Modeling Comovement among Emerging Stock Markets: The Case of Budapest and Istanbul

Numan Ülkü
Central European University Business School, Budapest
ulkun@ceubusiness.org

Abstract
A double world-index model is proposed as an ideal way of characterizing the comovement among emerging stock markets, and applied to Budapest-Istanbul as an interesting case. An exclusive increase in the correlation between Budapest and Istanbul during the recent crisis period is documented. To decompose this correlation into information dynamics, a structural vector autoregression (SVAR) model is employed which controls for global indices that enter the system exogenously. Impulse response results suggest significant lagged responses, which imply predictability. Istanbul and Budapest contain incremental information for each other after controlling for global factors, particularly during and after the recent global crisis. Istanbul appears to respond to global information faster.

Keywords: Comovement of stock markets; European emerging markets; structural VAR; world index model.

JEL Classification: G15, G14, C32

1. Introduction

Linkages among national stock market indices have been extensively investigated in academic literature, with the focus being mainly on measuring diversification benefits for international portfolio investors and assessing transmission of information and contagion across national markets. This paper documents an interesting evolution of the linkage between two European emerging markets with little structural links before and during the recent global crisis, proposing an ideal specification to characterize the comovement between two emerging markets.

In recent periods, particularly since the beginning of the recent global crisis, short term traders in Istanbul vigilantly keep an eye on East European market indices, particularly that of Hungary, to get some clue on the future movements of Turkish stock market. Interestingly, Hungarian traders do the same by keeping an eye on Istanbul. This paper is inspired by this intriguing observation, which is at odds with the notion of efficient markets. While studies investigating the linkages among CEE markets and between CEE and developed markets are numerous, relating Istanbul to this region adds a new insight to this strand of the literature.

The correlation between Budapest Stock Exchange index (BUX) and Istanbul Stock Exchange index (ISE-100) has substantively increased, in particular during the recent global crisis period. While increasing subperiod correlations during and after global turbulence is a well-known fact, the correlation between BUX and ISE has grown beyond and above many international gauges. Specifically, BUX (ISE) return has become a significant factor for ISE (BUX) even after controlling for any relevant global indices. We further document that returns of both market indices have, during the recent periods, contained predictive information about the future returns of the other. The economic significance of this predictability is not trivial.

This study contributes to the literature by proposing and implementing a two world-index model as a theory-driven structural vector autoregression (SVAR) specification to characterize the incremental short-term dynamics between two emerging markets. Besides this, the Budapest-Istanbul case presents an interesting opportunity to illustrate many of the methodological issues debated in the comovements literature. A comparison of analysis with monthly and daily data offers useful lessons to practitioners employing simple correlations. In particular, Budapest-Istanbul case during our sample period refers to the interdependence-contagion debate (see Forbes and Rigobon, 2002; Corsetti et al., 2005), when the increase in correlation results from a common (global) factor, as opposed to one crisis country in the pair. The absence of a cointegrating relationship but presence of a very high correlation between Budapest and Istanbul market returns is instructive on reaching conclusions from cointegration tests. Finally, this study documents an interesting evolution of the degree of comovement between two European emerging markets with little direct trade link. The results presented give rise to a hypothesis that geographical organization of international investors may be a factor driving contagion.

Specifically, after checking for a cointegration relationship between BUX and ISE, a SVAR model in returns is employed where MSCI Europe and MSCI Emerging Market indices are permitted to affect BUX and ISE both contemporaneously and with lagged values but not be affected by them. Impulse response functions derived from this model enable measurement of the exclusive relationship and predictive information content (lagged responses) of BUX and ISE on each other. Results on daily frequency suggest significant lagged responses in both directions, but particularly significant lagged response of BUX to ISE during and after the recent crisis.

In the next section, the work in this paper is related to the extant literature, with a particular focus on discussing some methodological issues. In Section 3, a preliminary analysis is presented to document the evolving linkage between BUX and ISE based on a global market index model. In Section 4, the dynamic interaction between BUX and ISE is characterized by employing a SVAR model following standard cointegration analysis. In the final section, a summary of main results is followed by a discussion of potential explanations for the documented increase in the BUX-ISE linkage.

2. Related Literature

The literature on comovements of national stock indices is vast, and providing a list of all previous work on a global scale is an open-ended task. The introductory reader is referred to Syriopoulos (2004) for an extensive review of this literature. Here, we summarize key aspects of extant research in this strand of literature:

Aim and Scope: The primary purpose of this line of research is measuring benefits to international diversification. While a high degree of integration and comovement has been found among developed markets, the attention has focused on the comovement of emerging markets over the last two decades. A second focus has been characterizing information transmission and contagion effects and explaining the time-variation in the degree of comovement.

Methodology: The most basic methodology is correlation test, which is of direct significance as diversification benefits are inversely proportional to correlations between national indices. As correlations are found to vary over time, it is common to report the path of return correlations over sub-sample periods. Because correlation is linked to volatility, some studies compute conditional correlations using GARCH framework and some studies report heteroscedasticity-adjusted correlation coefficients. However, contemporaneous

correlations may lead to an overstatement of diversification benefits as they ignore long term dependencies between indices. Long term relationships are best addressed within cointegration framework. Stock market log price series are typically difference stationary I(1), hence suitable for cointegration methodology. Short term interaction, on the other hand, is best analyzed employing VAR methodology: Impulse response functions portray the effect of a shock in one index on another over a number of future periods, while variance decomposition provides a means of measuring relative role of national indices in explaining the movements of each other. Finally, some studies employ factor models as a theory-driven approach to decompose the sources of the correlations.
Main Findings: Developed markets have been found to be highly integrated. The correlations among national stock market indices have tended to increase over the last 4 decades. This increase has been attributed to globalization trend and deregulation of national markets, however some studies indicated that extreme volatility, in particular in bear markets, is responsible for most of this increase. In earlier studies, emerging markets were found "segmented" implying significant diversification benefits, while studies covering more recent periods find them increasingly integrated with developed markets and among each other. A more dramatic source of increase in comovements is global financial crises. Many studies report significantly higher contemporaneous correlations and cointegrating relationships during and after crisis periods, and attribute this to contagion. The implication is reduced diversification benefits for emerging market investors.

Having summarized the highlights of the global scale research on comovements of national stock markets, a review of findings of studies involving Hungary and Turkey is presented below:

Research covering earlier periods and employing cointegration methodology generally finds that CEE (Central and Eastern Europe) markets, including Budapest, and Istanbul are segmented, with low correlations to developed markets, presenting significant diversification benefits. Employing weekly data from Czech Republic, Hungary and Poland over the 1995-2001 period and Johansen approach, Gilmore and McManus (2002) find that these three CEE stock markets are not cointegrated with the US market. The only significant Granger-causality is detected from Hungary to Poland. Scheicher (2001) combines a VAR with a multivariate GARCH component to correct for the impact of volatility on time-varying correlations. Using daily data from 1/1/1995 to 7/10/1997 for the Czech, Hungarian and Polish indices (in US$), he finds low correlations to UK markets, and limited regional interactions.

Using daily data over the 2001-2004 period and employing Engle-Granger approach, Küçükçolak (2008) finds that Turkey, unlike Greece, is not cointegrated with UK, Germany and France. Korkmaz and Çevik (2008), using monthly data from 12 developed and 22 emerging markets and Turkey over the 1995 – 2007 period, find 7 and 5 pair-wise cointegration relationships between Turkey and developed and emerging markets[1], respectively. This paper, the only study to report cointegration test results between Hungary and Turkey, finds no cointegration between BUX and ISE.

However, with some methodological differences and use of more recent data, some studies report stronger cointegration: Syriopoulos (2004), using daily data on 4 CEE, DAX and S&P500 indices for the 1997-2003 period, finds that while CEE markets exhibit some linkages to each other, particularly Hungary and Poland are closely linked to Western markets. Based on VAR innovation accounting, he suggests linkages with Western markets are stronger than linkages with their neighbors, and that US markets lead Hungary and Poland. Voronkova (2004) employs Gregory-Hansen model that allows structural breaks in cointegrating relationships to find that CEE markets have become increasingly cointegrated with the UK, Germany, France and US markets. Using daily data for the September 1993 - April 2002, she reports structural breaks around 1997-98 (Asia and Russia crises) after which CEE markets exhibit cointegrating relationships which are omitted by conventional cointegration tests.

