribution on each equity return. Such a model, leaving to empirical matters the question of the number of factors and their economic meaning, allows to explore the unknown structure of equity returns comovements. Not surprisingly, application of APT have produced a wide range of results. Some applications have used as factors macro-economic variables such as rate of GDP growth, inflation, interest rate, or micro-economic such as book-to-price and size (Fama and French 1995, Fama and French 1996). At the opposite purely statistical factors derived by non structural analysis or correlated indices were adopted. In a wide setting, a number of studies (Baca, Garbe and Weiss 1996, Beckers, Grinold, Rudd and Stekek 1992, Beckers, Connor and Curds 1996, Cavaglia, Brightmman and Aked 2000, Rouwenhorst 1999, Brooks, Faff and McKenzie 2002) postulated that security prices are determined by a global equity market factor, country specific factors, global and/or local industry factors and common company characteristics (micro-economic indexes).

2.1 Explorative factor analysis: number and features of risk factors

A natural statistical counterpart for APT analysis has been widely acknowledged to be developed in latent factor analysis framework. In fact, this methodology provides dimensionality reduction allowing a representation of a system of P variables into a more parsimonious one of $K < P$ uncorrelated latent factors. The further assumption with respect to the economic model is orthogonality of factors, that is

$$E\left(\mathbf{f}_t\mathbf{f}_t'\right) = 0$$

which as relevant feature produces the decomposition of the original covariance matrix into two components

$$\begin{aligned} \Sigma &= E\left[(B\mathbf{f}_t + \mathbf{e}_t)(B\mathbf{f}_t + \mathbf{e}_t)'\right] \\ &= BB' + \Psi \end{aligned} \tag{2}$$

where the correlation structure of the original system is completely explained by means of the coefficients' matrix B, that is by the common risk factors, because of diagonality of Ψ. In the statistical factor analysis nomenclature the matrices in decomposition (2) are respectively named *communality* and *specificities matrices*, which in financial interpretation remind to the common and idiosyncratic risk's components. The undesirable features of factor analysis modeling come from the fact that there is not a clear way of deciding if the model is appropriate or not, and if so, how many factors are relevant. Finally the estimated factors are not uniquely identifiable. The simultaneous decomposition (2) and estimation could be implemented by means of different way according to different purposes. In the following analysis, a normal multivariate distribution for equity returns is assumed to retrieve factors through likelihood maximization and to verify how many of them are significant. The main criteria to choose the number of significant factors are maximum likelihood, likelihood ratio test and Akaike and Schwartz information criteria. To avoid the overfitting effect of likelihood ratio test, a cross validation technique, which consists in calculating the likelihood value after splitting data set into sub-sets composed by alternate observations has been implemented (Conway and Reinganum 1988). The results are presented in table 2. Information criteria provide indication for a one factor model, while likelihood value and ratio tests find significant evidence of more factors with the relevant incremental explanatory power obtained in passing from one to two factors specification. Cross validation provides coherent results (see Tab. 2).

An alternative approach to determine factors' number in a factor analysis is based upon measurement of quantity of variance, i.e. information, explained by the model; the approach includes the ratio of global variance explained by the specific factor representation, the *eigenvalue 1 criterium* that is the number of factors whose eigenvalue is greater than unity, as proposed by Guttman (Jobson 1992), and, among the others, by the number of the off-diagonal elements of the estimated matrix Ψ greater than a threshold level, for example $|\psi_{ij}| > 0.5$. Table 3 provides evidence of two significant factors which explains about the 70% of overall variance. Results are robust to the frequency of observations given that we controlled for weekly and monthly returns.

Off-diagonal elements greater than the threshold value are 68% for $K = 1$, 11% for $K = 2$ and 2% for $K = 3$ so that the most high reduction

of number of out of threshold specificities is produced by introduction of a second factor.

Table 2: Likelihood Based Results

Likelihood Based Results				
N. of factors	**1**	**2**	**3**	**4**
LR test	483.77	102.70	43.42	16.91
p -value	*0.0000*	*0.0000*	*0.0007*	*0.1110*
Likelihood	-1.97	-0.42	-0.18	-0.07
Schwartz criterium	112.09	160.01	203.70	241.97
Akaike criterium	41.96	58.42	74.18	88.07
Cross-validation results				
Sub-set 1				
Likelihood	-2.76	-1.21	-1.09	-1.01
Schwartz criterium	98.54	139.93	177.79	241.97
Akaike criterium	42.76	59.21	75.01	88.07
Sub-set 2				
Likelihood	-1.94	-1.32	-1.15	-1.18
Schwartz criterium	97.71	140.04	177.96	241.97
Akaike criterium	41.94	59.32	75.18	88.07

For a K factor model a test of goodness of fit is carried out by comparing restricted estimate ${}_K\widehat{\Sigma}$ to $\frac{n-1}{n}S$ which is the maximum likelihood unristricted estimator of Σ. The null hypothesis is that the residual correlation matrix is diagonal (spherical) after removing the K common factors. The test statistic, in large sample, follows a χ^2 distribution. Akaike and Schwartz information criteria are likelihood based methods which penalize the likelihood function statistic for the increasing numbers of factors in the analysis. Denoting the value of log-likelihood statistic L, the Akaike criterium is $(L + 2q)$ where $q = n\,(K + 1) - \frac{K(K-1)}{2}$. The Schwartz criterium is given by $(L + q \ln N^*)$ where N^* is the Bartlett's correction $N^* = \left[\frac{N-(2n+4K+11)}{6}\right]$. According these criteria, the number of factors K is chosen to minimize the value of the criterium.

