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Author(s): Ayse Yuce and Can Simga-Mugan
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AYSE YUCE AND CAN SIMGA-MUGAN

Linkages Among Eastern European Stock Markets and the Major Stock Exchanges

Over the last two decades, the flow of capital across national borders has become much less restricted. Investors have begun including assets of foreign countries into their portfolios in an effort to further reduce risk and diversify effectively. At the same time, developing countries that borrowed heavily from commercial banks during the 1970s have realized that the external capital markets are not the only, nor necessarily the best, source of funds for development. In an effort to obtain capital from different sources, some developing countries have established their own stock markets, while others that already had stock markets have decreased restrictions on foreign investment.

As the market for capital has become more global and less local, the importance of stock exchanges outside the developed countries has increased. Investors perceive that growth opportunities are greater in those nations that are not yet economically mature. Until recently, very little was known about the statistical properties and diversification possibilities of emerging markets. Traditionally investors have avoided these markets because of the political risks involved, and also because of the restrictions against foreign investors in these markets. However, in recent years the political risk of emerging markets has been reduced tremendously. Additionally, there exists a trend within the developing countries to ease the restrictions that discourage foreign investment.

Ayse Yuce is affiliated with the Faculty of Management at the University of Northern British Columbia, Canada. Can Simga-Mugan is affiliated with the Department of Management at Bilkent University in Ankara, Turkey.

After the collapse of the Soviet Union, the liberalization movement took place in all of the Eastern European countries. Their trade policies, openness toward foreign capital, and privatization processes developed differently. Eastern European countries established their stock exchanges in 1990s as part of decentralizing and liberalizing their economies, and stock markets became the main exchanges for the privatized companies. Earlier research has shown that deregulation and liberalization, improvements in communication technology, and financial services can induce long-run relationships among stock markets (Jeon and Chiang1991; Blackman et al. 1994).

Although there are direct and indirect capital flows from developed markets to the Eastern European markets, the close economic ties of the earlier days among these nations still prevail. The main motivating factors for our research were the recent developments in the Eastern European stock markets, and their resonating effects on the emerging and developed markets. Furthermore, results of earlier studies on the effects of liberalization movements, and the interest of international investors in these markets, reinforced our concern about these markets. There have only been a few studies about the Eastern European stock markets (Choudhry 1996; Yuce and Simga-Mugan 1996). Therefore, in an effort to expand our knowledge of the Eastern European markets, we have examined their characteristics and have explored the existence of interdependencies among them, as well as their relationships with the major stock markets. Strong economic and political ties, as well as the trade relationships among the Eastern European countries, can indirectly link their stock prices over time, and may induce long-term relationships (i.e., cointegration) among them. The existence of cointegration among two markets indicates the existence of an error correction model, which we may use to forecast the return values of these two markets.

A major contribution of this paper is to reveal to investors from the developed markets whether they may receive arbitrage profits by forming diversified portfolios with the stocks of these Eastern European markets. For the investors from these emerging markets, the study will help to determine whether they may receive arbitrage profits by diversifying among themselves, and the developed markets. The rest of the paper is organized as follows: Next, a brief review the previous studies is offered; in the third section, our data and methodology are introduced; and finally, our results and interpretations are provided.

Previous Studies

Recently, national economies have become more internationalized due to increased trade, and as a result of greater cooperation between national governments to remove the barriers to the free flow of goods and services, as well as financial, physical and human capital. The relationships between equity markets in various countries have been extensively examined in prior empirical studies. Early studies made a strong case for international portfolio diversification and the benefits of international diversification have been documented. Such diversification allows investors to reduce the total risk of a portfolio, while enhancing the performance opportunities.

The lack of interdependence across national stock markets has been presented as evidence supporting the benefits of international portfolio diversification. Agmon (1972), using monthly return data, found no significant leads or lags among the common stocks of Germany, Japan, the United Kingdom, and the United States. Studies such as Lessard (1976) and Jorion and Schwartz (1986), using regression models to test for the existence (but not the degree) of market segmentation, suggested that market segmentation does exist in some national equity markets.

