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Contagion Effects of Central and East European Currency Crises

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Abstract

The paper analyses the contagion effects across stock markets. Contagion is defined as a significant increase in stock market comovements after a shock in form of a currency crisis. The empirical analysis is based on the recently introduced concept of adjusted correlation coefficients. This concept is applied to investigate the contagion effects of the Czech currency crisis in May 1997 and the Russian currency crisis in August 1998 on thirty stock markets in various regions of the world. The study shows that contagion effects depend on the strength and timing of the initial impulse. Some markets even benefited from another country‘s malaise.

Keywords: Currency Crisis, Contagion, Central and Eastern Europe

JEL Classification: G15, F30

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I Introduction

In August 1998, the Russian stock market plummet in the course of the Russian currency crisis and then partially rebounded. As shown in Figures 1 to 6, these movements were mirrored in markets in Western Europe, South America and Asia. The Russian case shows that dramatic movements in one stock market can have significant impacts on other markets. Against this background it is interesting to ask why stock markets of very different sizes and market characteristics and located throughout the world show similar price movements (see Table 1). Are common exogenous shocks responsible for the price co-movements or are the stock markets already so deeply integrated with each other that a similar price pattern could have been expected anyway?

This paper investigates contagion effects as a propagation mechanism of currency crises across stock markets. I use the term ‘contagion‘ in Masson’s (1998) sense, namely that “contagion involves changes in expectations that are *not* related to changes in a country’s macroeconomic fundamentals“ (Masson 1998, p. 5, italics mine) so as to distinguish it from spill-over effects, which *do* effect the fundamentals of a country.

A typical transmission mechanism of contagion discussed in the literature focuses on trade linkages (e.g. Gerlach/Smets 1995 and Eichengreen/Rose/Wyplosz 1996). The idea behind this approach is that a devaluation in one country enhances its competiveness, leading to trade deficits and mounting problems for its trading partners in maintaining a fixed exchange rate. Their findings are in favour of spill-over effects and not contagion to describe the spreading of a currency crisis.

Contagion effects as a mean of transmission of a currency crisis result mainly from information externalities and liquidity effects. Information externalities assume that it is possible to extract new information from a currency crisis in one country on the macroeconomic situation in another country. However, it is difficult to show that such hidden information is revealed through a currency crisis. In contrast, liquidity effects are more plausible as an explanation for contagion effects. The portfolio optimisation behaviour of international, institutional investors play a crucial role here. A currency crisis and a subsequent drop in stock prices represent a capital loss for the investors‘ stock portfolios. This may result in liquidity problems for some investors to which they react with a (partial) re-allocation of their portfolios (Rigobon 1998). In addition, stock engagements in countries in similar macroeconomic conditions or the same risk class like the crisis country will be re-evaluated. Higher liquidity positions of investors and capital exports not only out of the crisis country are a consequence of higher uncertainty following a currency crisis. However, contagion effects are also possible without relying upon cross-border capital transactions. A currency crisis in a country is likely to blur the return expectations of companies in another country. This may be the case if important customers in the crisis country for domestic products break away.

Previous studies on contagion effects of currency crises across stock markets focused on contagion effects in general (Forbes/Rigobon 1998a and 1998b). My analysis extends previous studies in two respects: First, the effects of both the Czech currency crisis in May 1997 and the Russian currency crisis in August 1998 are investigated and second, I distingiush between positive and negative contagion effects. In doing so, I explicitly allow for the case that other markets might benefit from a currency crisis in another country while other studies concentrated only on the fact that other markets might also be dragged down. In order to better assess the results of the empirical analysis the Asian crisis is also considered for comparison reasons. The analysis draws upon studies by Forbes/Rigobon (1998a and 1998b) on the Asian currency crisis, the Mexican currency crisis, and the U.S. stock market crash of 1997.

The article is organised as follows: The following section outlines the correlation analysis as the methodological basis for the empirical analysis. The third section describes the stock market sample, the observation period, and the data sources. The results are presented in the fourth section. Concluding remarks are made in the last section.

II Methodology

The methodological basis for the study of contagion effects across stock markets is a correlation analysis. The correlation in stock market returns across markets is given by:

$$\hat{\rho}_{i,j} = cor(R_i\, R_j) = \frac{\mathrm{cov}(R_i\, R_j)}{\sigma_i\, \sigma_j} = \frac{\frac{1}{n}\sum_{t=1}^{n}(R_i - \mu_i)(R_j - \mu_j)}{\sigma_i\, \sigma_j} \qquad (1)$$

where, for two markets *i* and *j* (with i≠j), R_i is the return to stock market *i* at time *t*, μ_i is the mean return of stock markt *i* over the period 1 to *n*, σ_i is the standard deviation of returns over the same period.[1] The variables for market *j* are defined likewise.