The presence of a second risk factor in European equity market is quite

Table 3: Number of Factors of Monthly and Weekly Returns

N. of factors	Eigenvalues 1	2	3	4	Variance Ratio	LR test	p-value
Monthly returns							
1	6.257				63.0	160.27	0.000
2	6.240	1.067			73.1	63.27	0.000
3	6.222	1.152	0.546		85.3	33.43	0.015
4	6.351	0.999	0.667	0.302	90.2	18.12	0.079
Weekly returns							
1	5.927				59.3	483.77	0.000
2	5.800	1.200			70.0	102.70	0.000
3	5.820	1.235	0.334		73.9	43.42	0.000
4	5.395	1.616	0.655	0.170	78.4	16.91	0.111

surprising at this level of aggregation; rolling back the observation window, we controlled when the new correlation structure arose: the second factor appears evident only in recent periods, beginning from 1997. A further control was performed through cross-sectional validation technique. Explanatory power of factor loadings, estimated by maximum likelihood, have been tested cross-sectionally through the following specification:

$$\begin{aligned} R_{it} &= \lambda_{0t} + \lambda_{1t}\widehat{b}_{i1} + \lambda_{2t}\widehat{b}_{i2} + e_{it} \\ t &= 1, ..., 252 \qquad i = 1, ..., 10 \end{aligned} \tag{3}$$

Estimation of (3) confirms that the new factor appeared recently, with a very high percentage of significative cross sectional coefficients in 1999 and 2000 (Tab. 4).

The explorative risk-factor analysis should be concluded by providing latent factor interpretation; the first factor as usual represents market risk; the highest the coefficients loadings, the greater is the correlation of industries with market movements. The second factor (Tab. 5), which explains about 12% of total risk, is positively related to non cyclical and cyclical service sectors including media and telecommunication, to information technology sector and with a lesser extent to general industries while it shows negative or no relation with respect to other sectors. Being related to technological and media sectors, it could be interpreted as a *new economy* factor.

Table 4: Cross Sectional Regression Tests

	N.	Number of significative coefficients λ_0	λ_1	λ_2	F	Percentage of significative coefficients λ_0	λ_1	λ_2	F
1996	51	19	13	4	8	37.3	25.5	7.8	15.7
1997	52	13	10	3	5	25.0	19.2	5.8	9.6
1998	53	5	7	7	4	9.4	13.2	13.2	7.5
1999	52	10	9	21	14	19.2	17.3	40.4	26.9
2000	44	9	9	30	28	20.5	20.5	68.2	63.6
Tot.	252	56	48	65	59	22.2	19.0	25.8	23.4

3. THE EXTENDED CAPITAL ASSET PRICING MODEL

The explorative analysis shows covariations in returns related to a *new economy* factor, beyond systematic market risk. In order to explicitly test the explanatory power of risk factors on equity patterns we provide an explicit formulation of the *new economy* factor and we test it through an extended CAPM. An advantage is that, in portfolio management, the observable variable explaining returns could be adopted as hedging instrument.

The general setting is implemented by means of the introduction of further regressors into the original CAPM (Sharpe 1964), following Fama and French methodology (Fama and French 1996), the new formulation is as follows,

$$E\left(R_i\right) - R_f = \beta_{iM}\, E\left(R_M - R_f\right) + \beta_{i\Pi}\, E\left(R_{\Pi_{\min}} - R_{\Pi_{\max}}\right)$$

where $E\left(R_{\Pi_{\min}} - R_{\Pi_{\max}}\right)$ should be determined by differential returns of two portfolio opposite with respect to a specified criterium. The adopted

Table 5: Two Factors Model Estimates

	b_1	b_2
Resources	0.523	-0.160
Basic	0.872	0.000
General Industrials	0.849	0.369
Cyclical Goods	0.913	-0.142
Non Cyclical Goods	0.780	-0.236
Cyclical Services	0.762	0.517
Non-Cyclical Services	0.656	0.604
Utilities	0.656	0.000
Information Technology	0.649	0.562
Financials	0.860	0.000

measurements for *new* and *old economy* proxies consisted in defining the spread in terms of differential returns between the most and less *new economy* - correlated sectors, that is non cyclical services and utilities industries indexes.