The stock market crash of 1987 has provided new insights into the economic nature of the globalization of stock markets. Dwyer and Hafer (1988), using daily data for seven months before and after the October 1987 crash, showed no evidence that the *levels* of stock price indices for the United States, Japan, Germany, and the United Kingdom are related. They reported statistical evidence, however, that the *changes* in the stock price indices in these four markets are generally related. This finding suggests that there is no long-run interdependence among the markets, but some short-run (temporary) linkages exist.

However, more recent studies examining the stock price indices around the stock market crash of 1987 by Eun and Shim (1989), Von Furstenberg and Jeon (1989), and Bertera and Mayer (1990) reported a substantial amount of interdependence among national stock markets.

Many studies have examined the international linkage between the United States and Japan. Becker et al. (1990), Hamao et al. (1990), and Kasa (1991) found high correlation between the two markets with an asymmetric spillover effect from the United States to the Japanese market; Smith et al. (1993) and Aggerwal and Park (1994), however, found that U.S. equity prices do not lead Japanese equity prices, and stated that gains from international diversification are obtainable.

European countries have also been examined for interdependencies between stock exchange markets, as well (Corhay et al. 1993). Mathur and Subrahmanyam (1990), Arshanapalli and Doukas (1993), Malliaris and Urrutia (1994), and Gerrits and Yuce (1999) used the concept of Granger causality, along with cointegration and error-correction models, to analyze the linkages and dynamic interactions among stock prices. Recently, considerable attention has been given to possible linkages and interdependencies in major Asian countries. Lee et al. (1990), Chowdhury (1994), and Kwan (1995), using cointegration tests and vector autoregression analyses, reported that international diversification in those countries can be effective.

In this paper, we explore the linkages among stock prices in the Eastern European markets (i.e., Prague, Warsaw, Budapest, Moscow, Istanbul). We also examine the effects of the developed stock markets (e.g., Frankfurt, London, New York, Tokyo) on the Eastern European stock markets.

Data and Methodology

The data used to investigate short-run and long-run interdependencies of the Eastern European stock markets consist of the weekly closing prices for the following equity market indexes: Prague, Budapest, Moscow, Warsaw, Istanbul, London, Frankfurt, New York, and Tokyo. Weekly closing data for all indices were collected over the period beginning September 20, 1994 and ending December 31, 1999. The sample consisted of 295 observations.

In the analysis, the prices are expressed as logarithms:
CZE_t = l*n* (closing price of the Prague stock index at week *t*)
HUN_t = l*n* (closing price of the Budapest stock index at week *t*)
RUS_t = l*n* (closing price of the Moscow stock index at week t)
POL_t = l*n* (closing price of the Warsaw stock index at week *t*)
ISE_t = l*n* (closing price of the Istanbul stock index at week *t*)
DAX_t = l*n*(closing price of the Frankfurt stock index at week *t*)
NYS_t = l*n* (closing price of the New York stock index at week *t*)
LON_t = l*n* (closing price of the London stock index at week *t*)
JAP_t = l*n* (closing price of the Tokyo stock index at week *t*)

First differences of these series are continuous rates of return. Initially, we perform the Augmented Dickey-Fuller (1979) and Phillips-

Perron (1988) tests to determine whether or not the series are stationary. The Augmented Dickey-Fuller test is as follows:

$$\Delta X_t = \alpha + \beta X_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta X_{t-i} + d + e_t$$

If unit roots exists (i.e., the series is nonstationary), then the β coefficient of the series is not significantly different from zero. The Phillips-Perron (1988) test corrects the test statistic for possible time dependencies in the series by using non-parametric techniques. The critical values used in Dickey-Fuller tests are applicable to Phillips-Perron test as well. The existence of a cointegrating vector in bivariate relationship of the series is investigated with Augmented Dickey-Fuller and Phillips-Perron methods. We run the following regressions between different series and obtain error terms u_t s.

$$X_t = a + gY_t + u_t$$

If bivariate cointegration exists between different series, then the stochastic error terms obtained from these regressions should be stationary. Therefore, we check the existence of unit roots in the error terms.