Forbes/Rigobon (1998) have shown that in the case of a split-sample analysis the correlation coefficient is biased. The bias is due to the fact that the correlation of equation (1) does not control for the abnormal variance of stock market returns during periods of crisis relative to the average variance during periods of stability. When using equation (1) the correlation is estimated conditional on the movement of the other market. The consequence is that during periods of increased volatility on market *j*, the estimated unadjusted correlation between markets *i* and *j* is greater than the true, unconditional correlation during the period. Hence, the correlation coefficient of equation (1) is biased upward and the cross-market correlation will be exaggerated. Forbes/Rigobon use the unconditional correlation coefficient $\rho_{i,j}$, to adjust for the bias:

[1] For simplicity the time subscript *t* is dropped.

$$\rho_{i,j} = \frac{\hat{\rho}_{i,j}}{\left[1+\delta-\delta(\hat{\rho}_{i,j})^2\right]^{1/2}} \tag{2}$$

with

$$\delta = \frac{(R_j)^2 - \sigma_j^2}{\sigma_j^2} \tag{3}$$

In investigating the contagion effects the whole sample period is devided into a ‘tranquil‘ period and a ‘crisis‘ period. It is assumed that the crisis period is characterised by a higher variance of stock prices. This assumption seems justified by the fact that during crisis periods heavy trading activities can be observed. There is contagion if the correlation coefficients for each period differ significantly from each other. More specifically, it is useful to distinguish between ‘positive‘ and ‘negative‘ contagion effects. The terms ‘positive‘ and ‘negative‘ refer to the sign of the correlation coefficient. A positive contagion effect is present if the correlation coefficient during the crisis period is significantly higher than the correlation coefficient during the tranquil period. In the case of a negative contagion effect the opposite is true - the correlation coefficient of the crisis period is significantly lower than the correlation coefficient of the tranquil period. Formally, the null hypotheses for a positive and a negative contagion effect, respectively, are given by:

a) H_0: $\rho_{i,j}^T \geq \rho_{i,j}^C$ H_1: $\rho_{i,j}^T < \rho_{i,j}^C$, (4)

b) H_0: $\rho_{i,j}^T \leq \rho_{i,j}^C$ H_1: $\rho_{i,j}^T > \rho_{i,j}^C$, (5)

where the superscripts *C* and *T* denote the crisis period and the tranquil period, respectively, $\rho_{i,j}^T$ and $\rho_{i,j}^C$ denote the correlation coefficients of the markets *i* and *j* for the tranquil and the crisis period. The correlation coefficients are subject to Fisher‘s Z-transformation so as to be normally distributed. Fisher‘s Z-transformation is given by:

$$Z_{i,j}^l = \frac{1}{2}\ln\left(\frac{1+\rho_{i,j}^l}{1-\rho_{i,j}^l}\right), \qquad l = T, C;\ i \neq j \tag{6}$$

Then it is possible to calculate the test statistic *z* :

$$z_{i,j} = \frac{Z_{i,j}^C - Z_{i,j}^T}{\sigma(\cdot)} \tag{7}$$

with

$$\sigma(\cdot) = \left(\frac{1}{n^T-3} + \frac{1}{n^C-3}\right)^{1/2},\ i \neq j \tag{8}$$

where n^T und n^C are the number of observations during the tranquil and crisis period, respectively. The test statistic is distributed with degrees of freedom calculated as: $df = n^T + n^C - 4$. The correlations among stock returns measured in US-Dollar are also investigated to capture any possible effects from exchange rate movements.

III Data

The empirical analysis considers stock markets from four regions of the world: Western Europe, Central and Eastern Europe, America, and Asia. Western Europe comprises the seven largest markets as well as the adjacent markets to Central and Eastern Europe: Austria, Finland, and Sweden. From Central and Eastern Europe are those markets chosen for which the stock exchange indices are available for a sufficiently long period of time. America comprises the markets in the U.S., Mexico and the three largest South American markets: Argentina, Brasil, and Chile. From Asia are the six largest stock markets taken.

The whole sample comprises the period from April, 3 1995 to November, 30 1998. The beginning of the observation period was chosen such as to avoid any possible contagion effects from the Mexican crisis in December 1994. The beginning of the Czech crisis is set at May 27, 1997; the day on which the currency band of the Czech Koruna against the exchange rate basket was widened. The Asian crisis is assumed to begin on August 14, 1997; the day on which the exchange rate peg of the Indonesian Rupiah to the US-Dollar was abandoned. The Russian crisis is set to begin on August 17, 1998 when the exchange rate band of the RUB/USD exchange rate was expanded. For comparison reasons the crisis period for all three currency crises is assumed to last three months.