[1] Those 5 emerging markets are Czech Republic, Egypt, India, Israel and Taiwan.

In the analysis of short-term interaction, Berument and İnce (2005) study the impulse response functions from a structural block recursive VAR model which allows S&P500 index to affect ISE with its current and lag values but not vice versa. Using daily data from 23/10/1987 to 8/7/2004 with various subperiods, they show that S&P500 returns affect ISE returns positively up to 4 lags. Ceylan (2005) repeats the same methodology to assess the effect of G-7 markets on ISE using daily data from 4/1/1988 to 31/12/2004, and finds that all G-7 indices (Japan the least) have a positive and significant effect on ISE, mostly contemporaneous, but also at some lags.

Egert and Kocenda (2007) employ data at 5-minute frequency for DAX, CAC, UKX, BUX, PX-50 and WIG-20 indices for the 2/6/2003-9/2/2005 period, which does not correspond to any crisis. They do not find any cointegration relationship, but identify (sometimes bi-directional) short-term spill-over effects in both returns and volatilities. Cerny and Koblas (2008), using the same data set, compare Granger causality results at various intraday frequencies and conclude that information transmission is very fast, the bulk of the reaction occurring within 1 hour. Finally, using heteroscedasticity-adjusted correlations, Serwa and Bohl (2005) conclude that CEE markets are not more prone to contagion than West European markets.

We conclude the literature review with a discussion on several critical methodological issues:

A basic approach to characterize the degree of comovement is correlation analysis. However, the correlation has its well-known limitations: Contemporaneous correlation coefficients of returns do not incorporate lagged responses of one market to innovations in the other. They may not capture long-term linkages. Most importantly, correlation coefficients are sensitive to volatility. While in the literature the standard methodology to overcome these limitations has been the cointegration framework with an embedded GARCH specification, it has its own limitations in leading to an intuitive economic interpretation. King et al. (1994), pointing to the inability of ARCH models to disentangle the source of changes in volatility, employ a factor model to decompose sources of changes in the degree of comovement. Morana and Beltratti (2008) follow a similar approach employing principal component analysis.

Forbes and Rigobon (2002) provide a detailed illustration of the bias in correlation coefficients conditional on volatility. The intuition is that when national stock market returns have two components, a common (global) and a local one, an increase in the variance of the common factor relative to local factor results in an upward bias in measured correlation coefficient even though the true relationship between two national indices remains constant. Hence, it is important to decompose the sources of variation in the degree of comovement. While it is necessary to employ factor models or principal component analysis in analyzing comovements between large developed markets, for small emerging markets a simpler world index model can successfully account for global factors. It is interesting to note that such an approach is scarce in this line of literature which investigates interdependence between emerging markets.

While heteroscedasticity-adjusted correlation coefficients can be a remedy to the effect of changing volatility, contemporaneous return correlations ignore long-term relationships. Hence, cointegration techniques are crucial in measuring international diversification benefits for long term portfolio investors, and nicely account for the possibility of a long term equilibrium relationship to which national indices are gradually pulled over time. However, the intuition behind the use of cointegration framework in measuring the degree of comovement between national indices needs to be well-understood. The finding of cointegration implies that country-specific shocks to returns were always followed by exactly offsetting shocks (Richards, 1995), which amounts to ruling out permanent macroeconomic performance differences. Cointegration results are sensitive to performance contingencies of the sample period, thus need to be complemented by a theory-driven approach.[2] Short-term linkages (dynamic interaction) between two market returns, on the other hand, illuminate the propagation mechanisms and market participants' perception of implications of return shocks in one market for the other.

There are also a few minor issues which we would like to discuss here: The use of daily data requires a careful treatment of missing observations due to holidays. Missing observations may cause problems in time series methods involving many lags. Moreover, the days following national holidays are also problematic, because the daily returns on such days incorporate two days' information on the holiday-country whereas only one day's in others, causing a mismatch. Many studies do not mention how holidays are treated; others, for example Voronkova (2004), handle the problem by filling the holiday with previous day's price. This, however, may cause an understatement of contemporaneous correlation as it implies a zero return for the holiday and a mismatch for the next day, and can be particularly problematic in the analysis of short term dynamics.

Finally, the synchrony of trading hours is of crucial importance in studies of short term information content using daily data. The problem is best illustrated by the results of Berument and İnce (2005) and Ceylan (2005): The impulse response functions reported in these papers suggest a larger contemporaneous response of ISE to European markets but a larger lagged response to North American markets, which in fact is spurred by time (globally available information) differences within a day. This may distort conclusions in measuring spillover effects and predictive content.

3. Characterizing BUX – ISE linkage

In this section, a preliminary analysis is presented with the aim of illustrating the steps in the derivation of the specification proposed in this paper and to intuitively depict many methodological pitfalls. In the first part of this illustration, monthly data on BUX and ISE as well as S&P500, UKX, MSCI-World, MSCI-Europe and MSCI-Emerging Markets indices are used. The sample period is from May 1998 to December 2009. All indices are used in local currency terms to avoid currency movements clouding equity returns.[3] All returns are calculated as logged differences of monthly index closing levels. Monthly data is an ideal means of describing contemporaneous comovements of national stock indices as it captures some lead-lag patterns in daily returns. The time-variation in the degree of comovement can be monitored by dividing the sample into subperiods, particularly into crisis vs. non-crisis regimes.

Table 1 reports contemporaneous bivariate correlations of monthly returns for the whole sample as well as for subperiods. The subperiods are selected to represent crisis versus noncrisis intervals. The correlations among the developed markets are high in all subperiods, but vary mainly across crisis versus non-crisis subperiods. The correlation of ISE, BUX and MSCI Emerging Markets index with developed market indices has significantly increased in the second half of the sample. However, the increase is driven by the recent global crisis period. The bottom panel of Table 1 presents the correlations during the former global crisis period (the 2000-03 period that comprises the burst of Nasdaq bubble,

[2] There has been intensive debate on market efficiency implications of cointegration findings (see Richards (1995)). In case of a weak contemporaneous correlation but strong long term cointegration, one possibility is that markets overreact to own country-specific shocks which are reverted over time. Another possible explanation is that participants in one market underreact to permanent shocks in the other which will be transmitted via structural economic links. Significant lagged terms in VAR equations of returns may arise when participants in one market initially underreact or overreact to a common global shock. Given possible explanations like this, findings of cointegration tests should be assessed in light of an economic model, as Richards (1995) calls for.

[3] Use of foreign currency denominated index series may distort the correlations between developed market indices. See, for example, Dickinson (2000) who warns against the possibility that exchange rate movements could offset the innovations of stock indices. In our case, it may result in an overstatement of comovements as Hungarian forint and Turkish lira respond to the same common global factors as BUX and ISE do.

September 11 attack, and the Iraq war) for comparison purposes. It suggests that while the increase in correlations among developed markets was similar during both crisis periods, the increase in correlations of BUX and ISE with developed markets is much more dramatic this time.

Table 1: Contemporaneous correlations of monthly returns

Full-sample

	SP	UKX	ISE	BUX	EM	E
UKX	0.843					
ISE	0.534	0.557				
BUX	0.651	0.598	0.553			
EM	0.784	0.728	0.603	0.734		
E	0.861	0.935	0.610	0.663	0.748	
W	0.966	0.877	0.568	0.689	0.849	0.896

1998:5 - 2003:12 2004:1 - 2009:12

	SP	UKX	ISE	BUX	EM	E	W
SP		0.845	0.621	0.764	0.825	0.900	0.971
UKX	0.846		0.651	0.708	0.788	0.957	0.877
ISE	0.516	0.545		0.730	0.741	0.715	0.669
BUX	0.572	0.514	0.499		0.810	0.770	0.807
EM	0.755	0.675	0.581	0.674		0.812	0.907
E	0.835	0.920	0.589	0.587	0.698		0.914
W	0.968	0.883	0.560	0.596	0.793	0.888	

The lower left half shows the 1998:5 - 2003:12 subperiod, the upper right half shows 2004:1 - 2009:12 subperiod.