Then we investigate the existence of multiple cointegrating vectors among the variables. The Johansen (1988) approach estimates long-term relationships between nonstationary variables using a maximum likelihood procedure, which tests for the number of cointegrating relationships and estimates the parameters of these cointegration relationships.

The Johansen tests are on the rank of the coefficient matrix Π of the equation (Johansen and Juselius 1990):

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu + \varepsilon_t$$

to test the main hypothesis of the existence of r cointegration vectors
H_0:Π has a reduced rank, $r < 9$
where X_t is a 9×1 vector of $I(1)$ variables and $\Gamma_1 \ldots\ldots \Gamma_{k-1}$, Γ are 9×9 matrices of unknown parameters. Π coefficient matrix contains information about long-term relationships. The reduced rank condition implies that the process ΔX_t is stationary and X_t is nonstationary. The distribution of test statistics are found in Osterwald-Lenum (1992).

Finally we use the methodology suggested by Engle and Granger (1987) and Granger (1988) to search for short and long term linkages between any two cointegrated series. First we estimate the values of κ for different pair of series from the regression equations.

$$X_t = a + \kappa Y_t + \varepsilon_t$$

then using different κs, we estimate values of Ψ_t such that:

$\Psi_t = X_t - \kappa Y_t$

If two series (X and Y) are cointegrated, then there exists an error correction model as follows:

$$\Delta X_t = \xi + \zeta \Psi_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta X_{t-i} + \sum_{j=1}^{m} \beta_j \Delta Y_{t-j} + \varepsilon_t$$

For the cointegrated series we formulate and investigate the error correction equations. For the noncointegrated Eastern European stock markets we formulate the vector autoregressive models as follows:

$\Delta CEK_t = \Delta CEK_{t-1} + \Delta POL_{t-1} + \Delta RUS_{t-1} + \Delta ISE_{t-1} + \Delta FRANK_{t-1} + \Delta NYS_{t-1} + \Delta LON_{t-1} + \Delta HK_{t-1}$

Results and Interpretation

We start our investigation of the long-term relationship among the series by checking the stationarity of the series. The autocorrelations in the series do not die out gradually, indicating the possibility of unit root, and nonstationarity.

To check the presence of unit root in the series, we use both Phillips-Perron and the Augmented Dickey-Fuller methods. Our null hypothesis is that a unit root exists. We use Akaike information criterion (AIC) to choose the lag length. Accordingly, one lag that corresponds to five working days is chosen.

Table 1 shows the results of the unit roots tests for each of the series. Our null hypothesis is as follows:

H_0: A unit root exists in the series. β is not significantly different from zero.

$$\Delta X_t = \alpha + \beta X_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta X_{t-i} + d + e_t$$

All of the test statistics are less in absolute value than the critical value of –3.43 at one percent, indicating that we fail to reject the presence of unit root in all series.

Next, we check the presence of unit root in the difference series, and find that difference transformations lead to stationary series. The results are reported in Table 2. All the numbers are statistically significant leading us to reject the presence of unit root in the difference series.

Table 2 rejects the presence of unit roots in the series based on the critical values at one percent level, which indicates that all of the rates

Table 1

Unit Root Tests for the Level Series

$$\Delta X_t = \alpha + \beta X_{t-1} + \Sigma_{i=1}^{m} \gamma_i \Delta X_{t-i} + d + e_t$$

	Phillips-Perron	Augmented Dickey-Fuller
CZE	–1.91	–1.92
HUN	–1.08	–1.02
POL	–1.84	–2.02
RUS	–1.00	–1.00
ISE	–1.73	–1.71
DAX	–0.06	–0.06
NYS	–0.34	–0.28
LON	–3.04	–2.44
JAP	–3.38	–2.61
Critical values at 1%:	–3.43	–3.43

Table 2

Unit Root Tests for Difference Series

$$\Delta X_t = \alpha + \beta X_{t-1} + \Sigma_{i=1}^{m} \gamma_i \Delta X_{t-i} + d + e_t$$