The daily data for the exchange rates and the stock exchange indices are taken from DRI/McGraw-Hill. Missing data are generated through linear interpolation. The whole sample comprises 950 observations. The indices of the Central and East European stock exchanges are considerably shorter due to the late (re)openings of the stock exchanges. The shortest time series is the Croation stock index, Crobex, with 323 observations.

IV Results

The main results can be summarised as follows:

1. Markets of the same region are generally more closely correlated with each other than markets in different regions of the world.[2] The highest correlation among the European stock markets show the stock exchanges in the Netherlands and Switzerland with $\rho = 0{,}43$. The closest correlation among the Central and East European markets exists between the Russian and the Polish markets ($\rho = 0{,}39$). For America and Asia are the highest correlation coefficient $\rho = 0{,}31$ and $\rho = 0{,}23$ respectively. Such close

[2] The tables with the correlation coefficients in local and in US-Dollars for the three currency crises are available from the author upon request.

correlations are not observable among inter-regional relationships. The discrepancy between inter- and intra-regional correlation coefficients gets even bigger during crisis periods. The correlation coefficients increase for the various regions while the inter-regional correlation coefficients almost remain unchanged. This means that during crisis periods the comovements of the stock prices – at least intra-regionally – increases.

2. The correlation coefficients in local currencies usually differ from those measured in US-Dollar. The correlation coefficients in local currencies are in almost half of the cases greater than those measured in US-Dollar (see Table 2).The positive contagion effects also greater - irrespective of the origin of the crisis - when the stock returns are measured in local currencies (see Table 3). This indicates that exchange rate movements play an important role in the correlation relationships. A crisis-hit country typically devalues its currency against the US-Dollar. The depreciation of the local currency reduces the stock return in US-Dollar and subsequently the correlations with other markets shrink. As a result, the number of significant correlation relationships is also reduced. In the case of negative contagion effects the exchange rate movements have the opposite effect. They reinforce the negative correlation between the US-Dollar returns because of the reinvestment in stocks in other countries which leads – as least in tendency – to an appreciation of the currencies. Consequently, the number of significant correlations increases compared to returns in local currencies.

3. The positive contagion effects of the Czech crisis on other markets were negligible compared to the Russian and Asian crisis. During the Czech crisis only up to 3% of the markets showed positive contagion effects while in the case of the other crises it were at least 7% of the markets (see Table 3). An important reason for the different effects are presumably the considerable differences in market size measured by the market capitalisation and the degree of integration of the Czech and Asian markets into the international financial markets. A sharp drop in stock prices on the Prague Stock Exchange represents a much smaller initial impulse than the shock resulting from a collapse of the Kuala Lumpur Stock Exchange which is about five times larger.

4. The positive contagion effects of the Russian crisis were more or less an European phenomenon while the effects of the Asian crisis were stronger and globally more wide spread (see Table 3). Contagion effects of the Russian crisis showed about 9% to 20% of all market combinations in which West European markets were involved. These were the strongest effects considering the stock returns measured in local currencies. The effects were considerably weaker for other regions. The strongest effects of the Asian crisis were also being felt in Western Europe. The contagion effects in other regions were usually stronger than in Asia itself. This result only partially supports the findings of other studies (e.g. Eichengreen/Rose/Wyplosz 1996;

Forbes/Rigobon 1998a; Glick/Rose 1998). Their main finding was that contagion effects are primarily regional phenomena.

There were some contagion effects of the Russian crisis on other markets but they were generally weaker than the effects of the Asian crisis. Even the contagion effects of the Asian crisis onto the Central and East European markets were greater than the effects of the Russian crisis. Remarkably during the Russian crisis was the spreading of the contagion to the emerging markets in South America but not to Asian markets (see Table 3).

5. The negative contagion effects were the strongest in the course of the Czech crisis. They considerably exceeded the positive contagion effects. Although there were also negative contagion effects during the Asian crisis but they were much weaker than the positive effects. In case of the Russian crisis were not any negative contagion effects at all. In tendency, negative contagion effects indicate a substitution reaction of investors. Obviously, investors were selling stocks on the crisis-hit market and on positively infected markets. The liquid financial resources were then reinvested in stocks in other markets. This behaviour resulted in opposite stock price movements between the crisis market and the other markets. An important reason for the different strength and the regional distribution is - besides the size of the crisis market - the timing and the sequence of the crises. The Czech crisis of May 1997 was interpreted by international investors as a singular event which was neither taken as symptomatic for other emerging markets nor as symptomatic for the markets in the same region. This hypothesis is supported by the widespread negative contagion effects in Central and Eastern Europe. These are signs that other emerging markets in the same region benefited from the Czech malaise. While the substitution reactions of investors to the following Asian crisis for precautionary reasons were considerably lower. The substitution strategy had become completely obsolete in the course of the Russian crisis in August 1998. This was already the third currency crisis within fifteen months. This may have shaken the confidence among investors in stock investments following the Czech and Asian experiences. The missing negative contagion effects in the Russian case show that the strategy of international investors was not so much a reallocation of their portfolios but rather they reduced their overall engagement in stocks and preferred either cash or other assets like bonds.