2004:1 - 2007:7 2007:8 - 2009:12

	SP	UKX	ISE	BUX	EM	E	W
SP		0.880	0.730	0.862	0.869	0.926	0.978
UKX	0.606		0.741	0.761	0.838	0.968	0.908
ISE	0.297	0.422		0.852	0.786	0.829	0.768
BUX	0.407	0.536	0.490		0.845	0.838	0.888
EM	0.607	0.568	0.643	0.713		0.860	0.937
E	0.745	0.910	0.435	0.534	0.610		0.939
W	0.915	0.675	0.408	0.543	0.792	0.768	

The lower left half refers to 2004:1 - 2007:8 (the non-crisis period); the upper right half refers to 2007:8 - 2009:12 (the crisis period).

2000:12 - 2003-4

	SP	UKX	ISE	BUX	EM	E
UKX	0.902					
ISE	0.673	0.623				
BUX	0.645	0.642	0.457			
EM	0.836	0.784	0.677	0.668		
E	0.947	0.962	0.665	0.637	0.841	
W	0.981	0.927	0.680	0.642	0.852	0.966

The subperiod covering the previous global crisis

Notes: SP: S&P500 index of US, UKX: FTSE-100 index of UK, ISE: Istanbul Stock Exchange-100 index of Turkey, BUX: Budapest Stock Exchange Index of Hungary, EM: MSCI Emerging Markets Index, E: MSCI Europe index, W: MSCI World Index.

Our particular interest in this study is the correlation between BUX and ISE, and the determinants of its evolution over time. Table 1 suggests that while the correlation has increased to 0.73 in the second half of our sample from 0.50 in the first half, this increase is solely driven by the recent global crisis period during which the correlation rose to 0.85. Note that during the previous (2000-03) crisis, unlike during the recent one, the correlation between BUX and ISE had not increased (had even decreased), although the 2000-03 crisis period had significant global events and influences. The same is not true, however, for ISE and BUX's correlations with world markets: These correlations increased both in the previous and current crisis, though more sharply in the latter. Hence, the preliminary analysis of correlation coefficients suggests an unprecedented increase in the degree of comovement between Budapest and Istanbul during the recent crisis period.

Our goal is to provide a characterization of the comovement between BUX and ISE and the causes of the variation in its degree, especially from the perspective of information linkage. For this purpose and in the light of the methodology discussion in the previous section, we employ a theory-driven approach here, which partly borrows from the work of Morana and Beltratti (2008).[4] They define the market return in country j as a function of a common (global) factor:

$$r_{jt} = E_{t-1}(r_{jt}) + \beta_{jt}F_t + \varepsilon_{jt} \quad (1)$$

where F_t is the common factor, such that $E(F_t) = 0$ and $V_{t-1}(F_t) = \sigma^2_{Ft}$, β_j is the sensitivity of country j to the common factor, and ε_{jt} is country specific innovation such that $E(\varepsilon_{jt}) = 0$, $V_{t-1}(\varepsilon_{jt}) = \sigma^2_{jt}$, and $Cov(\varepsilon_{jt}, \varepsilon_{it}) = 0$.

$$Cov_{t-1}(r_{jt}, r_{it}) = \beta_i\beta_j\sigma^2_{Ft} \quad (2)$$

$$Cor_{t-1}(r_{jt}, r_{it}) = \frac{\beta_{it}\beta_{jt}\sigma^2_{Ft}}{\sqrt{\beta^2_{it}\sigma^2_{Ft}+\sigma^2_{it}}\sqrt{\beta^2_{jt}\sigma^2_{Ft}+\sigma^2_{jt}}} \quad (3)$$

The first derivative of $Cor_{t-1}(r_{jt}, r_{it})$ with respect to σ^2_{Ft} is:

$$\frac{1}{2}\beta_{it}\beta_{jt}\frac{\sigma^2_{Ft}\beta^2_{it}\sigma^2_{jt}+\sigma^2_{Ft}\sigma^2_{it}\beta^2_{jt}+2\sigma^2_{it}\sigma^2_{jt}}{(\sqrt{(\sigma^2_{Ft}\beta^2_{it}+\sigma^2_{it})})^3(\sqrt{(\sigma^2_{Ft}\beta^2_{jt}+\sigma^2_{jt})})^3} > 0 \quad (4)$$

This provides a more precise illustration of the argument in Forbes and Rigobon (2002) and Corsetti et al. (2005) for the different case where the crisis results from the common factor (i.e., the correlation increases in the volatility of the common factor although the relationship between two markets remains constant). Hence, the relationship between two emerging markets needs to be augmented with appropriate global indices to control for changing variance of the common factor.

Morana and Beltratti (2008) obtain the common factor via principal component analysis in a four country setting of developed markets. King et al. (1994), who have a similar approach, employ factor analysis because they use economic variables. Instead, in this paper we employ a different approach which is appropriate for an emerging market (small economy) setting: We use global developed and emerging market indices as common factors.[5] We try S&P500, FTSE-100, MSCI-World, MSCI-Europe indices to capture global market information. Considering the possibility that emerging markets may be responding to a different information set, we also employ MSCI Emerging Markets index.[6] To choose the best world index specification, Equation 5 below is estimated:

$$R_{i,t} = \beta_{0,i} + \beta_{1,i}F_t + \beta_{2,i}F_{t-1} + \varepsilon_{i,t} \quad (5)$$

where R_i is the monthly log return of BUX and ISE (i = BUX, ISE), F is the monthly log return of the common factor (any of these global indices), and $\varepsilon_{i,t}$ is the domestic component of unexpected realized return. To account for the possibility of lagged responses of Hungary and Turkey to global information, lagged returns of these indices (F_{t-1}) are included. This single-equation specification is robust to the endogeneity problem by the reasonable assumption that Hungary and Turkey are not likely to affect US, UK, World and Emerging Market Index returns.[7] As F is exogenous, OLS procedure is unbiased. We are interested in the R^2 of this regression, which provides a view of the relative importance of global (common) factors in comparison to domestic factors.

Table 2: Estimation results for Equation (5)

[4] Later in the next section we will employ VAR framework to confirm the insight derived here.
[5] A similar approach was employed independently by Fedorova and Vaihekoski (2009) in an asset pricing context.
[6] The MSCI indices used in this study are market capitalization-weighted (based on free float).
[7] Hungary and Turkey are components of MSCI Emerging Markets index. However, as it has 22 component countries, Hungary and Turkey are unlikely to have a significant effect on this index to bias our results.

Panel A: BUX results

Common Index (F)	β_0	β_1	β_2	R^2
S&P500	0.0078	1.119	0.253	0.452
	(0.0054)	(0.179)[a]	(0.145)[a]	
UKX	0.0089	1.155	0.316	0.393
	(0.0057)	(0.194)[a]	(0.147)[a]	
MSCI-World	0.0070	1.175	0.173	0.496
	(0.0053)	(0.165)[a]	(0.125)[a]	
MSCI-Europe	0.0087	1.123	0.173	0.477
	(0.0053)	(0.168)[a]	(0.118)[a]	
MSCI-Emerging Markets	0.0019	0.770	0.089	0.532
	(0.0050)	(0.105)[a]	(0.065)[a]	

Panel B: ISE results

Common Index (F)	β_0	β_1	β_2	R^2
S&P500	0.0189	1.540	0.214	0.289
	(0.0104)	(0.216)	(0.216)	
UKX	0.0203	1.807	0.148	0.313
	(0.0102)	(0.233)	(0.233)	
MSCI-World	0.0179	1.645	0.059	0.323
	(0.0101)	(0.212)	(0.212)	
MSCI-Europe	0.0201	1.734	0.024	0.378
	(0.0097)	(0.194)	(0.194)	
MSCI-Emerging Markets	0.0115	1.107	-0.049	0.361
	(0.0098)	(0.128)	(0.126)	

Notes: The numbers in parentheses are standard errors. "a" denotes White-heteroscedasticity adjusted standard errors.

Estimation results (for the full sample) are presented in Table 2. Hungary appears to be more strongly correlated to global markets, compared to Turkey. Some of the lagged coefficients are significant around borderline levels for Hungary, but none for Turkey. Results indicate that MSCI-Europe and MSCI-Emerging Markets indices have the highest explanatory power for BUX and ISE (for BUX MSCI-World is also high).