	Phillips-Perron	Augmented Dickey-Fuller
DCZE	–110.74*	–17.11*
DHUN	–135.15*	–16.25*
DPOL	–146.03*	–14.43*
DRUS	–52.00*	–15.88*
DISE	–40.40*	–16.45*
DDAX	–288.94*	–18.01*
DNYS	–416.72*	–17.52*
DLON	–85.20*	–23.68*
DJAP	–206.70*	–26.56*
Critical values at 1%:	–3.43	–3.43

are integrated of order 1, $I(1)$. Therefore, we could state that the emerging markets series characteristics are similar to those of the developed market series.

Characteristics of individual difference series are examined and the

Table 3

Distributional Characteristics

	Mean	Std. dev.	Coefficient of excess skewness	Coefficient of excess kurtosis
ΔCEK	0.021	0.4685	0.4838	279.9196
ΔHUN	0.030	0.4177	0.7517	284.9621
ΔPOL	0.032	0.5573	0.8400	287.0142
ΔRUS	0.016	0.2981	–1.5864	233.9651
ΔISE	0.030	0.6463	–4.4679	202.9500
ΔDAX	0.029	0.4509	1.0512	291.8206
ΔNYS	0.031	0.4807	1.1017	292.9751
ΔLON	0.030	0.4897	–0.4407	258.3639
ΔJAP	0.033	0.5727	0.8436	287.0970

findings are provided in Table 3. From the table, we observe that the Moscow exchange was the least volatile, and the Istanbul stock exchange is the most volatile, market during the period covered by this study. One reason for this finding could be the privatization process that is going on in Turkey. Also, Turkey has been accepted as the new candidate for the European Union. The administration has introduced new economic structuring programs. These heavy programs have caused volatility in the Istanbul stock exchange. On the other hand, the Russian economy has experienced a downturn in the last few years, which has affected the Moscow stock market. We observe that Prague, Budapest, and Warsaw stock markets exhibit positive skewness, while Istanbul and Moscow stock markets exhibit negative skewness. All markets display heavy leptokurtosis behavior.

We first examine whether or not multiple cointegration exists among the series. We search for a common trend among the markets. Table 4 displays the results of Johansen tests. When we test the hypothesis that there is no common trend among the series, we fail to reject the null hypothesis that H_0: $r = 0$, there is no common trend among the series.

The test statistic has a value of 96.750, which is less than the critical value of 202.92; thus, we cannot reject the null hypothesis of no cointegrating vectors. Therefore, we could state that there is no evidence of multivariate cointegration relation in the data.

Then we proceed to check whether there is a bivariate cointegration

Table 4

Johansen Cointegration Tests

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu + \varepsilon_t$$

H_0:P has a reduced rank, $r < 9$

H_0:	Alternative	Statistic	95% critical value
$r = 0$	$r = 1$	96.750	202.92
r£ 1	$r = 2$	59.910	165.58
r£ 2	$r = 3$	31.494	131.70
r£ 3	$r = 4$	21.380	102.14
r£ 4	$r = 5$	16.038	76.07
r£ 5	$r = 6$	11.056	53.12
r£ 6	$r = 7$	8.697	34.91
r£ 7	$r = 8$	6.740	19.96
r£ 8	$r = 9$	0.574	9.24

relation between the series. We again use Phillips-Perron and Augmented Dickey-Fuller tests on the residuals of cointegrating regressions. If any two series are found to be cointegrated, then it indicates a long-run equilibrium relation between them.

The results of cointegration analysis with the Augmented Dickey-Fuller and Phillips-Perron methods are presented in Table 5. Based on the critical values at the one percent level, we cannot reject the presence of a unit root in most of the equations. If two series are cointegrated, then the error terms of the regression equations between two nonstationary series should have no unit roots. We reject the no unit root in error terms only for the relationship between Budapest and London stock markets, indicating the existence of cointegration relationships between Budapest and London series at the one percent level.