V Concluding Remarks

In assessing the results of the empirical analysis some special factors have to be considered.

The markets under consideration are quite heterogenous with respect to some market characteristics. The inclusion of small markets may be problematic as thin trading causes a higher price volatility on these markets. This in turn may lead to an overestimation of the contagion effects. While the determination of the crisis period can have the opposite effect. The timing and the length of the crises are chosen somewhat arbitrarily. Especially, the beginning of the Asian currency crisis with shortly succeeding crises is hard to pin down as there was not a singular event that triggered the crisis. A relatively short crisis period may in tendency result in an underestimation of the contagion effects if it takes some time for them to spread. Therefore, it may be helpful for future research to extend the crisis period. However, at least for the Russian currency crisis this is not possible for the time being. Forecasts on the fallout of the contagion effects of future currency crises are problematic. However, this study shows that the intuitively straightforward presumption is correct. Namely, that the fallouts of the contagion effects with respect to their strength and their regional distribution are strongly influenced by the size and the integration of the original crisis market into the world economy. Big markets which are well integrated into the international financial system should cause stronger repercussions than relatively small and isolated markets.

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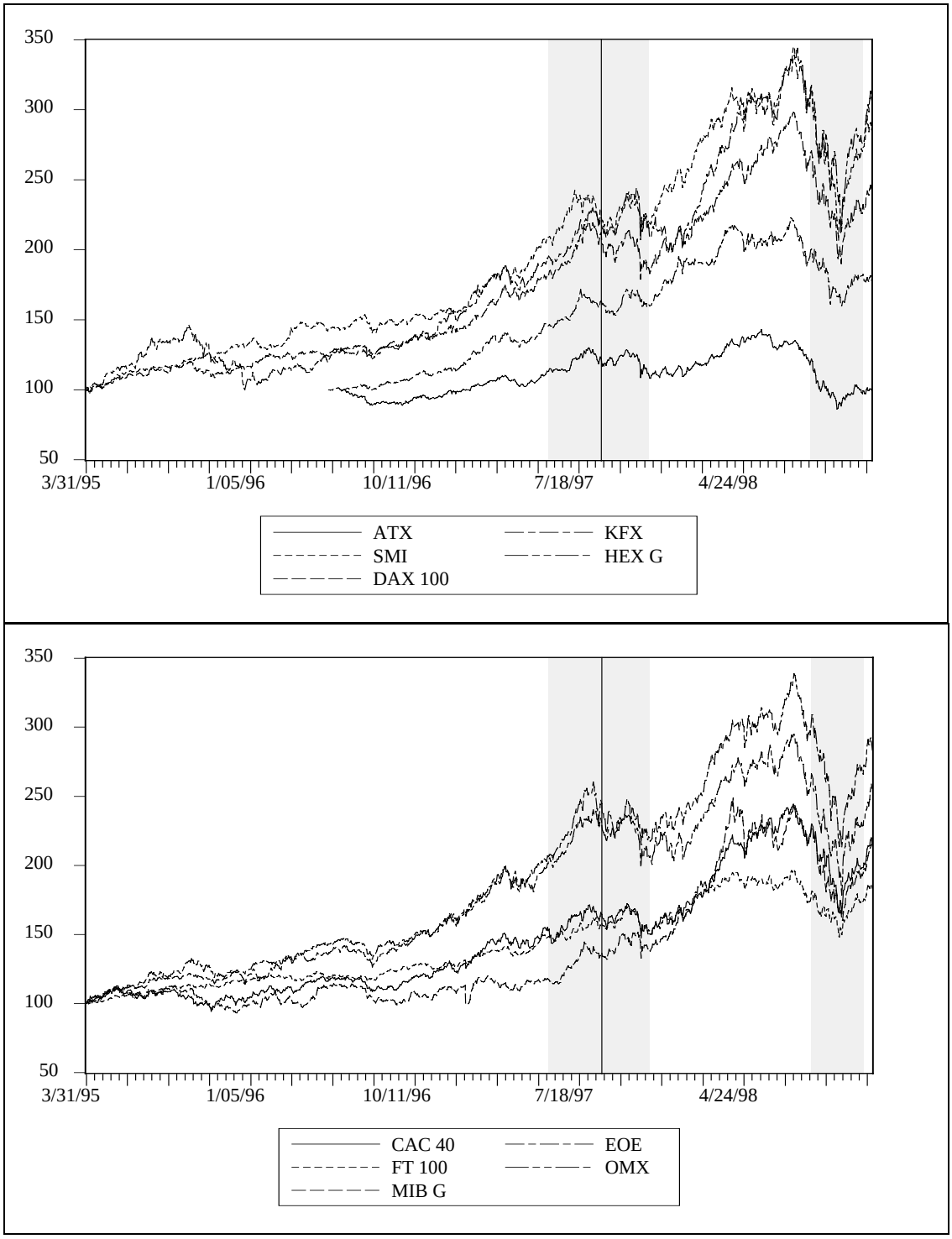
Appendix

