Stochastic Trends and Cycles in National Stock Market Indices: Evidence from the U.S., the U.K. and Switzerland

FRANK WESTERMANN*

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1. INTRODUCTION

After the Stock market crash of 1987, an apparent pattern of co-movement among national stock markets has motivated an extensive literature started by FÜRTSENBERG and JEON (1989), BERTERO and MAYER (1990), HAMAO et al. (1990), KOCH and KOCH (1991) and CHEUNG and NG (1992), who document the correlation of different stock markets around this time. More generally, the co-movement of stock markets has been further examined in a vector autoregression (VAR) framework by EUN and SHIM (1989), SMITH et al. (1993), MASHI and MASHI (1997), and KNIF and PYNNONEN (1999). Not conditioning the specific event of a crash, the authors find evidence of Granger causality among national markets.[1]

A comparably large literature focuses on estimating the long run co-movements in national stock price indexes, finding mixed evidence about long run common trends. BLACKMAN et al. (1994), MASHI and MASHI (1997), JOCHUM et al. (1999) find evidence in favor of cointegration for mature as well as emerging stock markets. KASA (1992) finds the strongest evidence in favor of cointegration, where all stock markets follow only one common stochastic trend in the long run.[2] STENGOS and PANAS (1992) on the other hand cannot reject the null of no cointegration. Recently this literature has been criticized by RICHARDS (1999) for ignoring the small sample properties of the estimators used. RICHARDS findings support the null hypothesis of no cointegration, using small sample critical values proposed by CHEUNG and LAI (1993), or generating the critical values by Monte Carlo Simulation.

* CESifo (University of Munich and ifo Institute), Schackstr. 4, D-80539 München.

1. Earlier studies on the correlation of national stock markets, following LEVY and SARNAT (1970), found only little evidence of co-movement in data from the 60s and 70s.
2. Some of the articles listed as VAR-studies also incorporate cointegrating vectors in an error correction model, but do not focus on this topic primarily.

FAMA (1981, 1990) and SCHWERT (1990), among others, have shown that national stock markets are linked to their aggregate economic activity. SHILLER (1989, Chapter 19) argues, for instance, that stock prices tend to be low in recessions and high in boom times. This suggests that stock markets should not only move in tandem in the long run, but rather have a short run co-movement if real markets are integrated and experience similar shocks. ENGLE and KOZICKI (1993) have argued that this is the case and document the existence of common cycles in real per capita GDP among G7 countries. This results has been confirmed by BEINE et al. (2000) for European Countries. CHEUNG and WESTERMANN (2000) and PARNISARI (2000) report a common serial correlation feature also for business cycles in Switzerland with those in the United States and other European countries.

The contribution of the present paper is to analyze whether a similar pattern of common cycles is also present in national stock markets. We thereby test the implication which follows from the combination of the argument of SHILLER (1989), with that of ENGLE and KOZICKI (1993) – a common serial correlation pattern in national stock indicies. Most existing short run analysis of stock markets is done in a VAR framework, analyzing lead-lag relationships in the data as described above. Methodologically, our paper differs from the existing work by testing for *common shocks*, rather than the *spillover of shocks*. The setup of our empirical exercise allows for both, common stochastic trends and common stochastic cycles. Specifically, we apply the cointegration test (JOHANSEN, 1991) and the multivariate common features test (VAHID and ENGLE, 1993) to stock market data in three countries, the United States, the United Kingdom and Switzerland.

We find that for weekly data from 1991 to 1999, the S&P500, FTSE and SMI stock indexes are not cointegrated, when applying finite sample critical values suggested by CHEUNG and LAI (1993). We thus confirm the results of RICHARDS (1995). On the other hand, we do find evidence of a common serial correlation feature in the data. The number of stochastic processes driving these three markets in the short run is smaller than the number of variables. In fact our results indicate that all three markets are close to be driven by only one stochastic cycle in the short run.

Investigating the coefficients in the co-feature vectors reveals that not all indices are significant. In particular, the FTSE stock market index is not a member of the co-feature relationship. While the presence of some serial correlation co-movement is evident, the strong conclusion of only one common cyclefor *all* countries, is therefore not supported by the data.

Furthermore, we confirm earlier results on Granger causality in the short run. We find that the U.S. significantly causes the other two markets. In a forecast error variance decomposition, we show that while the effects are of considerable size, the price uncertainty is largely attributable to shocks to the respective national stock market. These results are consistent with the findings in ISAKOV and PERIGNON (2000).