According to both tests, there are no cointegration relationships between Eastern European countries. We expected to find long-term relationships between Prague, Budapest, Warsaw, Moscow, and Istanbul. The majority of the trade of the Czech Republic and Poland is with Russia. Similarly, Turkey and Russia have demonstrated strong economic relationships in the last decade by forming joint venture companies, and by being parties in the Black Sea region economic treaty. Between Turkey and Russia there has been a so called luggage trade since the last decade. Russian citizens travel to Turkey to buy goods,

Table 5

Bivariate Cointegration Tests

$\Delta X_t = \alpha + \beta X_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta X_{t-i} + d + e_t$

Dep. Var.	Indep. Var.	Phillips-Perron	Dickey-Fuller
CEK	POL	–2.53	–2.62
	HUN	–2.06	–2.53
	RUS	–1.78	–1.79
	DAX	–2.35	–2.32
	NYS	–2.40	–2.44
	LON	–3.73	–3.32
	ISE	–2.12	–2.09
	CAN	–3.27	–2.97
HUN	CEK	–2.00	–2.12
	POL	–3.13	–3.17
	RUS	–0.69	–0.59
	DAX	–2.17	–2.05
	NYS	–1.64	–1.56s
	LON	–6.75*	–5.39*
	ISE	–2.34	–2.16
	JAP	–1.80	–1.49
POL	CEK	–2.52	–2.75
	HUN	–3.47	–3.61
	RUS	–1.99	–2.12
	ISE	–2.66	–2.82
	DAX	–2.54	–2.75
	NYS	–2.60	–2.79
	LON	–3.79	–3.48
	JAP	–1.88	–2.06
RUS	CEK	–0.95	–0.96
	HUN	–0.76	–0.72
	POL	–1.23	–1.20
	DAX	–0.93	–0.92
	NYS	–0.88	–0.88
	LON	–0.95	–0.92
	ISE	–1.06	–1.02
	JAP	–1.20	–1.08
ISE	CEK	–2.09	–2.04
	POL	–2.53	–2.61
	RUS	–1.77	–1.72
	HUN	–2.76	–2.59
	DAX	–2.61	–2.52
	NYS	–2.29	–2.20
	LON	–3.89	–3.39
	JAP	–2.81	–2.39
LON	HUN	–7.92*	–6.17*

*Critical values at 1% level : –3.90

Table 6

Error Correction Models

$$\Delta HUN_t = a + bZ_{t-1} + c\Delta HUN_{t-1} + d\Delta LON_{t-1}$$

Dep. Var.	Z_{t-1}	ΔHUNL	ΔLONL
ΔHUN	0.5649	–0.5188	0.5008
	(27.58)*	–(4.57)*	5.1512*
ΔLON	–1.3328	–0.3315	0.3145
	–(43.38)*	–(3.60)*	3.9985*

*Critical values at 1% level: 2.326.

put them in luggage, and transport the goods to Russia to sell them and obtain a profit. We expected these trade relationships to cause cointegration between Eastern European countries, but we failed to find these relationships. This indicates that it is possible to form diversified portfolios using stocks from these countries.

On the other hand, we find cointegration relation between Budapest and London stock market according to both Phillips-Perron and Dickey-Fuller tests. This indicates that a cointegration relationship may exist between these markets. We have formulated the error correction models between Budapest and London stock markets, and have checked whether or not the coefficients of the long term-variables are significant. The results are presented in Table 6.

The finding of no cointegration among Prague, Warsaw, Istanbul, Moscow, New York, Frankfurt, London, and Tokyo stock exchanges indicates that it is not possible to do forecasting by using the historical prices of the other series in the long run. On the other hand, the HUN and LON series exhibit a long-run relationship. Therefore, returns in these markets can be forecast and arbitrage profits can be obtained.

Table 6 shows that the coefficients of the long-term components (Z_1) of both error correction models are significantly different from zero at the one percent level, indicating the existence of long-run equilibrium between the HUN and LON series. The results imply that the London market leads the Budapest market.

Therefore, we checked the Granger causality between the series and found that the London market significantly Granger causes the Budapest market ($p < 0.01$, with an F-statistics of 30.27).

