Are There Common Trends in European Stock Markets

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Abstract

In this paper, we investigate whether stock price indices of different European countries display a common long run trending behaviour using a multivariate cointegration process. Empirical results reveal that price series are cointegrated both if one considers the countries pairwise, as well as when the complete set is investigated, giving some indication of an integrated European financial market.

KEY WORDS: Common trends, Cointegration, Economic interdependence, Multivariate cointegration, Unit roots

1 Introduction

The objective of the paper is to investigate whether price indices of different European countries display a common long run trending behaviour.

The interdependence of stock markets has been the subject of extensive research for the last two decades. This interest is caused by the increase in the flow of capitals across national bounderies, possible gains from international diversification and the existence of lead-lag interrelationships among stock exchanges. Various methodologies hace been so far employed. Without attempting an extensive list of these studies, early interesting papers on international portfolio diversification are Grubel (1968), Levy and Sarnat(1970) and Solnik (1974). As for lead and lag relationships, see Agmon (1974) and Hamao, Masulis and Ng (1990).

The research methodology employed in this paper is different. As it is well known, stock price series are non stationary. Calculating returns series as differences in log prices and, in some cases, by differencing the series, can produce a stationary process. By using returns in the analysis, information about the long-run components in the price series is lost. This is a major drawback for the analysis of the time series of stock prices, especially when long term relationships are studied. The possible presence of long term components in price series cannot be captured, for instance, by a random walk return generating process model.

An approach that can be interesting for modelling stock prices when series are not stationary is the use of the concept of cointegration. This concept is particularly relevant if it can be shown that the stock prices of two or more countries are subject to a common market trend, as one could expect to be the case of the European countries. Cointegration among a set of variables implies that there exists some fundamental economic forces which makes variables move stochastically together over time. Cointegration thus allows estimation and testing of long run economic theoretical relationships between integrated economic time series.

2 Data

The price indices of five European stock markets were collected from DATASTREAM for the period 1/1/73 to 30/9/91. They are indices for France (CAC General), Germany (Commerzbank), Italy (Milan Banca), the Netherlands (ANP-CBS general) and the U.K. (FT All-Shares).

3 Methodology

Cointegration among a set of variables implies that there exists some fundamental economic forces which makes variables move stochastically together over time. According to Engle and Granger (1987) the components of the vector x_t are said to be cointegrated of order d, b, denoted by $CI(d, b)$, if all the components of x_t are $I(d)$ and there exists a vector $\alpha(\neq 0)$ so that $z_t = \alpha' x_t$ is $I(d-b), b > 0$. The vector α is called the cointegrating vector. In the case where $d = b = 1$, if x_t is cointegrated then each variable in x_t is $I(1)$ and a linear combination of them will be $I(0)$.

The interpretation given to $\alpha' x_t$ is that of long run equilibrium or relationship. Cointegration has been found to hold for a lot of macroeconomic phenomena as well as for interest rates, exchange rates, .. (see inter alia Campbell and Shiller, 1987; Baillie and Bollerlev, 1989). Assume that we can attach an economic interpretation to the condition $\alpha' x_t$ in terms of economic equilibrium, then the quantity z_t can be interpreted as the disequilibrium in period t. If the variables in x_t are cointegrated with cointegrating vector (or matrix if x_t has more than two components) then z_t will be stationary and thus bounded, so that any deviation from the equilibrium will be stationary and will thus be characterised by the fact it will come back to the neighbourhood of its mean (here zero) within a finite time horizon.

Cointegration provides a way of modelling and estimating long run relationships among integrated economic variables which apparently move together over time towards stable relationships. The most simple way for the estimation of cointegrating relationships, and more precisely the detection of these, is the initial static regression framework which was proposed by Engle and Granger (1987). In this simple framework, testing for cointegration among a set of time series is similar to testing for unit roots. The only difference is that we no longer search for unit roots in a observed time series. The null hypothesis to be tested is no cointegration and we search for a unit root in the static regression residuals, i.e. in the deviation from the hypothesized long run equilibrium.