Section 2 gives a preliminary analysis of the data. Section 3 presents the results of the cointegration analysis and VAR model. Section 4 reports the evidence on common serial correlation and section 5 concludes the paper.

2. PRELIMINARY ANALYSIS

Weekly indexes of asset prices in the U.K. (FTSE), Switzerland (SMI) and the U.S. (S&P500) are used in this study. The sample period covers from 1993:1 to 1999:47. The data are end of the week closing prices in logs and were provided by Reuters as in Yahoo! Inc. (finance)/ Commodity Systems Inc.[3]

The augmented Dickey and Fuller (ADF) test allowing for both an intercept and a time trend is employed to determine whether there is a unit root in the data. Let X_{it} be the stock price index of country i (i = the U.S., Switzerland and the U.K.) at time t. The ADF test is based on the regression equation:

$$\Delta X_{it} = \mu_0 + \mu_1 t + \alpha X_{it-1} + \beta_1 \Delta X_{it-1} + \ldots + \beta_1 \Delta X_{it-p} + \varepsilon_t, \tag{1}$$

where Δ is the first difference operator and ε_t is an error term. The Akaike information criterion is used to determine p, the lag parameter. Results of applying the ADF test to the data and their first differences are shown in Table 1. The null hypothesis of a null root is not rejected for the levels and is rejected for the first differenced data. Thus, there is one unit root in each of the three stock market indexes, a result that is consistent with the literature. In the subsequent analysis, we assume the data are difference stationary.

Table 1: Unit Root Test Results

	Levels	First Differences
S&P500	0.67	−10.56*
FTSE	1.19	−10.54*
SMI	0.01	−9.80*

Note: The ADF test statistics calculated from the levels and first differences of the industrial production indexes in logs are reported. The lag parameters were set to two lags. Qualitatively there are no differences for the range of 1–10 lags. "*" indicates significance at the five percent level. The unit root hypothesis is not rejected for the series in levels, but is rejected for their first differences.

The sample correlation coefficients for the first differenced data are 0.55 (Switzerland and the U.K.), 0.42 (The U.K. and the U.S.), and 0.39 (Switzerland and the U.S.). These sample statistics suggest that there is overall quite high correlation, which is highest between the two European countries. More vigorous analyses of the interactions between stock indexes are given in the following sections.

3. Three missing data points in the Swiss SMI index where constructed as the mean of the two neighboring values (Aug. 2nd, 1999, July 26th 1999 and Feb. 1st 1999).

3. LONG RUN AND SHORT RUN INTERACTIONS

3.1. Cointegration Test

The cointegration technique and a vector autoregression model are used to study the long-run and short-run interactions. Information about the long-run behavior is not the focus of this paper, but it is essential for specifying an appropriate model to analyze short-run interactions.

Table 2: Cointegration Test Results

H(0)	Trace Statistic	Maximum Eigenvalue Statistic
$r = 0$	26.56	20.00
$r \leq 1$	6.56	6.55
$r \leq 2$	0.006	0.006

Note: The trace and maximum eigenvalue statistics computed from the trivariate system consisting of S&P500, FTSE and SMI stock indexes are reported. All statistics are not significant according to the finite sample critical values reported in CHEUNG and LAI (1993). Thus the null hypothesis of no-co-integration is not rejected. Two lags were selected as the optimal lag structure by both the AIC and SBC Criterion.

The JOHANSEN (1991) procedure is used to test for the presence of cointegration. As the procedure itself is well known, a detailed description is omitted. The Johansen test results are reported in Table 2. Both the trace and maximum eigenvalue statistics suggest that we cannot reject the null hypothesis of no cointegration. These stock markets under consideration do not experience common permanent shocks that drive their long-term swings and, thus, do not share common long-run trends. This results confirms the findings by RICHARDS (1999) and PANAS (1992), but stands in contrast to other findings mentioned in the introduction.