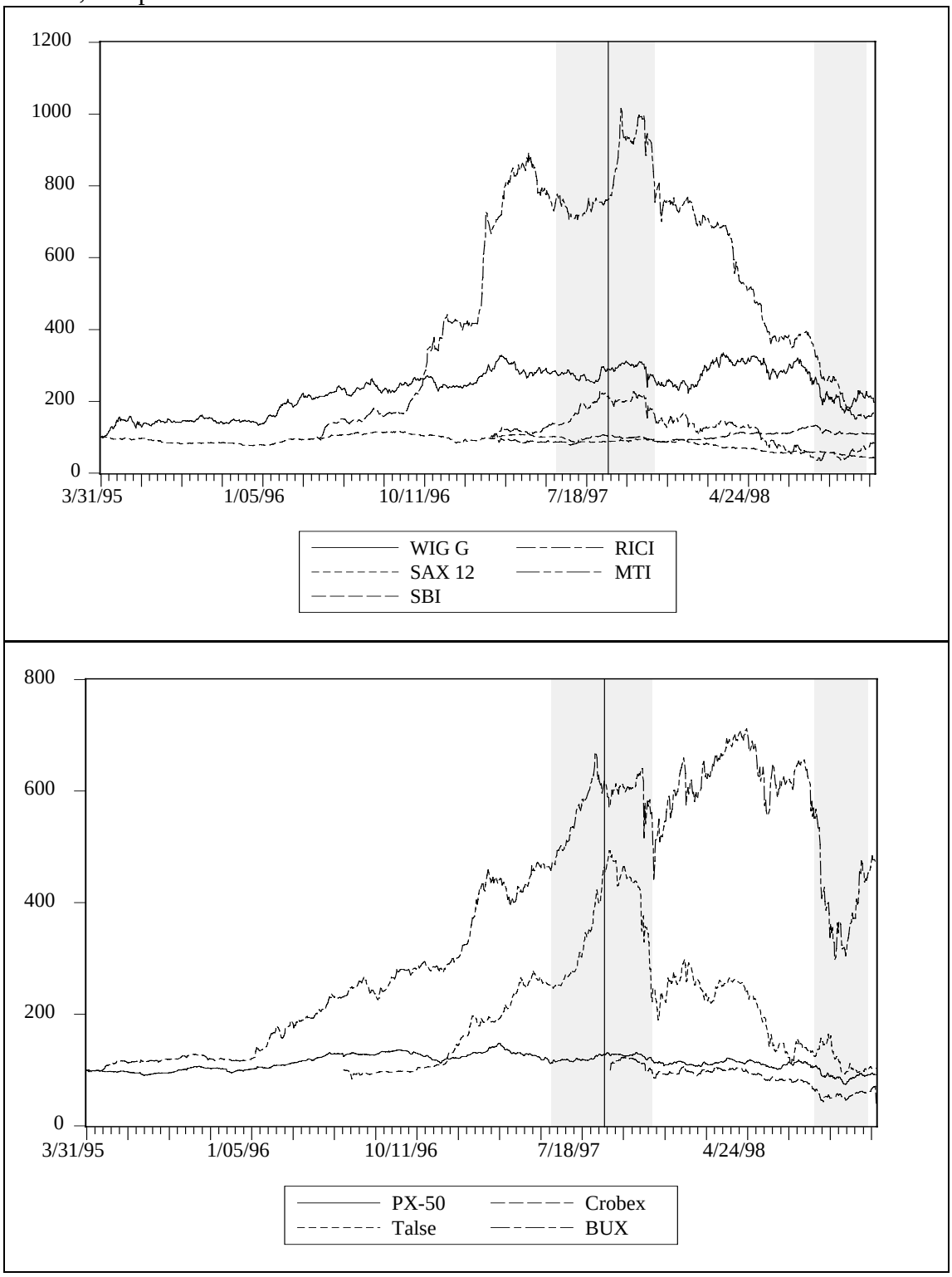
Graph 1:
Development of Selected West European Stock Market Indices,
3 April 1995 – 30 November 1998



Source: DRI/McGraw-Hill

Note: The shaded areas mark the crisis periods during the Czech crisis (27 May – 25 Aug 1997), the Asian crisis (14 Aug – 12 Nov 1997), and the Russian crisis (17 Aug – 13 Nov 1998). The vertical line denotes the end of the Czech crisis.