4 Empirical Results and Interpretation

Using biweekly data for the countries mentioned above, we first use this framework for the detection of cointegration relationships. In order to avoid the potential drawbacks of this approach -see below-, we first limit ourselves to pairwise relationships between stock prices. Prior to cointegration analysis, one must however first precise the integration order of the individual series. This is analysed using traditional unit root tests including the well known Dickey and Fuller (1979, 1981) test in its augmented version (we used a 4^th order lagged polynomial in the first differences) and Phillips-Perron (1988) semi-parametrically corrected version. In the latter case, the lag truncation used in the construction of the long run variance estimator proposed by Newey and West (1987) was fixed after some experiments at 4 lags.

As shown in Table 1, the unit root hypothesis, hence the $I(1)$ character, of the series is not rejected at a 5% significance level.

test	France	Germany	Italy	Netherl.	U.K.
τ	-0.9764	-1.0019	-0.6778	-0.8647	-1.8743
τ_μ	-1.9971	-1.5724	-1.4526	-1.7397	-2.7145
τ^*	-0.6528	-0.8515	-0.7487	-0.6965	-1.5225
τ_μ^*	-2.4099	-1.9949	-1.8004	-1.9763	-2.7403
Z	-0.9419	-0.9139	-0.6495	-0.8188	-1.8765
Z_μ	-2.1875	-1.85434	-1.6397	-1.9285	-2.8307

Table 1: **Unit Root tests**

The second step is then to investigate pairwaise cointegration by means of static cointegration regressions where null hypothesis of no cointegration is tested using Dickey-Fuller tests (τ), Augmented Dickey Fuller (τ^*) tests (1981) and the Phillips and Ouliaris (1990) semi-parametrically corrected ADF tests(Z). The subscript "μ" denotes that a linear trend is added in the regresion model. The results are reported in Table 2. In each row corresponds to the results of a simple least squares estimation of the static cointegration regression

$$p_{i,t} = \alpha + \beta p_{j,t} + \varepsilon_t \tag{1}$$

As in the case of the unit root tests the lag truncation in the case of the ADF and the Z statistics is fixed at 4 periods. Critical values are taken from Phillips and Ouiliaris (1990), they are tabulated for 500 observations and one explanatory variable, they are equal to -2.7619 at 5% and -2.4505 at 10% . Significant values of the tests are indicated by a '*' at the 5% level and '**' at the 10% level. The second and third columns are the least squares estimates of the parameters of the static cointegration regression model while the fourth column if the usual R^2.

i/j	$\hat{\alpha}$	$\hat{\beta}$	R^2	ADF	Z
NL/UK	-2.8760	1.1969	.97	-2.5544**	- 2.0120
NL/GER	-5.1697	1.3995	.95	- 2.2740	-2.3231
NL/IT	-.3551	.8829	.84	-1.4592	-1.5429
NL/FR	-.5139	.978 8	.92	-2.6560**	-2.5141**
UK/GER	- 1.6227	1.1278	.89	-2.4501	-2.2454
UK/IT	2.0820	.7418	.88	-1.9166	- 1.8136
UK/FR	2.018	.8095	.93	-3.2163*	-2.7967*
GER/IT	3.5157	.6179	.87	- 2.7093**	-2.5821**
GER/FR	3.4591	.6779	.92	-2.5122**	-2.3479
IT/FR	.4679	.9884	.88	-3.2984	-2.9618*

Table 2: **Bivariate Cointegration tests**

Although extremely simple and appealing for empirical applications, this static regression framework suffers from several drawbacks (for an overview, see Dolado et al, 1991 or Chapter 2 in Urbain, 1992). Among these we may mention:

1. the substantial finite sample biases , the impossibility of identifying more then one cointegrated vector among a k dimensional set of variables with $k > 2$, for which we may naturally find at most $k-1$ cointegrating relationships,

2. the need of semi-parametric correction or model augmentation for conducting inference on the cointegrating relationships by means of χ^2 statistics.

As a response to these limitations and drawbacks, a number of studies have proposed alternative modelling approaches and estimation methods for the estimation of cointegrating relationships among nonstationary economic variables. These include modified single equation procedures and, various multivariate approaches, see Dolado et al. (1991). Among these, and taking a finite order Gaussian VAR model as starting point, Johansen (1988) and Johansen and Juselius(1990) have proposed a maximum likelihood approach for both the problem of estimating and testing the number of cointegrating relationships among the components of a k-vector x_t of variables. Since the Johansen method is used in the empirical analysis of this work we present it in more details.