A stepwise regression analysis[8] to select the most adequate global index model to characterize BUX and ISE returns suggested that MSCI-Emerging Markets index contains additional information beyond that contained by developed market indices. The highest adjusted R^2s are obtained when both MSCI-Europe and MSCI-Emerging Market indices are included, which is also the most adequate model according to Schwarz and Akaike criteria, for both BUX and ISE. Hence, in the remainder of this section we focus on the following model:

$$R_{i,t} = \beta_{0,i} + \beta_{1,i} E_t + \beta_{2,i} E_{t-1} + \beta_{3,i} EM_t + \varepsilon_{i,t} \qquad (6)$$

where i=BUX, ISE , E is the return of the MSCI-Europe index, and EM is the return of MSCI-Emerging Markets index.[9] Estimation results of Equation (6) with a detailed subsample breakdown are presented in Table 3.

Table 3: Estimation results for Equation (6)

Panel A: BUX results

Period	β_0	β_1	β_2	β_3	R^2
Full-sample	0.0046	0.506	0.524	0.147	0.573
	(0.0051)	(0.160)[a]	(0.150)[a]	(0.107)[a]	
1998:5 - 2003:12	0.0049	0.504	0.508	0.079	0.474
	(0.0088)	(0.242)[a]	(0.271)[a]	(0.151)[a]	
2004:1 - 2009:12	0.0039	0.506	0.530	0.246	0.711
	(0.0051)	(0.193)	(0.112)	(0.117)	
2004:1 - 2007:7	0.0054	0.363	0.692	0.172	0.520
	(0.0074)	(0.314)	(0.160)	(0.262)	
2007:8 - 2009:12	0.0011	0.619	0.431	0.243	0.783
	(0.0097)	(0.289)	(0.170)	(0.155)	
2000:12 - 2003:4	0.0121	0.265	0.455	-0.025	0.465
	(0.0130)	(0.316)	(0.288)	(0.188)	

Panel B: ISE results

Period	β_0	β_1	β_2	β_3	R^2
Full-sample	0.0157	1.062	0.571	-0.004	0.419
	(0.0095)	(0.289)	(0.186)	(0.189)	
1998:5 - 2003:12	0.0269	1.223	0.696	0.146	0.402
	(0.180)	(0.468)	(0.329)	(0.321)	
2004:1 - 2009:12	0.0069	0.703	0.563	-0.114	0.589
	(0.0073)	(0.273)	(0.158)	(0.166)	
2004:1 - 2007:7	0.0023	0.199	0.887	0.056	0.406
	(0.0108)	(0.457)	(0.233)	(0.380)	
2007:8 - 2009:12	0.0116	1.108	0.315	-0.151	0.713
	(0.0131)	(0.388)	(0.229)	(0.209)	
2000:12 - 2003:4	0.0113	0.537	1.279	-0.525	0.518
	(0.0300)	(0.731)	(0.665)	(0.433)	

Notes: The numbers in parentheses are standard errors. "a" denotes White-heteroscedasticity adjusted standard errors.

The R^2 values are significantly higher in the second half compared to the first half. While R^2 values are higher also in the noncrisis subperiod of the second half, they sharply increase during crisis periods compared to noncrisis

[8] Detailed results are available from the author. Only the results for the selected model are reported here.

[9] The full-sample correlation between E and EM is 0.748 which does not immediately cause multicollinearity but poses some risk, particularly in some subperiods. As our interest in this section focuses on R^2 values, and not t-tests, multicollinearity does not affect our task. Note that the lagged term of only one of the global indices is included, as the incremental contribution of a second lagged term is negligible.

periods. Hence, we can conclude that both Hungary and Turkey exhibit a trend of increasing comovement with world markets due to globalization as well as correlation jumps due to global crises. In the second half of the sample, lagged values of E seem to have some statistically significant explanatory power on BUX.[10]

In the final step, BUX and ISE are added into each other's equation to see their incremental information content for each other after controlling for global common factors. Specifically, the following equations are estimated:

$$BUX_t = \beta_{0,i} + \beta_1 E_t + \beta_2 E_{t-1} + \beta_3 EM_t + \beta_4 ISE_t + \varepsilon_{i,t} \quad (7)$$

$$ISE_t = \beta_{0,i} + \beta_1 E_t + \beta_2 E_{t-1} + \beta_3 EM_t + \beta_4 BUX_t + \varepsilon_{i,t} \quad (8)$$

Estimation results are presented in Table 4 where only β_4 and R^2 values are reported as our interest here is to measure the incremental information content only. For reader's convenience, the incremental variation explained by ISE and BUX's inclusion into each other's equation, Δ, is also reported as it is the key parameter of interest here.

Table 4: Estimation Results for Equation (7) and (8)

Panel A: BUX results

Period	β_4	R^2	Δ
Full-sample	0.068 (0.066)[a]	0.580	0.007
1998:5 - 2003:12	0.051 (0.076)[a]	0.480	0.006
2004:1 - 2009:12	0.205 (0.082)	0.736	0.025
2004:1 - 2007:7	0.019 (0.112)	0.520	0.000
2007:8 - 2009:12	0.400 (0.128)	0.845	0.062
2000:12 - 2003:4	-0.019 (0.088)	0.466	0.001

Panel B: ISE results

Period	β_4	R^2	Δ
Full-sample	0.258 (0.243)[a]	0.429	0.010
1998:5 - 2003:12	0.221 (0.322)[a]	0.408	0.006
2004:1 - 2009:12	0.412 (0.218)[a]	0.624	0.035
2004:1 - 2007:7	0.041 (0.236)	0.406	0.000
2007:8 - 2009:12	0.723 (0.231)	0.796	0.083
2000:12 - 2003:4	-0.103 (0.471)	0.519	0.001

Under the assumption of no omitted variables (i.e. that no other common factor exists), Δ is an indicator of exclusive linkage between BUX and ISE which cannot be explained by common factors (neither by the changing responsiveness of BUX and ISE to common factors nor by the changing variance of common factors). Hence, the results presented in Table 4 convey the key message of this section. We observe an increase in the *exclusive* BUX-ISE linkage in the second half, which is completely driven by the recent global crisis period, as BUX and ISE contained no additional information for each other in the 2004:1 2007:7 subperiod. The incremental information content which becomes evident in the 2007:8 2009:12 subperiod is a significant structural change. Moreover, it is an unprecedented change as BUX and ISE contained negligible incremental information for each other during the 2000-03 crisis period.

At this point, one is tempted to see whether this linkage is exclusively between BUX and ISE or between all CEE markets and ISE. For this purpose, we replace BUX in Equation (8) with the *MSCI Eastern Europe ex Russia* index (EExR), which covers Hungary, Poland and Czech Republic stock markets. The estimation result for the 2007:8 – 2009:12 subperiod suggests that EExR does not enter the equation significantly (t=1.36), whereas BUX entered significantly (t=3.13, as can be calculated from the 5th row in Panel B of Table 4). The contribution of EExR to R^2 is merely 2.1%, whereas BUX alone increases R^2 by 8.3%. We also tried WIG-20 index of Poland. During the recent crisis period WIG-20's contribution to both BUX and ISE is much less (Δ is 4.2% and 2.5% in BUX and ISE equations, respectively). During the 2004:1 – 2007:8 period, however, WIG-20 had a

[10] Unreported analysis indicated that until the beginning of the recent crisis, EM had larger explanatory power for both BUX and ISE, whereas during and after the recent global crisis, which originated from developed economies, the role of E has surpassed that of EM.

significant contribution to BUX equation (Δ = 4.0% vs. ISE's contribution of 0.1%). These comparisons suggest that the increased linkage during the last crisis is uniquely between BUX and ISE, which is quite intriguing.

4. Analysis in VAR and Cointegration Framework

In this section, short term dynamics and the long term relation between BUX and ISE are characterized using daily data. This analysis also enables us to see whether BUX and ISE contain predictive information about the future returns of each other. We analyze short-term dynamics under VAR framework and long term relationship under cointegration framework, in line with the standard time series procedure. A specific novelty of this paper is the SVAR specification where global market returns are allowed to affect BUX and ISE returns, but not vice versa. This is achieved via block exogeneity in the VAR equation.

The summary statistics of BUX, ISE, E and EM daily returns are presented in Table 7 below. The analysis starts with tests for unit roots. As typically always is the case with stock market indices, logged levels of BUX and ISE, as well as E and EM, turn out to be first difference stationary I(1), both with monthly and daily data. Unit root test statistics by ADF and PP procedures (not reported to save space, available upon request) range between 5-10 times of critical values for first differences. Hence, we can safely proceed with cointegration analysis with logged levels and VAR framework with first differences (log returns).