We have rejected the hypothesis that the London exchange does not Granger cause the Budapest exchange.

We fail to reject the hypothesis that the Budapest market does not cause the London market. These findings conform to the cointegration findings reported above. The London market Granger causes the Budapest market.

For the equation that the Budapest market return is the independent variable, the coefficient of London stock market is significant, with a t ratio of 5.15, which shows that the London stock market affects the Budapest stock market, both in the long run and the short run. The long run relationship can occur because the London stock exchange is the biggest stock exchange in Europe. It can affect the Budapest exchange more than the New York or the Tokyo exchanges. On the other hand, the Budapest stock exchange is very illiquid, with thin trading. The liquidity of the Hungarian market is heavily affected by the changes in foreign investors' desires (*IFC Factbook on Emerging Markets* 1996, 1997). This may cause the finding of cointegration as well.

We model the rest of the Eastern European markets by establishing vector autoregressive processes showing effects of developed markets, and the other Eastern European stock exchanges. Since the Budapest market is cointegrated with the London market, it is not included in the equations. The vector autoregressive models are formulated as follows, based on AIC.

$$\Delta CEK_t = \Delta CEK_{t-1} + \Delta POL_{t-1} + \Delta RUS_{t-1} + \Delta ISE_{t-1} + \Delta NYS_{t-1} + \Delta LON_{t-1} + \Delta DAX_{t-1} + \Delta JAP_{t-1}$$
$$\Delta RUS_t = \Delta CEK_{t-1} + \Delta POL_{t-1} + \Delta RUS_{t-1} + \Delta ISE_{t-1} + \Delta NYS_{t-1} + \Delta LON_{t-1} + \Delta DAX_{t-1} + \Delta JAP_{t-1}$$
$$\Delta ISE_t = \Delta CEK_{t-1} + \Delta POL_{t-1} + \Delta RUS_{t-1} + \Delta ISE_{t-1} + \Delta NYS_{t-1} + \Delta LON_{t-1} + \Delta DAX_{t-1} + \Delta JAP_{t-1}$$
$$\Delta POL_t = \Delta CEK_{t-1} + \Delta POL_{t-1} + \Delta RUS_{t-1} + \Delta ISE_{t-1} + \Delta NYS_{t-1} + \Delta LON_{t-1} + \Delta DAX_{t-1} + \Delta JAP_{t-1}$$

The developed markets and the emerging markets do not significantly affect the Prague, the Moscow, the Warsaw, or the Istanbul stock exchange. No t-ratio is significant in Table 7.

We expected to find long-run and short-run dependencies between the Prague and Moscow stock markets, and between the Warsaw and

Table 7

Vector Autoregression Models

$$\Delta CEK_t = \Delta CEK_{t-1} + \Delta POL_{t-1} + \Delta RUS_{t-1} + \Delta ISE_{t-1} + \Delta NYS_{t-1} + \Delta LON_{t-1} + \Delta DAX_{t-1} + \Delta JAP_{t-1}$$

Dep.Var.	ΔCEKL	ΔPOLL	ΔRUSL	ΔISEL	ΔNYSL	ΔDAXL	ΔLONL	ΔJAPL
ΔCEK	0.144	0.038	0.027	–0.002	–0.081	–0.346	0.222	–0.010
	(0.360)	(0.080)	(0.091)	–(0.017)	–(0.060)	–(0.273)	(0.916)	–(0.020)
ΔPOL	0.971	0.168	0.088	0.004	–0.307	–0.094	–0.011	0.051
	(0.204)	(0.294)	(0.251)	(0.036)	–(0.190)	–(0.062)	–(0.040)	(0.098)
ΔRUS	0.041	0.081	0.004	–0.024	0.171	–0.270	0.034	–0.051
	(0.162)	(0.267)	(0.091)	–(0.378)	(0.198)	–(0.334)	(0.224)	–(0.181)
ΔISE	–0.040	–0.211	–0.125	–0.036	–0.196	0.422	0.024	0.160
	–(0.073)	–(0.319)	–(0.310)	–(0.262)	–(0.105)	(0.241)	(0.071)	(0.263)

*Critical values at 1% level : 2.326.