Consider a VAR representation of the vector stochastic process x_t:

$$x_t = \sum_{i=1}^{n} \Pi_i x_{t-i} + \varepsilon_t \tag{2}$$

and reparametrise it in vector autoregressive error correction format

$$\Delta x_t = \sum_{i=1}^{n-1} \Gamma_i \Delta x_{t-i} + \Gamma_n x_{t-n} + \mu + \varepsilon_t \tag{3}$$

where ε_t denotes a k-dimensional normal variate with mean zero and non-singular, p.d.s. covariance matrix Σ and μ is vector of constant terms. It is assumed that the roots of the implicit characteristic polynomial are outside or on the unit circle : $\Gamma_i = -I + \Pi_1 + \ldots + \Pi_i$ with $i = 1, \ldots.., n$. Γ_i are here *interim* multipliers.

If Γ_n has full rank , than x_t is stationary and all the components are $I(0)$. If rank$(\Gamma_n) = 0$, then all components of x_t are $I(1)$ and the model is a VAR in first differences. The interesting cases arise when rank$(\Gamma_n) = r < k$ in which case there are $k-r$ nonstationary linear combination which have the effects of *common trend* and r linear combinations which are stationary, i.e. there are r *cointegrating* relationships. Γ_n can then be written as $\alpha\beta'$ where both α and β are $(k \times r)$ matrices of full column rank. The r first rows of β' are the r cointegrating vectors while the elements of α are referred to as the *loading factors*, i.e. the weights of the different cointegrating vectors in the different equations.[1] Provided that none of the elements of x_t are integrated of an order higher then one, the maximum likelihood estimates of a basis of the cointegrating space, denoted by $sp(\beta)$, is given by the empirical canonical variates of x_{t-n} with respect to Δx_t corrected for the short run dynamic and the deterministic components. The number of cointegrating relationships is given by the number of significant canonical correlations. Their significance can be tested by means of sequence of Likelihood Ratio (LR) tests whose limiting distribution is expressed in terms of vector Brownian motions (see Johansen, 1988).Two possible test statistics can be used for the hypothesis of r cointegrating vectors. First the so-called *trace test*, i.e. the LR test statistic for the hypothesis that there are at most r cointegrating vectors, given by :

$$-2log(Q) = -T \sum_{i=r+1}^{k} log(1-\lambda_i) \tag{4}$$

where $\lambda_{r+1}, ..., \lambda_k$ are the $k-r$ smallest squared canonical correlations . An alternative is to use the *maximum eigenvalue test* which seeks to compare the hypothesis of r cointegrating vectors against that of $r-1$ cointegrating vectors. The LR test statistic for this hypothesis is given by :

$$-2log(Q) = -Tlog(1-\lambda_r) \tag{5}$$

The limiting distribution of $-2ln(Q)$, which is a function of a $k-r$ dimensional vector Brownian motion, is not independent of the unknown drift term (see Johansen and Juselius, 1990). Critical values have been tabulated by Johansen and Juselius (1990) for various hypothesis concerning the behaviour of the deterministic components.

In any empirical application of the Johansen procedure, the choice of the lag length selected in the VAR has been shown to be important both in

[1]Note that the cointegrating matrix is not identified, but the space spanned by its columns is : for any non-singular $(r \times r)$ matrix P we can define $\beta^* = \beta P'$ and $\alpha^* = \alpha P^{-1}$ so that $\alpha^* \beta^{*'} = \alpha\beta'$.

terms of size and power of the cointegration tests. Using various criteria, it appears that the use of a second order VAR model is sufficient to capture the dynamic present in the data. We therefore fitted a vector error correction models such as (3) to our five dimensional vector of variables x_t where the elements of this vector are the stock price series from our selected countries. Note that the model was fitted with a constant and a linear trend term in order to capture the trending character of the series. It is here worth making a remark concerning the potential problem that one can encounter with these financial time series which, as we have seen for the returns, often display conditional heteroskedastic behaviour. First of all, in contrasts to the previous section we base this analysis on bi-weekly data in order to avoid technical problems that we encountered with data set of daily data.