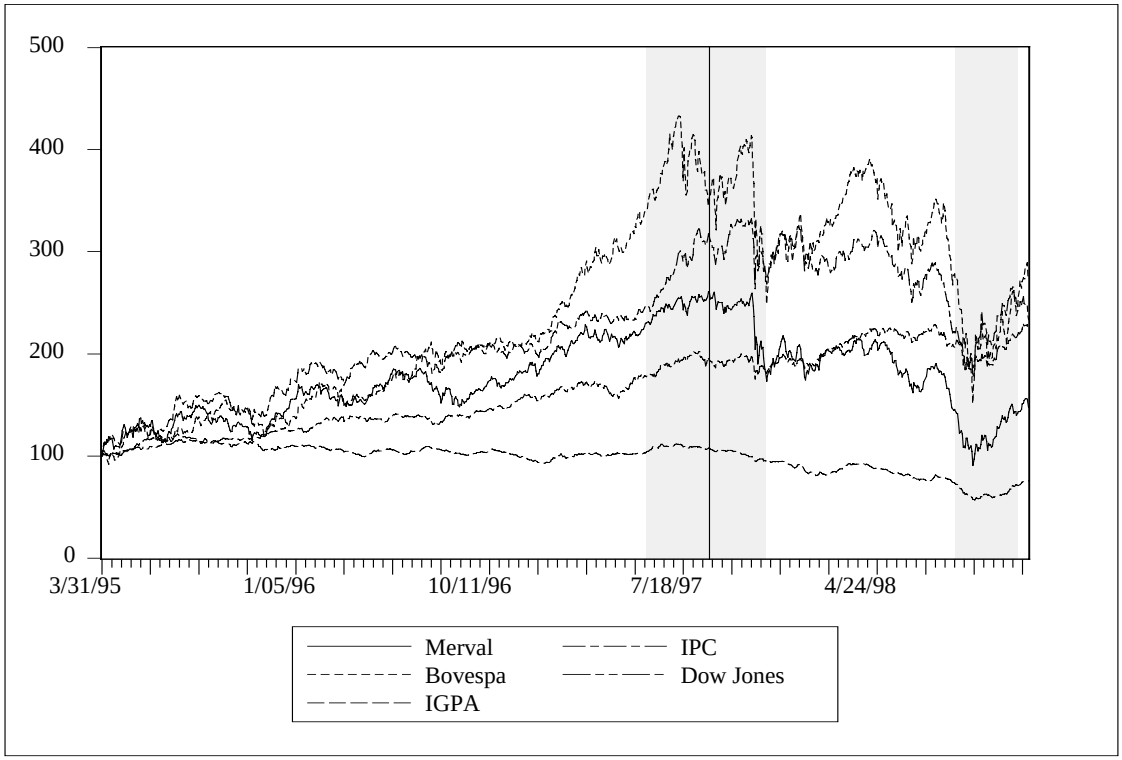
Graph 2:
Development of Selected Central and East European Stock Market Indices, 3 April 1995 – 30 November 1998



Source: DRI/McGraw-Hill

Note: The shaded areas mark the crisis periods during the Czech crisis (27 May – 25 Aug 1997), the Asian crisis (14 Aug – 12 Nov 1997), and the Russian crisis (17 Aug – 13 Nov 1998). The vertical line denotes the end of the Czech crisis.