Moscow stock markets. This result shows that the economies of the Eastern European countries have become very independent of the Russian econom, as these countries reorient their trade and financial businesses towards the European Union.

Conclusions

We used the notion of cointegration to examine long-run linkages and short-run dynamic interactions among stock price indices in nine stock exchanges (Prague, Moscow, Warsaw, Istanbul, Budapest, London, New York, Frankfurt, and Tokyo). The data used in this study were weekly closing prices of the stock exchanges. The sample consisted of 295 observations and covered the period September 20, 1994 through December 31, 1999.

Tests of stationarity allow us to conclude that the level series are nonstationary; but, the difference series are stationary. Thus, all series are integrated of order one, $I(1)$. Johansen tests provide no evidence of a multivariate cointegrating vector among the stock exchanges investigated. Thus, there appears to have no long-run linkages among the markets.

We expected to find cointegration relation among the Eastern European stock markets, because of the close economic ties among them.

However, no such relationships have been found. Neither the developed markets nor the emerging markets affect the Warsaw and the Prague stock exchanges. This finding indicates that Eastern European economies have become more independent from the Russian economy in recent years, and that there is no significant effect from Russian stock exchange on the returns of the Prague, Warsaw, and Budapest stock exchanges.

There is no significant relationship between the Istanbul and Moscow stock markets, either. The luggage trade has not significantly affected these exchanges, nor has it induced a long-run relationship. Although the Istanbul stock exchange has reacted strongly to the Russian stock market crash of 1998, we failed to find any significant long-run relationship between the Istanbul and Moscow stock markets. This finding is quite surprising, considering the recent economic ties that have been established between these countries.

On the other hand, a bivariate cointegration relationship is observed between the London and Budapest markets, indicating long-term linkage, and returns on these markets can be estimated from this relationship. This finding shows that using an error-correction equation, it is possible to forecast the returns of the Budapest stock exchange. However, we have to be cautious: The Budapest stock exchange is characterized by thin trading, which may have caused this finding. To be sure, we have to test this relationship in the new decade; and, if we still find the same result, then we can assuredly use it to exploit profit opportunities in this market.

The results of our study reveal that, currently, there are no arbitrage opportunities for foreign investors in most of these markets (except Budapest), and that the stocks of these markets can be effectively used to diversify international portfolios.

References

Aggerwal, R., and Y.S. Park. 1994. "The Relationship Between Daily U.S. and Japanese Equity Prices: Evidence from Spot Versus Futures Markets." *Journal of Banking and Finance* 18: 757–73.

Agmon, T. 1972. "The Relations Between Equity Markets: A Study of Share Price Co-Movements in the United States, United Kingdom, Germany, and Japan." *Journal of Finance* 27: 839–55.

Arshanapalli, B., and J. Doukas. 1993. "International Stock Market Linkages: Evidence from the Pre- and Post-October 1987 Period." *Journal of Banking and Finance* 17: 193–208.

Becker, K.G., J.E. Finnerty, and M. Gupta. 1990. "The Intertemporal Relations Between the U.S. and Japanese Stock Markets." *Journal of Finance* 45: 1297–1306.

Blackman, S., K. Holden, and A. Thomas. 1994. "Long-Term Relationships Between International Share Prices." *Applied Financial Economics* 4: 297–304.

Choudhry, T. 1996. "Interdependence of Stock Markets: Evidence from Europe During the 1920s and 1930s." *Applied Financial Economics* 6: 243–49.

Chowdhury, A.R. 1994. "Stock Market Interdependencies: Evidence from the Asian NIEs. *Journal of Macroeconomics* 16: 629–51.

Corhay, A., A. Rad, and J. Urbain. 1993. "Common Stochastic Trends in European Stock Markets." *Economic Letters* 42: 385–90.

Dickey, D.A., and W. Fuller. 1979. "Distribution of the Estimators for Autoregression Time Series with a Unit Root." *Journal of American Statistical Association* 74: 427–31.