The results are reported in Table (3). as shown, the maximum eigenvalue test test detects the presence of a single cointegration vector at a 10% level. This potential cointegrating vector involves all our six stock prices. Although we do only reject the null of no- cointegration at a 10% level, it should be noted that the LR tests has been shown to lack of power aganist stationary alternative with a root near to one (Johansen, 1990). Wheter potential ARCH effects (see Engle, 1982) affect the power is not yet known. We may nevertheless conjecture, in analogy to traditional unit root tests - see Urbain (1991), that ARCH and GARCH effects do not imply too important size and power distortions of the cointegration test.

Trace Test	H_0	Max. Eigenvalue
3.999	$r \leq 5$	3.999
8.1161	$r \leq 4$	12.1153
13.6373	$r \leq 2$	25.7528
13.9301	$r \leq 1$	39.6829
27.4446	$r = 0$	67.1275**

Table 3: Johansen's cointegration test

Note that a graphical inspection of the time series evolution of the linear combination corresponding to the cointegrating vector reinforces the idea that we have isolated a stationary liner combination. as the time series

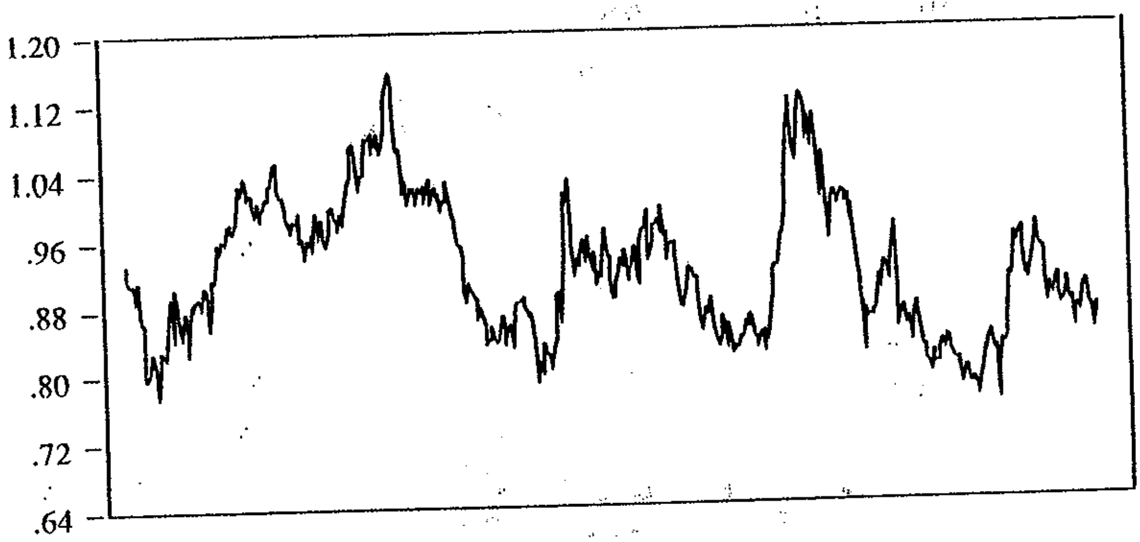

Figure 1: Cointegrating Relationship

profile of long run relationship, represented in Figure 1, appears as stationary and bounded in time .

5 Conclusions and Suggestions for Further Research

Cointegration models, which focuse on the analysis of long term relationships between series, could be also be a relevant framework for the study of the potential links between different national stock markets.

We find that evidence of cointegration between the price series of several indices of our sample. This reveals the existence of some common long run trend among them.

Further research is nevertheless desirable. In particular, we conjecture that, while these series have a common behaviour in their long run evolution, they apparently also share some common behaviour in the persistency of their volatility. The elaboration of multivariate models allowing both to model common trends and common factors in the variance function are certainly a very interesting potential framework in which all these question could be analysed in a unifying way. In particular it would provide a useful framework for the study of the international links that seem to exist among the European stock markets.

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