Table 7: Summary Statistics of daily returns

	Panel A: 1/1/2004-31/7/2007					Panel B: 1/1/2007-31/12/2009				
	n	Mean	St.Dev.	Skewness	Kurtosis	n	Mean	St.Dev.	Skewness	Kurtosis
BUX	875	0.001283	0.013536	-0.330	4.479	579	-0.000529	0.024155	0.121	8.462
ISE	875	0.001161	0.017722	-0.386	4.575	579	0.000045	0.023243	0.021	5.306
E	875	0.000521	0.007317	-0.491	5.439	579	-0.000528	0.018943	0.010	6.966
EM	875	0.000896	0.008460	-0.766	6.784	579	-0.000124	0.018371	-0.704	15.697

The natural next step is to check for cointegration, as the presence of a cointegration relationship would imply a long term relationship between BUX and ISE, towards which any deviations are pulled over time, hence would require the inclusion of an error correction term in the VAR equation. We employ Johansen framework:

$$\Delta y_t = \delta + \sum_{p=1}^{p-1} \Gamma \Delta y_{t-1} + \Pi y_{t-p} + \varepsilon_t \qquad (9)$$

where y' = [ln(BUX), ln(ISE)], $\mathbf{\Gamma}$ is a 2x2 matrix of VAR coefficients, Δ is the first difference operator, and ε_t is a (2x1) vector of error terms. $\mathbf{\Pi}$ can be decomposed as $\alpha\beta'$ where β represents the cointegrating equation and α represents the error correction coefficients. Results based on trace and maximum eigenvalue statistics for the two subsamples, 1/1/2004-31/7/2007 (the non-crisis period) and 1/8/2007-31/12/2009 (the crisis period) are presented below in Table 8.

Table 8: Cointegration Test Results between BUX and ISE with Daily Data

Unrestricted Cointegration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.012823	9.54059	15.41	20.04
At most 1	0.002259	1.422685	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates no cointegration at both 5% and 1% levels

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.012823	8.117905	14.07	18.63
At most 1	0.002259	1.422685	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigenvalue test indicates no cointegration at both 5% and 1% levels

A. Results for the 1/1/2004-31/7/2007 subsample

Unrestricted Cointegration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.00947	9.602624	15.41	20.04
At most 1	0.000911	0.839307	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates no cointegration at both 5% and 1% levels

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.00947	8.763318	14.07	18.63
At most 1	0.000911	0.839307	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigenvalue test indicates no cointegration at both 5% and 1% levels

B. Results for the 1/8/2007 – 31/12/2009 subsample

The null hypothesis of no cointegration cannot be rejected at conventional levels of significance neither in the full sample (not reported) nor in either of the subsamples. Alternative specifications of the constant term and trend were tested, and results were the same. Further, the same cointegration tests were performed in a multivariate framework where y′ = [ln(E), ln(EM), ln(BUX), ln(ISE)], and the null hypothesis of no cointegration could not be rejected neither in the full sample nor in either of the subsamples.[11]

At this point, a reminder on the function of cointegration test is warranted, as some papers merely focus on cointegration tests and report only whether a set of stock indices (in pairs or in groups) are cointegrated or not. Cointegration tests merely investigate the possibility of a long term equilibrium relationship, negligence of which in the VAR would cause misspecification. In our BUX-ISE example, lack of cointegration did not mean absence of return correlation. Nor, the cointegration test could pick the significant increase in correlations in the second subsample. The absence of cointegration between national stock market indices may simply result from permanent macroeconomic

[11] All these results, which are not reported here to save space, are available from the author.

performance differences, while its presence may only reflect performance contingencies of the sample period. Thus, cointegration test results should not be the end of the analysis. Accordingly, here they only guide us on whether an error correction term should be included in the VAR model, or not.

Based on the absence of cointegration, we drop the error correction term, and move on to our SVAR framework, where global indices are treated as exogenous by imposing block exogeneity. The SVAR specification employed here is the main methodological contribution of this paper. In previous applications of SVAR models in this strand of literature, only the impulse response of an emerging market index to a developed market index, which enters the system exogenously, is obtained (e.g. Berument and İnce, 2005). We portray BUX and ISE's impulse response to each other, holding MSCI Europe and MSCI Emerging Markets exogenous. This specification ought to be the standard way of documenting incremental interdependence between two non-cointegrated emerging markets, and can be extended to VECM in case of presence of cointegration relationship.

Specifically, the following VAR model is estimated in first differences (i.e. log returns):

$$\mathbf{\Delta y_t = A_1 \Delta y_{t-1} + A_2 \Delta y_{t-2} + \ldots. + A_p \Delta y_{t-p} + \varepsilon_t} \quad (10)$$

where $\mathbf{y}'$ = [ln(E), ln(EM), ln(BUX), ln(ISE)], $\mathbf{A_1}$ to $\mathbf{A_p}$ are 4x4 matrices of VAR coefficients, Δ is the first difference operator, and ε_t is the 4x1 vector of i.i.d. error terms. Similar to Zha (1999) SVAR model, we restrict contemporaneous and lagged values of BUX and ISE from affecting E and EM by imposing block exogeneity as follows:

$$\mathrm{A(L)}y(\mathrm{t}) = \varepsilon(\mathrm{t}) \quad (11)$$

where *A(L)* is a *4*x*4* matrix polynomial in the lag operator *L*, and $\varepsilon(t)$ is the *4*x1 vector of structural disturbances. Specified model is shown in Equation 12:

$$y(t) = \begin{bmatrix} E(t) \\ EM(t) \\ BUX(t) \\ ISE(t) \end{bmatrix} \qquad A(L) = \begin{bmatrix} \mathrm{A_{11}(L)} & 0 & 0 & 0 \\ \mathrm{A_{21}(L)} & \mathrm{A_{22}(L)} & 0 & 0 \\ \mathrm{A_{31}(L)} & \mathrm{A_{32}(L)} & \mathrm{A_{33}(L)} & \mathrm{A_{34}(L)} \\ \mathrm{A_{41}(L)} & \mathrm{A_{42}(L)} & \mathrm{A_{43}(L)} & \mathrm{A_{44}(L)} \end{bmatrix} \qquad \varepsilon(t) = \begin{bmatrix} \varepsilon_1(t) \\ \varepsilon_2(t) \\ \varepsilon_3(t) \\ \varepsilon_4(t) \end{bmatrix} \quad (12)$$

where the assumptions are that $\varepsilon(t)$ is uncorrelated with past $y(t - p)$ for $p>0$, and the coefficient matrix of L^0, A_0, is non-singular. The block exogeneity is represented by zero entries in A(L), and implies that E and EM are exogenous to BUX and ISE both contemporaneously and for lagged values.[12] This set of restrictions reflect a plausible hypothesis that conditions in developed markets as well as a general appetite towards emerging markets as a whole affect individual emerging markets, however none of the individual emerging markets is likely to affect world indices. This hypothesis would hold true except for contagious emerging market crises like Mexico-94, Thailand-97 or Russia-98; and no such crises have taken place in Hungary and Turkey during our sample period. Omission of this plausible restriction might result in biased impulse response coefficients and variance decompositions.