3.2. Short-Run Interactions

Given the cointegration result, we use a vector autoregression (VAR) model in first differences to explore the effects of short-term variation in the three stock markets. Specifically, the changes in stock price indexes (a proxy of returns) can be modeled using the following VAR structure

$$\Delta X_t = \mu + \sum_{i=1}^{p} \Gamma_i \Delta X_{t-i} + \varepsilon_t, \tag{2}$$

The index changes of the three stock markets have asymmetric effects on each other. Lagged variables of the S&P500 index help to explain movements in both of the other

two markets. Therefore, an increase in S&P500 index is likely to be followed by an upward swing in other stock market indexes in the short run. Lagged values of the FTSE index only help to explain the FTSE market itself. The Swiss SMI index, again helps to explain all other markets. Although significant at the 5 percent level, the parameter values of Switzerland are rather small. In Table 3 F-tests confirm the dominant role of the U.S. Using the Granger causality terminology, the S&P500 index causes the other stock markets. This result is consistent with the literature using VAR's to analyze stock markets, mentioned in the introduction.

Table 3: Pairwise Granger Causality tests

Null Hypothesis			F-Statistic
USA	does not cause	SWI	4.39*
SWI	does not cause	USA	0.12
USA	does not cause	UK	4.00*
UK	does not cause	USA	0.09
UK	does not cause	SWI	1.94
SWI	does not cause	UK	2.73

Note: The tests where implemented with 2 lags. "*" indicates significance at the five percent level.

So far, the empirical results are in accordance with the view that there are close linkages between the three stock markets. Although the three stock exchanges do not share a common trend in the long-run, on short-term variation, the markets appear to systematically respond to changes in the S&P500 index.

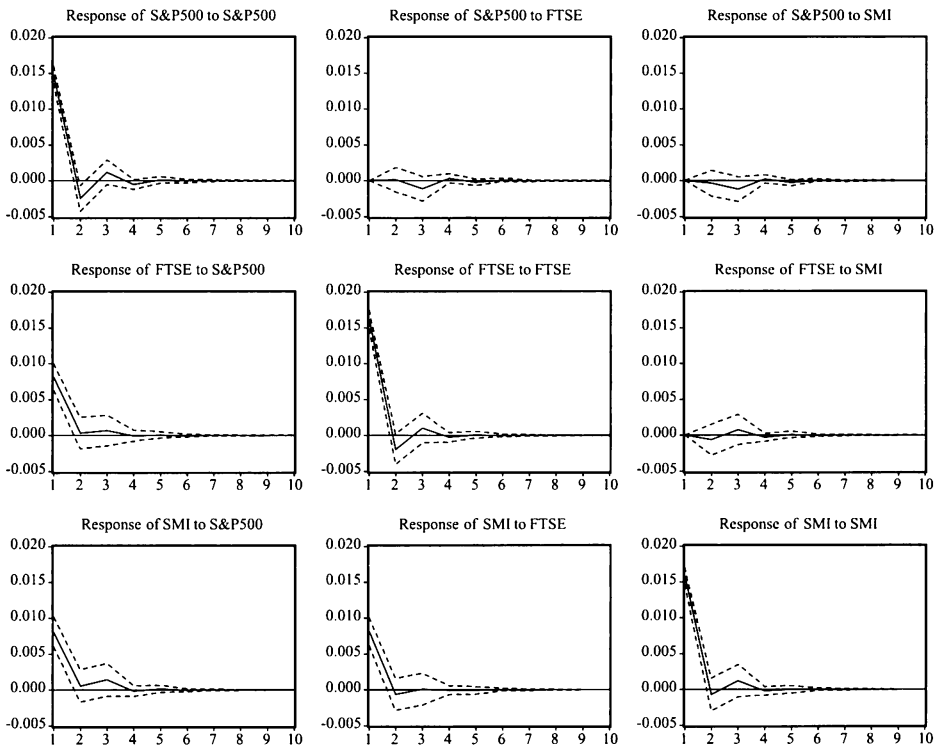
3.3. Impulse Response Functions and Forecast Error Variance Decompositions

To further assess the relative importance of price shocks, we present in the section the impulse response functions, tracing the MA representation of the VAR from section IIIb and decompose the forecast error variances into parts that are attributable to shocks emanating from the S&P500, FTSE and SMI index.