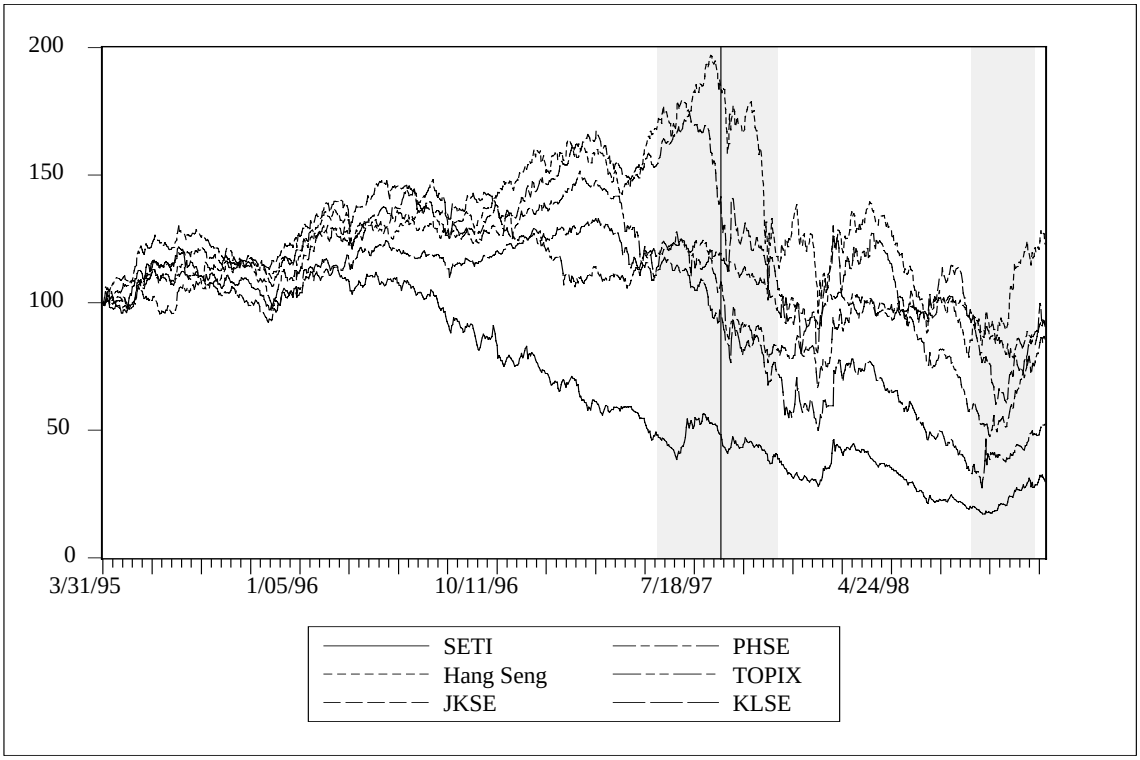
Graph 3:
Development of Selected American Stock Market Indices,
3 April 1995 – 30 November 1998



Source: DRI/McGraw-Hill

Note: The shaded areas mark the crisis periods during the Czech crisis (27 May – 25 Aug 1997), the Asian crisis (14 Aug – 12 Nov 1997), and the Russian crisis (17 Aug – 13 Nov 1998). The vertical line denotes the end of the Czech crisis.

Graph 4:
Development of Selected Asian Stock Market Indices,
3 April 1995 – 30 November 1998



Source: DRI/McGraw-Hill

Note: The shaded areas mark the crisis periods during the Czech crisis (27 May – 25 Aug 1997), the Asian crisis (14 Aug – 12 Nov 1997), and the Russian crisis (17 Aug – 13 Nov 1998). The vertical line denotes the end of the Czech crisis.

Table 1:
Market Characteristics of Selected Stock Exchanges

Country	**Stock Exchange**	**Index**	**Market-capitalisation** [a] (in Mio. USD)	**Turnover** (in Mio. USD)	**Number of listed Companies** [b]
Western Europe					
Austria	Vienna	ATX	35.436	1.766	100
Switzerland	Zurich	SMI	569.205	63.476	235
Germany	Frankfurt	DAX 100	970.167	135.746	733
Denmark	Copenhagen	KFX	92.693	6.041	241
Finland	Helsinki	HEX G	100.187	5.037	126
France	Paris	CAC 40	838.297	182.440	696
Great Britain	London	FT 100	2.015.200	277.229	2.427
Italy	Milan	MIB G	450.361	40.338	238
Netherlands	Amsterdam	EOE	522.184	38.926	213
Sweden	Stockholm	OMX	249.390	22.201	255
Central and Eastern Europe					
Czech	Prague	PX 50	12.964	n.a.	308
Estland	Tallinn	Talse	541	n.a.	28
Croatia	Zagreb	Crobex	2.547	n.a.	53
Hungary	Budapest	BUX	11.545	n.a.	53
Latvia[c]	Riga	RICI	337	16	65
Poland	Warsaw	WIG G	12.506	571	185
Russia	Moscow	MTI	12.885	n.a.	132
Slovakia	Bratislava	SAX 12	5.867	n.a.	220
Slovenia	Ljubljana	SBI	2.847	80	85
America					
Argentina	Buenos Aires	Merval	42.577	1.969	135
Brasil	Sao Paulo	Bovespa	155.806	10.849	548
Chile	Santiago	IGPA	46.675	272	288
Mexico	Mexico City	IPC	86.401	2.299	194
U.S.	New York	Dow Jones	8.749.316	663.070	2.284
Asia					
Hong Kong	Hong Kong	Hang Seng	277.536	13.375	657
Indonesia	Jakarta	JKSE	10.736	468	287
Japan	Tokyo	TOPIX	1.504.626	25.760	1.270
Malaysia	Kuala	KLSE	63.147	2.192	726
Philippines	Manila	PHSE	20.514	844	222
Thailand	Bangkok	SETI	22.085	1.170	422

[a)] End of September 1998. - [b)] Domestic companies excluding investment funds. - [c)] End of June 1998.