Dwyer, G.P., and R.W. Hafer. 1988. "Are National Stock Markets Linked?" *Federal Reserve Bank of St. Louis Review* 70: 3–14.

Engle, R.F., and C.W. Granger. 1987. "Co-Integration and Error Correction: Representation, Estimation, and Testing." *Econometrica* 55: 251–76.

Engle, R.F., and B.S. Yoo. 1987. "Forecasting and Testing in Co-Integrated Systems." *Journal of Econometrics* 35: 143–59.

Eun, C.S., and S. Shim. 1989. "International Transmission of Stock Market Movements." *Journal of Financial and Quantitative Analysis* 24: 241–56.

Gerrits, R., and A. Yuce. 1999. "Short- and Long-Term Links Among European and U.S. Stock Markets." *Applied Financial Economics* 9: 1–11.

Granger, C.W. 1988. "Some Developments in a Concept of Causality." *Journal of Econometrics* 39: 199–211.

Hamao, Y., R.W. Masulis, and V. Ng. 1990. "Correlations in Price Changes and Volatility Across International Stock Markets." *Review of Financial Studies* 3: 281–307.

IFC Factbook—Emerging Stock Markets. 1996, 1997. Washington, DC: International Finance Corporation.

Johansen, S. 1988. "Statistical Analysis of Cointegration Vectors." *Journal of Economic Dynamics and Control* 12: 231–54.

Johansen, S., and K. Juselius. 1990. "Maximum Likelihood Estimation and Inference on Cointegration With Applications to the Demand for Money." *Oxford Bulletin of Economics and Statistics* 52: 169–210.

Jeon, B., and T. Chiang. 1991. "A System of Stock Prices in World Stock Exchanges: Common Stochastic Trends for 1975–1990." *Journal of Economics and Business* 43: 329–38.

Jorion, P., and E. Schwartz. 1986. "Integration Versus Segmentation in the Canadian Stock Market." *Journal of Finance* 41: 603–16.

Kasa, K. 1992. "Common Stochastic Trends in International Stock Markets." *Journal of Monetary Economics* 29: 95–124.

Koutoulas, G., and L. Kryzanowski. 1994. "Integration or Segmentation of the Canadian Stock Market: Evidence Based on the APT." *Canadian Journal of Economics* 2: 329–51.

Kwan, A.C.C., A.B. Sim, and J.A. Cotsomitis. 1995. "The Causal Relationships Between Equity Indices on World Exchanges." *Applied Economics* 27: 33–37.

Lee, I., R. Petitt, and M.V. Swankoski. 1990. "Daily Return Relationships Among

Asian Stock Markets." *Journal of Business Finance and Accounting* 17: 265–84.

Lessard, D.A. 1976. "International Diversification." *Financial Analyst Journal* 32: 32–38.

Malliaris, A.G., and J. Urrita. 1992. "The International Crash of October 1987: Causality Tests." *Journal of Finance and Quantitative Analysis* 27: 353–64.

Mathur, I., and V. Subrahmanyam. 1990. "Interdependencies Among the Nordic and U.S. Stock Markets." *Scandinavian Journal of Economics* 4: 587–97.

Osterwald-Lenum, M. 1992. "A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics." *Oxford Bulletin of Economics and Statistics* 54: 461–72.

Phillips, Peter C.B., and Pierre Perron. 1988. "Testing for a Unit Root in Time Series Regression." *Biometrika* 75: 335–46.

Smith, K.L., J. Brocato, and J.E. Rogers. 1993. "Regularities in the Data Between Major Equity Markets: Evidence from Granger Causality Tests." *Applied Financial Economics* 3: 55–60.

Von Furstenberg, G.M., and B.N. Jeon. 1990. "Growing International Comovements in Stock Price Indexes." *Quarterly Review of Economics and Business* 30: 15–30.

Yuce, A., and C. Simga-Mugan. 1996. "An Investigation of the Short- and Long-Term Relationships Between Turkish Financial Markets." *European Journal of Finance* 2: 305–17.