The impulse response functions are graphed in Figure 1, the forecast error variance decompositions are graphed in Figure 2. Overall, the response to shocks from either one of the three countries is rather weak. The impulse response functions show, that none of the countries react significantly to one another country after the 1st lag. The reactions in the 1st period however are largely driven by our identifying assumption of a Choleski decomposition, ordering the US first, England second and Switzerland third. Furthermore, for the horizons under consideration, the U.S. shock is the only one that accounts for a substantial percentage of the total forecast error variance in other countries. Shocks from the U.K. and Swiss stock market account for, approximately, 70 % and 60 % of their own forecast uncertainty. That is, the uncertainty the U.K. and Switzerland

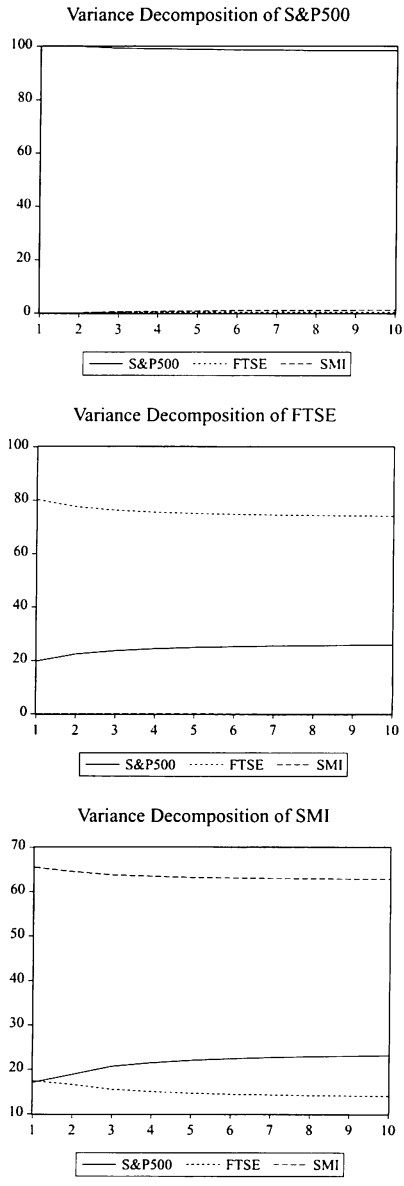
stock markets is mainly generated by shocks to its own stock price index. External shocks, either from the U.K. or Switzerland, play virtually no role in determining the U.S. price uncertainty. Again, this result is consistent with common findings in the literature. However it raises the following question: How does the high correlation among the first differences of the data reported in section 2 fit to the relatively small degree of the *transmission* of shocks? A possible answer to this question is that shock may be common across different markets and all three time series are driven by one common stochastic process. This question of common serial correlation is dealt with in the following section.

Figure 1: Impulse response functions



Note: The impulse response functions trace the MA representation of the VAR presented in Table 3. Finite sample critical values are generated by 1000 Monte Carlo replications.

Figure 2: Forecast Error Variance Decomposition for three major stock markets



Note: The proportions of the forecast error variance of the three stock markets ascribed to the S&P500, FTSE, and the SMI indicies shocks are traced by the lines labeled accordingly.

4. COMMON SERIAL CORRELATION

While for non-stationary series, cointegration describes the co-movement between long-run nonstationary stochastic trends, the co-movement among stationary series can be examined using the concept of common features (ENGLE and KOZICKI, 1993). The intuition for the common feature analysis is as follows. Let ΔX_{it} (i = the U.S., Switzerland and the U.K.), be the return in the three stock markets and suppose that the temporal dynamics, are driven by a common stochastic process. The effect of this common stochastic component can be removed by choosing an appropriate linear combination of ΔX_{it}'s. Thus, the presence of a common serial correlation cycle implies the existence of a linear combination of ΔX_{it}'s that is not correlated with the past information set. The testing procedure proposed by VAHID and ENGLE (1993) amounts to finding the sample canonical correlations between ΔX_t and $W(p) \equiv (\Delta X'_{t-1}, \ldots, \Delta X'_{t-p})'$. Specifically, the test statistic for the null hypothesis that the number of co-feature vectors is at least s is

$$C(p,s) = -(T-p-1)\sum_{j=1}^{s} \ln(1-\lambda_j), \tag{3}$$

where $\lambda_n \geq \ldots \geq \lambda_1$ are the squared canonical correlations between ΔX_t and $W(p)$ and n is the dimension of ΔX_t (i.e. n = 3 in this exercise). When s is the dimension of the cofeature space, $n - s$ is the number of common cycles. Under the null hypothesis, the statistic $C(p,s)$ has a χ^2-distribution with $s^2 + snp + sr - sn$ degrees of freedom, where r is the number of error correction terms included in $W(p)$(zero in our case).[4] See VAHID and ENGLE (1993) for a detailed discussion of the statistic.