Sources: Federation Internationale des Bourses de Valeurs (International Federation of Stock Exchanges), National Stock Exchanges.

Table 2:
Overview of the Adjusted Correlation Coefficients

Currency Crisis	Sample Period	Crisis Period	Possible Market Pairs	Number of Cases for which holds[a]: $\rho^C > \rho^T$		Number of Cases for which holds[b]: $\rho_{LC} > \rho_{\$}$	
				in local Currencies	in US-Dollar	Tranquil Period	Crisis Period
Czech Crisis[c]	1 Apr 1995 – 30 Nov 1998	27 May – 25 Aug 1997	406	101 (24.9%)	89 (21.9%)	211 (52.0%)	242 (59.6%)
Asian Crisis[c]	1 Apr 1995 – 30 Nov 1998	14 Aug – 12 Nov 1997	406	254 (62.6%)	213 (52.5%)	190 (46.8%)	280 (69.0%)
Russian Crisis	1 Apr 1995 – 30 Nov 1998	17 Aug – 13 Nov 1998	435	304 (69.9%)	278 (63.9%)	147 (33.8%)	279 (64.1%)

[a)] The superscripts *C* and *T* denote the crisis period and the tranquil period, respectively [b)] The subscripts LC and $ mean in local currencies and in US-Dollar, respectively. - [c)] Excluding Croatia, because the stock index, Crobex, is not available for a sufficiently long period of time.

Note: The percentage figures denote the share of market pairs fulfilling the condition in the total number of market pairs.

Table 3:
Contagion Effects of Selected Currency Crises

Currency Crisis	Crisis Period	Region	Possible Market Pairs[c]	Number of Market Pairs with			
				Positive Contagion Effects[a]		Negative Contagion Effects[b]	
				in local Currencies	in US-Dollar	in local Currencies	in US-Dollar
Czech Crisis[d]	27 May – 25 Aug 1997	Total[e]	406	11 (2.7%)	11 (2.7%)	94 (23.2%)	97 (24.4%)
		Western Europe	235	6 (2.6%)	3 (1.3%)	56 (23.8%)	64 (27.2%)
		Central and Eastern Europe	196	5 (2.6%)	9 (4.6%)	59 (30.1%)	46 (23.5%)
		America	130	6 (4.6%)	4 (3.1%)	10 (7.7%)	25 (19.2%)
		Asia	153	5 (3.3%)	3 (2.0%)	37 (24.2%)	31 (20.3%)
Asian Crisis[d]	14 Aug – 12 Nov 1997	Total[e]	406	70 (17.2%)	38 (9.4%)	18 (4.4%)	21 (5.2%)
		Western Europe	235	47 (20.0%)	21 (8.9%)	15 (6.4%)	17 (7.2%)
		Central and Eastern Europe	196	38 (19.4%)	26 (13.3%)	18 (9.2%)	19 (9.7%)
		America	130	15 (11.5%)	11 (8.5%)	1 (0.8%)	1 (0.8%)
		Asia	153	14 (9.2%)	5 (3.3%)	0	0
Russian Crisis	17 Aug – 13 Nov 1998	Total[e]	435	63 (14.5%)	32 (7.4%)	0	0
		Western Europe	245	50 (20.4%)	23 (9.4%)	0	0
		Central and Eastern Europe	225	39 (17.3%)	23 (10.2%)	0	0
		America	125	4 (3.2%)	5 (4.0%)	0	0
		Asia	159	3 (1.9%)	1 (0.6%)	0	0

[a)] Number of market pairs for which the null hypothesis [Equation (4)] can be rejected. - [b)] Number of market pairs for which the null hypothesis [Equation (5)] can be rejected. The terms ‘positive‘ and ‘negative‘ refer to the signs of the adjusted correlation coefficients. - [c)] Number of market pairs for which at least one country stems from the respective region. - [d)] Excluding Croatia, because the stock index, Crobex, is not available for a sufficiently long period of time. - [e)] Single counted.

Note: The percentage figures denote the share of market paires fulfilling the condition in the total number of market pairs.