Given that ARCH Lagrange Multiplier tests revealed significant heteroskedasticity in residual series and CUSUM tests detected a structural change of coefficients during 1999, the following specification was implemented:

$$R_{it} - R_{ft} = \alpha_i + \beta_{iM}\left(R_{Mt} - R_{ft}\right) + +I_{2000}\left[\beta_{i\Pi}\left(R_{\Pi_{NCS}t} - R_{\Pi_{UTI}t}\right)\right] + e_{it}$$

$$e_{it} \sim N(0, \sigma_{it}^2) \qquad \sigma_{it}^2 = \omega + \rho\sigma_{it-1}^2 + \gamma e_{it-1}^2 \tag{4}$$

The excess return $(R_{Mt} - R_{ft})$, indicates market risk premium, while the "new versus old economy" spread is the further risk premium to the new risk factor. For each equation, the null hypothesis $H_0 : \alpha_i = 0$ has a crucial role in the empirical verification in CAPM framework since it allows to evaluate return variability not explained by the model. From the estimation results, provided in table 6, it can be observed that $\widehat{\alpha_i}$ coefficients are generally not significant. The analyses of residuals series show absence of

autocorrelation and few violations of the normality hypothesis. The *new economy* coefficients are negative or null in traditional sectors' valuation models, positive for industries with media and telecommunication contents. The adopted specification always seems to explain a relevant component of variability suggesting that the return generating processes of stock market equity returns could be properly described by the two proposed factor.

Table 6: Extended CAPM estimates

	Coeff.	Std. Err.	t	p-value		
RES	0.039	0.144	0.273	0.785	R^2	0.259
	0.805	0.068	11.754	0.000	**DW**	2.229
	-0.317	0.073	-4.373	0.000	**JB**	*6.630
BAS	-0.023	0.089	-0.254	0.800	R^2	0.647
	0.861	0.039	22.117	0.000	**DW**	1.850
	-0.254	0.045	-5.602	0.000	**JB**	3.405
GEN	-0.081	0.056	-1.447	0.149	R^2	0.838
	1.024	0.026	39.563	0.000	**DW**	2.171
	-0.014	0.031	-0.459	0.647	**JB**	0.634
CYG	-0.137	0.089	-1.537	0.126	R^2	0.730
	1.144	0.039	29.393	0.000	**DW**	1.714
	-0.450	0.041	-10.964	0.000	**JB**	0.187
NCG	0.041	0.068	0.607	0.544	R^2	0.656
	0.827	0.031	26.590	0.000	**DW**	1.931
	-0.508	0.039	-13.178	0.000	**JB**	0.045
CYS	-0.015	0.061	-0.250	0.803	R^2	0.798
	0.818	0.025	32.913	0.000	**DW**	1.876
	0.141	0.034	4.139	0.000	**JB**	5.714
ITE	0.397	0.174	2.283	0.023	R^2	0.692
	1.372	0.074	18.554	0.000	**DW**	2.052
	0.371	0.068	5.430	0.000	**JB**	**40.047
FIN	-0.129	0.057	-2.268	0.024	R^2	0.830
	1.058	0.027	39.384	0.000	**DW**	1.728
	-0.294	0.027	-10.742	0.000	**JB**	3.503

4. CONCLUSIONS

The paper investigation originates from recent evidence that in top-down portfolio management approach securities are always less categorized according to nationality; in fact increasing integration of international stock market, in Europe especially due to Euro introduction, makes country diversification less significant. To go deepen into the new correlation structure of equity market, we studied annualized returns of industrial sector from January, 1997 to October, 2000. The statistical analysis of sectorial risk structure of European stock markets reveals the presence of a new risk factor in addition to the market risk factor. The second factor, which explains about 12% of total risk, is positively related to non cyclical (telecom) and cyclical (media) service sectors, as well as information technology, while it shows negative or no relation with respect to other sectors. For this cause it could be interpreted as a *new economy* factor. Following Fama and French, the spread between non cyclical services and utilities industries index returns has been adopted as proxy of this *new economy* factor. Explicit test of the further factor in a CAPM framework shows that it statistically explains returns variability in recent years.

APPENDIX

Table 7: Sectoral Classification - DATASTREAM

Datastream Sectoral Classification		
Resources	RES	Mining, Oil & Gas
Basic	BAS	Chemicals, Construction & Building Materials, Forestry & Paper, Steel & Other Metals
General Industrials	GEN	Aerospace & Defence, Diversified Industrials Electronic & Electrical Equipment, Engineering & Machinery
Cyclical Goods	CYG	Automobiles, Household Goods & Textiles
Non Cyclical Goods	NCG	Beverages, Food Producers & Processors, Health, Packaging, Personal Care & Household Products Pharmaceuticals, Tobacco
Cyclical Services	CYS	Distributors, Ratilers, General, Leisure, Entertainment & Hotels, Media & Photography Restaurants, Pubs, Breweries Support Services, Tarnsport
Non-Cyclical Services	NCS	Food & Drug Retailers, Telecom Services
Utilities	UTI	Electricity, Gas Distribution, Water
Information Technology	ITE	Information Information Hardware Software & Computer Services
Financials	FIN	Banks , Insurance, Life Assurance, Investment Companies, Real Estate, Speciality & Other Finance

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