The common serial correlation feature test results are presented in Table 4. Given the lag structure reported in the previous sections, the common feature test is conducted with $p = 2$.

Table 4: Test for Common Features

Null Hypothesis	Squared Canonical Correlation	Statistic C(p,s)	Degree of Freedom
s = 1	0.010	3.36	4
s = 2	0.048	18.58*	10
s = 3	0.112	55.16**	18

Note: The common feature test results are reported. The degree of freedom of the C(p,s) is calculated with n = 3, p = 2 and r = 0. "*" indicates significance at the one percent level. "**" indicates significance at the five percent level. The Co-Feature relationship, estimated with a GMM estimator is: S&P500 −0.93 (1.35) FTSE + 1.04 (2.18) SMI.

4. As the result on cointegration was very close, we also implemented the common features test including the estimated cointegrating vector. The results on the short run co-movements remained qualitatively unchanged.

Since two of the statistics are significant, there is evidence that all three stock markets share a common serial correlation feature among their price indexes. However, one needs to interpret this result with caution. Looking at the individual elements of the co-feature vector, we find that in the first co-feature vector, Switzerland is significant at the 5 % level, while the UK is not. Furthermore, different ways of estimating this co-feature vector provide different results on the significance level of Switzerland. We chose report the one based on a GMM estimator in table 4 as it has be shown to be the most efficient estimator by VAHID and ENGLE (1993). Also, the second co-feature vector is not significant at the 5 % level. Although a close decision (we can reject the second co-feature vector at the 5 but not at the 1 % level), the data does not support the hypothesis that all series are driven by only one cyclical element.

5. CONCLUDING REMARKS

Using recent time series techniques, we study the interaction between stock markets in the U.S., the U.K. and Switzerland. None of the series are found to share common permanent stochastic shocks that drive the long-run fluctuations of their stock market price indices. In the short run, The U.K. and Switzerland are Granger-caused by the U.S. S&P500 index. The impulse response functions and forecast error variance analysis, on the other hand, indicate that the effects of the S&P500 index tend to be short-lived and the U.K. and Swiss price indexes uncertainty is largely attributable to shocks to their own stock market. The study of common serial correlation shows that exist common short run fluctuations in national stock indexes.

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SUMMARY

Co-movements of stock market indices in the U.S., the U.K. and Switzerland are analyzed using recent time series procedures. None of the series are found to share common permanent stochastic shocks that drive their long-run fluctuations. In the short run, however, there is evidence of a common serial correlation feature. Further, it is found that the U.S. stock index Granger causes the two other markets. Nevertheless, impulse response functions show little evidence of international spillovers and in a variance decomposition of forecast errors, most of the fluctuations are found to be attributable to shocks from the respective domestic market.

ZUSAMMENFASSUNG

Gemeinsame Bewegungen in den Aktienindizes der USA, Englands und der Schweiz werden anhand von neueren Zeitreihenmethoden untersucht. Keine der Reihen zeigen gemeinsame langfristige Fluktuationen. In der kurzen Frist gibt es jedoch Evidenz von gemeinsamer Autokorrellation. Weiterhin wird gezeigt, dass der US Aktienindex "Granger" kausal für die beiden anderen Märkte ist. Die Impuls-Antwort-Funktionen zeigen jedoch nur wenig Evidenz von internationalen Übertragungen von Schocks und in einer Varianzzerlegung der Vorhersagefehler wird gezeigt, dass der größte Teil der Fluktuationen auf Schocks aus dem jeweiligen Inland zurückzuführen sind.

RÉSUMÉ

Le mouvement conjoint des indices de marche d'actions amèricains, britaniques et suisses est étudié a l'aide de méthode recentes de séries temporèlles. On n'observe pas de choc stochastique permanent commun a ces séries qui affecteraient conjointement leurs fluctuations a long terme. A court terme, en revanche, il y a une configuration commune de correlation temporelle. De surcroit, on peut montrer que l'indice amèricain "Granger" cause les deux autres indices. Neanmoins, les fonctions de reaction aux chocs simules ne montrent qu'une evidence faible de transmission internationale et dans la decomposition de la variance des erreurs de de prevision, la plupart des fluctuations sont attribuable a des chocs sur le marche domestique.