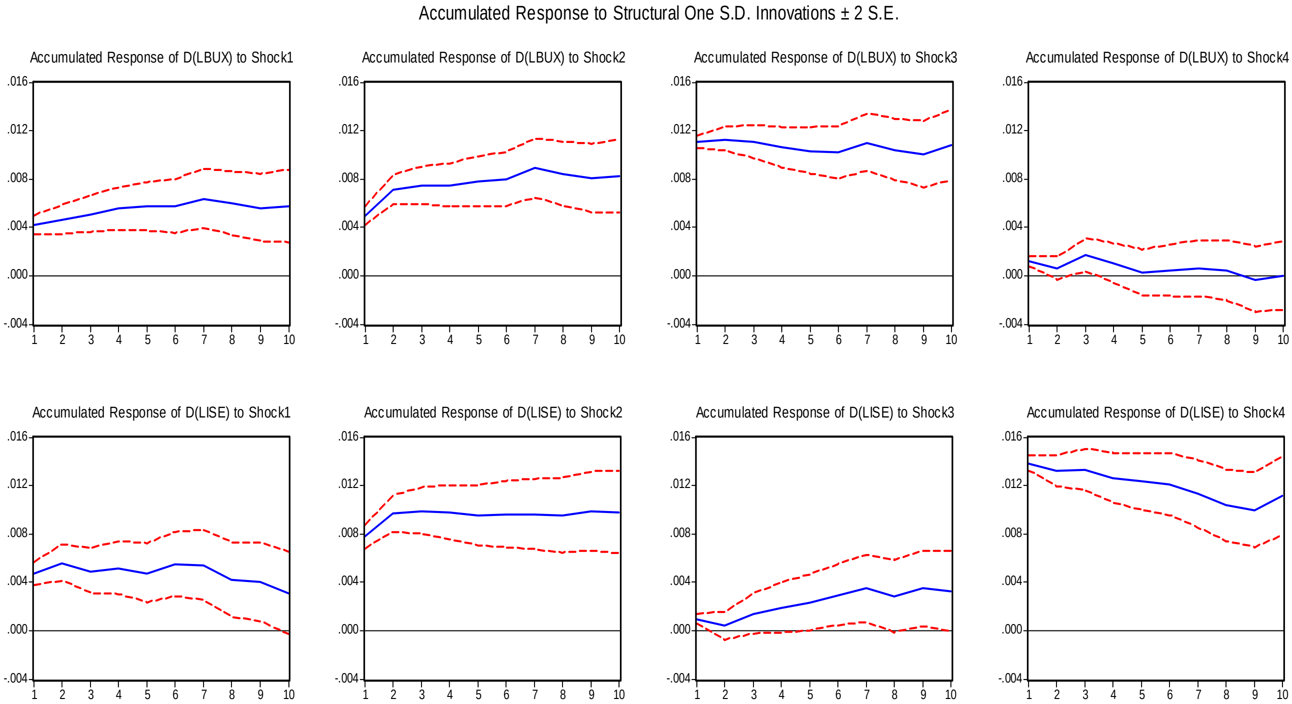
We take the lag order of SVAR 9 as suggested by the AIC. Impulse response functions (IRF) are derived based on the Choleski factorization, where we place E first and EM second. However, theory does not guide on the order between BUX and ISE, hence we perform robustness checks with the alternative ordering assumptions.

The dynamic relationship between BUX and ISE is analyzed by studying IRF's. IRF's enable to portray the dynamic response of a variable to a shock in another variable until the effect of the shock dies down. Hence, they provide a tool to distinguish temporary versus permanent shocks and to quantify the cumulative effect. In terms of contemporaneous effect, they reflect the impact of structural factorization. By portraying the trajectory of the lagged responses, they enable measurement of incremental predictive information contained in the returns of one index that helps predict future returns of another. In Figure 1 and 2 below, the impulse responses of BUX and ISE to a one standard deviation shock in E, EM, BUX and ISE, respectively, are portrayed for the non-crisis and crisis subsamples.

[12] Note that the above specification allows E to affect EM, but not vice versa.

Impulse responses to E and EM document the effect of global markets. Impulse responses to its own shock may help us judge under- or overreaction characteristics of BUX and ISE. Impulse response of BUX (ISE) to ISE (BUX) is the focus of this paper and will document the incremental information dynamics between BUX and ISE. We show cumulative impulse responses as borderline-significant responses at several lags can be visible only collectively. Asymptotic 2-standard error confidence bands are also provided to help a visual inspection of significance of the results.[13] Responses up to 10 periods are portrayed as they become insignificant thereafter.

Figure 1: Cumulative impulse responses of BUX and ISE to a shock to E, EM, BUX and ISE
(1.1.2004 – 31.7.2007)



Notes: The first row shows BUX's reponse to a 1 standard deviation shock in E, EM, BUX and ISE, respectively. The second row shows ISE's reponse to a 1 standard deviation shock in E, EM, BUX and ISE, respectively. The solid curve in the center represents cumulative impulse response coefficients. The dashed curves represent asymptotic 2-standard error confidence bands. Shock 1, 2, 3, 4 are shocks in E, EM, BUX and ISE, respectively.

BUX's responses to a shock in E and EM are seen in the first and second graphs of the first row, respectively. Followed by a significant positive contemporaneous response, BUX exhibits a positive cumulative lagged response to E and EM, which is significant only for EM. However, the bulk of the lagged response comes at one day lag (i.e. period 2), which requires caution in interpretation: Note that no such lagged jump is seen in period 2 in BUX's response to E. Remember that MSCI EM index contains national indices from different time zones. Therefore, the lagged response in period 2 may simply be a reflection of new global information revealed in American trading hours, in line with caveat in Section 2. While BUX exhibits more lagged response to EM in further periods, it is not that significant.

[13] To measure predictive content visually, draw a horizontal line from the value of IRF at period 1 (i.e. the intersection of IRF with the y-axis). If the horizontal line is below the error bands, this implies statistically significant predictability.

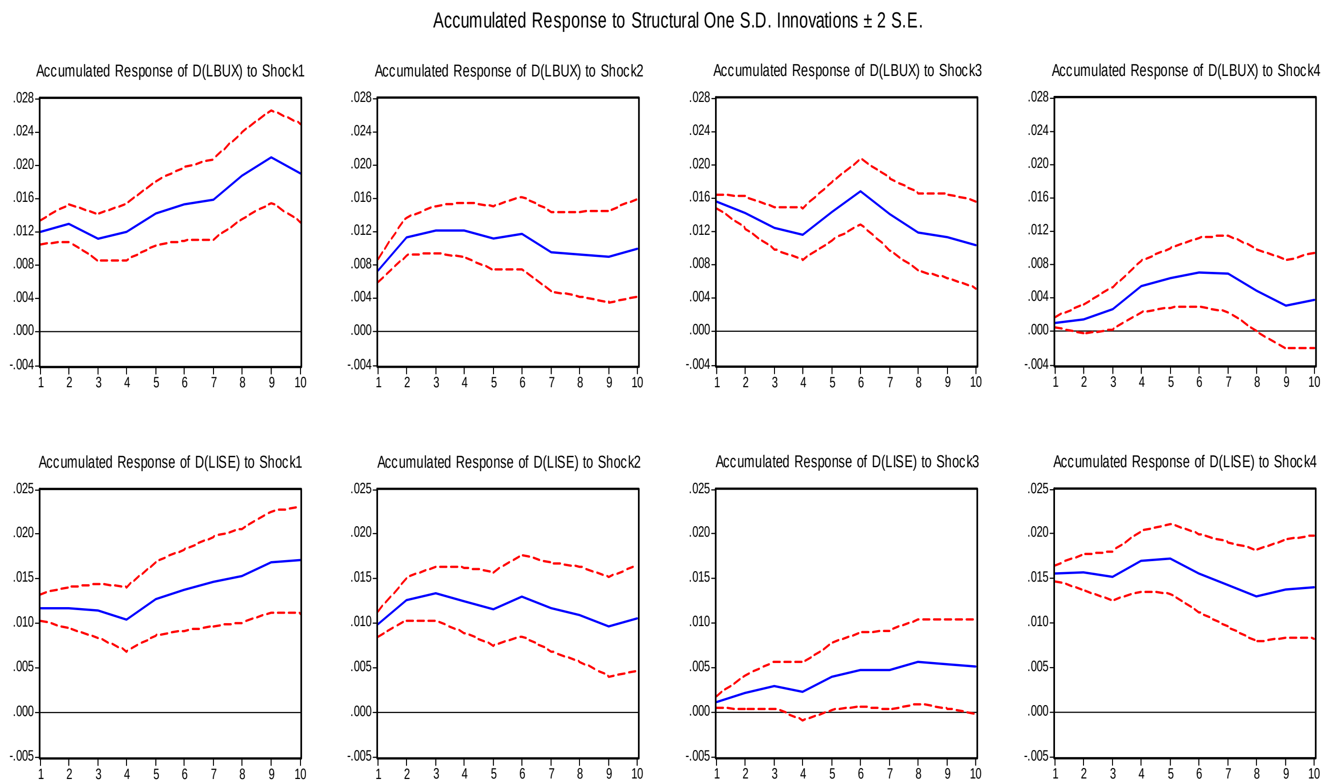
The impulse response of BUX to its own shock (third graph in the first row) suggests no significant continuation or reversal. This implies that domestic information shocks are incorporated in 1 trading day. Our focus is the response of BUX to a shock in ISE (fourth graph in the first row). The impact of a shock in ISE on BUX is quite small in magnitude and cumulative lagged responses are significant only in days 2, 3 and 4. Moreover, the shock is completely reversed within 9 trading days.

ISE's response to E (the first graph in the second row) is mainly contemporaneous (no lagged response) and partly reversed beyond the 8th day. Lagged response to EM is significant only in the second period, which is, as explained above, likely to be merely a reflection of time-zone differences. Note that ISE's response to a 1-standard deviation shock in EM is larger in magnitude compared to that in E. As the standard deviations of E and EM in the first subperiod are 0.73% and 0.85%, respectively, the difference in response cannot be fully explained by volatility differences. It appears that ISE was more responsive to global emerging markets in this non-crisis subperiod.

The response of ISE to its own shock is seen in the fourth graph of the second row, which suggests a partial reversal that becomes significant by the 9th trading day. This is consistent with overreaction to domestic information shocks. Our focus is the response of ISE to a shock in BUX (the third graph in the second row). Unlike BUX's response to ISE, we note a significant lagged response. While the instantaneous response is small in magnitude, the cumulative response grows nontrivially, and becomes borderline significant by the 7th trading day. This justifies traders in Istanbul keeping an eye on Budapest. This finding leads us to suspect that an additional factor proxied by BUX may contain additional information for ISE (beyond that already contained in E and EM), which is not priced in instantaneously but with some lag, possibly because it was not well-known by local traders in Turkey.

Next, we repeat the same analysis for the crisis subperiod.

Figure 2: Cumulative impulse responses of BUX and ISE to a shock in E, EM, BUX and ISE
(1.8.2007 - 31.12.2009)



Notes: See explanations below Figure 1.

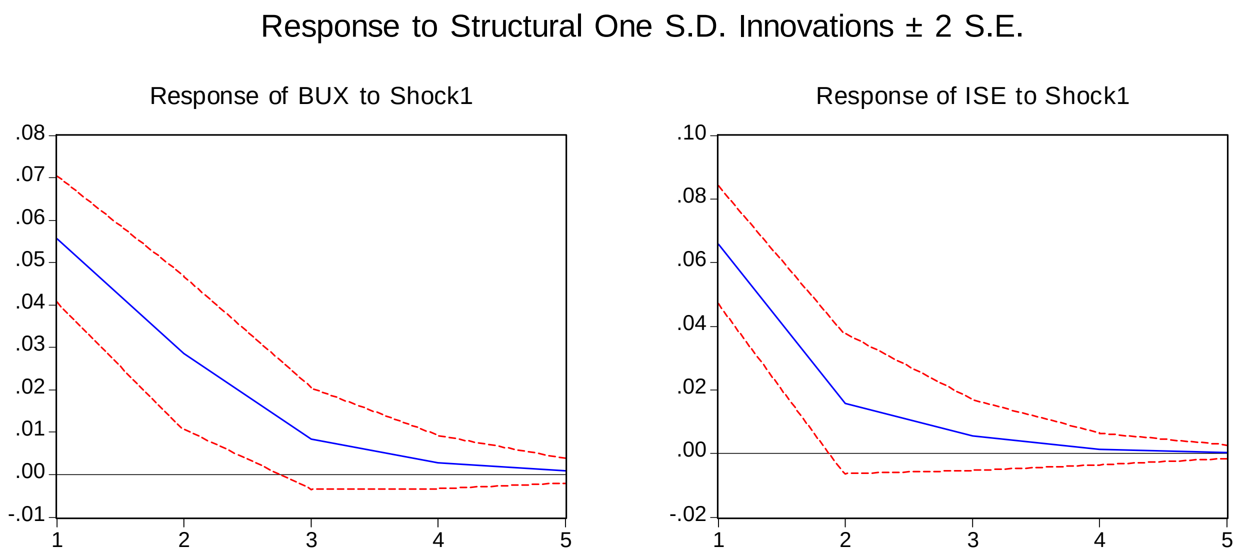
For both BUX and ISE, the relative magnitude of responses to E compared to EM increases in this subperiod, in line with the results of the preliminary analysis in the previous section. This is probably because the origin of recent global crisis was developed markets. BUX again exhibits a significant lagged response to E (first graph in the first row). Hence, one may argue that traders in Budapest are slow in incorporating information from European markets. BUX's lagged response to EM is not significant except for the 2^{nd} period which is attributed to time zone differences. Fourth graph in the first row, our focus, suggests, unlike in the noncrisis period, significant lagged response of BUX to a shock in ISE. This implies that traders in Budapest could derive incremental predictive information by keeping an eye on Istanbul.

In the crisis subperiod, ISE exhibits significant lagged response to E (first graph in the second row), but no significant lagged response to EM (second graph in the second row). This can be interpreted as underreaction to extremely bad news originating from developed markets. It is interesting to note that the lagged response starts to grow after the 5^{th} trading day. ISE exhibits significant lagged response to shocks in BUX (third graph in the second row), as in the non-crisis subperiod.

Overall, these results suggest that both BUX and ISE returns have contained incremental predictive information for each other, particularly during the recent global crisis period.

Below, the same analysis is repeated with monthly data. The lag order is 1 as suggested by AIC. All lagged responses except those to E are insignificant. Figure 3 depicts BUX and ISE's response to a shock in E (full-sample), and omits other IRF's which are insignificant. Note that impulse responses in Figure 3 are not cumulative. The message is that especially BUX exhibits a significant lagged response to E, even at monthly frequency. Thus, it can be argued that BUX is too slow to incorporate information from developed markets.

Figure 3: Impulse responses of BUX and ISE to a shock in E (1.1.2004 - 31.12.2009)



Notes: Shock 1 is a one-standard deviation shock in E. The solid curve in the center represents cumulative impulse response coefficients. The dashed curves represent asymptotic 2-standard error confidence bands.

Next, variance decomposition results, based on daily data and the SVAR model described above, are presented to find out the relative role of these indices in explaining the variation in BUX and ISE returns. The left panel of Table 9 provides the variance accounting for the non-crisis subperiod, which can be compared to crisis subperiod results on the right. A primary message is that for both BUX and ISE the relative role of global factors has significantly increased during the crisis subperiod. The forecast error variance due its own shocks[14] (measured at period 30) decreased by 23% for BUX and by 17% for ISE in the crisis subperiod. Thus, BUX's vulnerability to global factors increased more during the recent crisis subperiod. During the crisis subperiod BUX exhibits more lagged response to global factors than ISE does. This suggests that ISE incorporates global information faster when it is more important.

Table 9: Variance Decomposition Results

1.1.2004 - 31.7.2007						1.8.2007 - 31.12.2009					
Variance Decomposition of BUX:						Variance Decomposition of BUX:					
Period	S.E.	E	EM	BUX	ISE	Period	S.E.	E	EM	BUX	ISE
1	0.00729	20.13	7.32	71.50	1.05	1	0.01814	46.33	2.20	51.25	0.22
2	0.00731	20.68	8.57	69.58	1.17	2	0.01836	46.33	2.91	50.40	0.37
3	0.00734	20.73	8.57	69.33	1.36	3	0.01848	46.01	2.86	49.95	1.17
4	0.00736	20.68	8.55	69.37	1.41	4	0.01860	45.89	3.11	49.68	1.32
5	0.00737	20.73	8.53	69.15	1.59	5	0.01890	45.76	3.56	49.13	1.56
10	0.00750	21.11	8.79	68.44	1.66	10	0.01957	42.98	4.57	47.31	5.14
15	0.00754	20.94	8.79	68.54	1.73	15	0.01967	41.79	6.05	45.91	6.26
20	0.00755	20.95	8.80	68.52	1.74	20	0.01970	41.75	6.34	45.61	6.30
30	0.00755	20.96	8.79	68.51	1.74	30	0.01971	41.76	6.38	45.52	6.35
Variance Decomposition of ISE:						Variance Decomposition of ISE:					
Period	S.E.	E	EM	BUX	ISE	Period	S.E.	E	EM	BUX	ISE
1	0.00809	20.53	11.43	0.41	67.63	1	0.01699	49.46	3.19	0.24	47.11
2	0.00841	21.04	12.09	0.67	66.21	2	0.01741	48.64	4.52	0.66	46.18
3	0.00850	20.86	12.09	1.44	65.61	3	0.01752	48.61	4.55	0.69	46.15
4	0.00851	20.88	12.09	1.44	65.58	4	0.01764	48.66	4.60	0.75	45.99
5	0.00852	20.82	12.06	1.70	65.41	5	0.01773	48.83	4.72	0.88	45.57
10	0.00861	20.89	12.06	2.25	64.81	10	0.01890	47.14	4.70	0.99	47.17
15	0.00866	20.61	12.70	2.69	64.00	15	0.01905	46.91	5.16	1.15	46.77
20	0.00867	20.60	12.74	2.74	63.92	20	0.01910	46.80	5.21	1.23	46.77
30	0.00867	20.60	12.74	2.75	63.91	30	0.01912	46.78	5.20	1.25	46.76

The relative role of E in comparison to EM sharply increases during the crisis subperiod for both BUX and ISE.[15] As mentioned before, this is probably because the origin of the crisis was developed markets. Our focus is BUX and ISE's role for each other: During the non-crisis subperiod, ISE accounts for 1.74% of the forecast error variance in BUX by period 20, 0.69% of which is lagged response; while BUX accounts 2.74% of the forecast error variance in ISE, 2.33% of which is lagged response. This explains why traders in Istanbul might have learned to keep an eye on Budapest. Apparently, information about E and EM is almost instantaneously incorporated in ISE, while information about BUX, possibly representing a previously unattended new factor, took time to be priced in.

During the crisis subperiod, ISE accounts for 6.30% of forecast error variance in BUX by period 20, 6.13% of which is lagged response. Hence, there is a dramatic increase in ISE's role on BUX, most of which is incorporated with a delay. This delayed reaction is likely to be responsible for the increase in incremental correlation between BUX and ISE on monthly data, which is absent on daily data. This suggests the possibility of a new regional risk factor, which traders in Budapest cannot directly observe and do respond with some delay. The

[14] Forecast error variance due to its own shocks can be interpreted as domestic idiosyncratic factors provided that no other global factor is omitted.

[15] A direct comparison of the forecast error variance due to E and EM is sensitive to the ordering assumption underlying Table 8 that E is permitted to affect EM but not vice versa.

information content of BUX for ISE remains low in this subperiod (1.23 % of the forecast error variance, 0.99% of which is incorporated with a delay). Overall, while the incremental explanatory power of BUX and ISE for each other is relatively small, most of it is in the form of lagged response. Hence, it may represent an information factor to which traders do not instantaneously respond.

Measuring the Economic Significance of Predictive Information Content
The impulse response functions in Figure 1 and 2 enable quantification of lagged responses,[16] hence measurement of the economic significance of predictive content. The lagged responses of both BUX and ISE to E and to each other are significant during the crisis period. The cumulative lagged response of BUX to a 1 standard deviation shock in E (following an instantaneous response of 1.2%) is 0.8% by the 9th day. The standard deviation of E during the second subperiod is 1.9%. Hence, a trader who opens a position in BUX futures following a 1.9% log price change in E might have expected to earn a 0.8% additional return on the average for a 9-day holding period. Similarly, the cumulative lagged response of BUX to a 1 standard deviation shock in ISE (following a 0.1% instantaneous response) is 0.5% by the 7th day. The standard deviation of ISE during the second subperiod is 2.3%. Hence, a trader who opens a position in BUX futures following a 2.3% log price change in ISE might have expected to earn a 0.5% additional return on the average for a 7-day holding period. This predictability could be exploited in index futures markets at the lowest possible transaction costs. The transaction costs (bid-ask spread plus trading commissions) in BUX futures are estimated to amount to 0.2% per round trip. Hence, it might be possible to exploit this predictability though market depth would only permit small size trades.

The cumulative lagged response of ISE to a 1 standard deviation shock in E (following an instantaneous response of 1.1%) is 0.5% by the 10th day. Hence, a trader who opens a position in ISE futures following a 1.9% log price change in E might have expected to earn a 0.5% additional return on the average for a 10-day holding period. Similarly, the cumulative lagged response of ISE to 1 standard deviation shock in BUX (following a 0.1% instantaneous response) is 0.4% by the 8th day. The standard deviation of BUX during the second subperiod is 2.4%. Hence, a trader who opens a position in ISE futures following a 2.4% log price change in BUX might have expected to earn a 0.4% additional return on the average for an 8-day holding period. As the ISE-30 index futures market is quite active, bid-ask spreads regularly equals to 1 tick (25 index points), the transaction costs (bid-ask spread plus trading commissions) are quite low and estimated to amount to 0.08% per round trip. Hence, the observed predictability is economically significant. However, the market efficiency implication of this finding is obviously related to risk involved in such arbitrage positions.

Note that although the lagged responses to EM may also look substantial, it does not imply predictability as the lagged response on day 2 may result from time-zone (globally available information) differences as emphasized earlier.

5. Conclusions and Discussion

The Budapest-Istanbul case presents an excellent opportunity to review many methodological issues and economic implications of the comovement between two emerging stock markets. We have documented a significant jump in contemporaneous correlations during crisis periods. We have shown that daily contemporaneous correlations may underestimate the degree of interdependence due to lagged responses (and possibly cointegrating relationships in general). Having noted the bias in measured correlation between the returns of two national indices due to changing volatility of a common factor, we proposed an ideal specification for modeling the comovement between two emerging markets: a two world-index model which captures global market factors for developed and emerging markets. The advantage of implementing this model within a SVAR framework is to account for both changing volatility of the common factor and lagged interactive responses and cointegrating relationships, without losing economic intuition. Preliminary

[16] Available in table form from the author.

analysis with this model suggested BUX and ISE have recently represented a third significant factor for each other. Analysis within the VAR-cointegration framework indicated a special situation of high degree of comovement with no cointegrating relationship. This emphasized the lesson that cointegration analysis should not be the end of a study of comovements. The SVAR model we used to describe the short term incremental dynamics of BUX and ISE permitted global indices to affect emerging markets but not vice versa. This should be an ideal specification for studying the comovement between two emerging markets, to which an error correction term could be added in case a significant cointegrating vector exists. Using this model, we have shown that BUX exhibits significant lagged response to MSCI-Europe index, and both BUX and ISE to each other, in particular during the recent crisis period. BUX and ISE have recently represented a new information factor for each other. Further, the variance decomposition suggested that the relative role of developed markets in comparison to emerging market index for both BUX and ISE has significantly increased during the recent global period, apparently because the crisis originated from developed markets. This finding implies that propagation mechanisms may change based on relative importance of relevant information factors.

The recent emergence of BUX and ISE exclusively as an additional information factor for each other deserves further attention.[17] Recall that we could not find a similar increase in correlation between ISE and other CEE markets. The direct trade links between Hungary and Turkey are quite weak. There is no explicit macroeconomic policy coordination, and during the sample period Turkey and Hungary moved in opposite directions in terms of public debt. BUX and ISE indices used in this study do not represent similar industry compositions (ISE-100 index is heavily weighted by banks while BUX-12 is relatively balanced), so that comovements cannot be explained by global industry effects as argued by Roll (1992). Hence it is difficult to explain the increase in correlations during the recent crisis period with economic factors. The remaining alternative is contagion. Dickinson (2000), for example, concludes that "increased short-run linkages are more likely to represent increased international transmission of noise which is a consequence of stronger long-term linkages". Recall that we have found ISE leads BUX, particularly during the recent crises period, while Cerny and Koblas (2008) report that BUX is the leader among CEE markets in terms of the speed of information transmission. Istanbul and Budapest are the most active and liquid markets of the region. We can hypothesize that in recent years international institutional investors have increasingly formed divisions or dedicated funds that focus on certain geographical regions. The trades of these funds intensify on more liquid and more active markets, and their trades are correlated as they are driven by global appetite towards emerging markets. During a global crisis period, regional concentration and a flush of global news might have further increased these correlated trades with differential response times in different markets. Frank and Hesse (2009) nicely document the interlinkages between funding stress in developed markets and emerging market bond and equity markets, which would support the argument put forward here. Thus, we conclude by proposing an explanation for the intriguing increase in the degree of exclusive comovement between BUX and ISE.

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[17] See footnote 9 on p. 1182 in Corsetti et al. (2005). Neither Hungary nor Turkey was the origin of crisis in our case.

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