Financial Contagion among Members of the EU-8: A Cointegration and Granger Causality Approach

Purpose

The aim of this paper is to examine whether the banking crisis in the US and Western Europe that began in August 2007 spilled over to the currencies the EU-8 such that it could be viewed as financial contagion. The currencies of the EU-8 that will be studied are of the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland and Slovakia, daily, from 2005 to 2008.

Design/Methodology

Contagion is said to be revealed if there are greater links after August 2007 compared with before. The links or bonds are revealed by the number of cointegrating vectors and the extent of Granger-causality that exists among the currencies. The role of the Euro is also identified using the same techniques.

Findings

The bonds between these seven countries strengthen after the beginning of the banking crisis compared with before, whilst the ties with the Euro remains stable.

Research limitations/implications

A banking crisis not directly related to the EU-8 spilled over to a change in the correlations among their currencies. If the EU requires convergence of emerging with developed markets before currency assimilation, research is needed to explore how a

record of financial rectitude can be demonstrated whilst recognising that contagion is more likely to affect those emerging markets and information deficiencies.

Practical Implications

First, the EU should reconsider the entry requirements for the EU-8 still disqualified from joining the Euro. The protected 2 year period of displaying financial rectitude via targeting the Euro before accession is considered may now appear a burden that to great for small economies to bear. Second, it is not necessarily a crisis that changes the rewards from diversification, contagion may also do this.

Originality/value

The finding of increased bonding among emerging market currencies precipitated by a banking crisis in related geographical and financial markets, before a local crisis became evident is novel.

Key words Contagion, EU-8, Foreign Exchange Rates, Cointegration, Granger-causality

Paper Type Research Paper

Introduction

Modern portfolio theory advocates that investors should manage risk through diversification across a variety of assets (Cuthbertson, 1996). Dispersing investments across two assets that are not perfectly correlated should reduce risk exposure. Diversification in asset types is based on the view that each is a function of a distinctive group of variables (Hoesli *et al*., 1997). So, for example, diversification in property types is based on the presumption that each is a function of a distinctive group of variables: business services drive office rents; industrial performance affects industrial rents; and consumer demand influences retail rents. Thus, the market drivers should be different.

The credit crunch/banking crisis of 2007/8 entailed excessive lending in the US sub-prime market plus the marketing and miss-rating of complex debt instruments by western financial institutions. The timeline of events in the credit crisis (Bank of England, 2008) shows evidence of some financial distress, particularly relating to Bear Sterns, but the key announcement made on 9 8 07 of BNP Paribus suspending three sub-prime money market funds and the European Central Bank injecting €95bn to boost liquidity in the banking sector was the marker of a change. The London interbank lending system essentially fails to operate from this time on, precipitating, within a month, the first run on a British bank for over a century. This crisis might have spilled over to other markets not directly affected, altering the basis for portfolio diversification among these markets, including emergent European markets.

The aim of this paper is to examine whether the banking crisis in the US and Western Europe, that began in August 2007, spilled over to the currencies the EU-8 such that it could be viewed as financial contagion. The structure of the paper is as follows. In the first section, there is a review of literature concerning emerging

markets and financial contagion over numerous crises. This is followed by an outline of theoretical perspectives on contagion and then a review of the background or setting of the study, including hypotheses. The data and the methodology are then reviewed. The results reveal that there has been a strengthening of links among the EU-8 both in the long and short runs, whilst the bond with the Euro remains. It is concluded that financial contagion occurred from developed economy markets directly related to the crisis to emerging markets *before* a currency crisis hit one of the EU-8.

Emerging Markets and Contagion

Pericoli and Sbracia (2003) suggest a financial crisis is usually related to a currency, a stock market or a banking crisis. Financial assts used in this regard includes bonds (e.g. Yang, 2005) currencies (e.g. AuYong *et al*., 2004) and stock markets (e.g. Gilmore and McManus, 2002; Syriopoulos, 2007). Gilmore and McManus (2002) explore whether emerging equity markets of markets of Central Europe are segmented from the US and, hence, provide scope for diversification. They undertake Granger-causality and cointegration tests. As they find no cointegration and only one case of Granger-causality, they conclude that diversification is appropriate.

In their study of Central European stock markets, Serwa and Bohl (2005) point out that very few empirical studies have concentrated on contagion among these markets. The Russian crisis of 1998/9 led to increased correlations across Central European stock markets during the 1994–1999 period (Gelos and Sahay, 2001) with market sentiment being a conduit (Darvas and Szapáry, 2000).

Serwa and Bohl (2005) use the same approach as Forbes and Rigobon (2002) and Gelos and Sahay (2001) in examining the co-movement of stock index returns by

cross-market correlation. They find that Central European stock markets are no more likely to be subject to contagion than western stock markets over the 1997-2002 period. The Central European stock markets exhibit interdependence rather than contagion.

Split Sample Analysis using Cointegration and Granger-causality

Whilst exploring integration among eleven European and US stock markets, Yang *et al.* (2003) find that the establishing of European monetary union affected the integration of both EMU and non-EMU markets. This is an example of a study that entails splitting the data into before and after an event to examine whether the event left a mark upon the degree of integration among a number of financial markets. An approach to the investigation of shock analysis/ contagion and integration involves the use of cointegration with Granger-causality.

Using stock market indices of emerging Central European and developed stock markets, as with Gilmore and McManus, Syriopoulos (2007), examines financial market links. He finds that they seem to be more strongly linked to the markets of the US and Germany as a result of membership of the EU. To achieve this, he considers the stock markets of the Czech Republic, Slovakia, Hungary and Poland, in the two years prior three, and three quarters, after the establishment of EMU on the First of January 99. Stock market interdependence is based on testing for cointegration and the number of vectors, analysing the relevant ECM, and considering the speed of adjustment: greater interdependence is reflected in the number of vectors. In contrast with Gilmore and McManus, he finds that there is one cointegrating vector among the six indices for both before and after EMU. This includes the US S&P500 and the German Dax. Finding that both the developed economy indices had non-zero

loadings in the long run vector, Syriopoulos concludes that they both have a dominant influence on the emerging markets, which is line with Yang *et al.*. Although, the finding of one vector in both periods suggests that there is no strengthening of links, it does indicate that portfolio diversification is less effective and that immunity to external shocks is limited by a long run relationship with other markets.

The Granger-causality results for both the pre and post eras again suggest that both the developed-economy indices have a dominant influence on the emerging markets. The post EMU period is characterised by weaker short run links among the emerging markets, with Slovakia, in particular, following a more autonomous path.

Also exploring the impact of an event, AuYong *et al*. (2004) examine contagion among foreign exchange markets of emerging and Asian economies. The data, which is daily 14 countries' foreign exchange rates against the US Dollar from 1994 to 2001, is divided into seven sub-samples. Each series is assessed in each sub-period for pairwise and multiple cointegration. The pairwise cointegration results suggest major economies (Japan) and those close together Indonesia and Thailand) are cointegrated throughout, suggesting trade and proximity are important factors in contagion.

Arranging the 14 currencies into four groups, AuYong *et al*. show how the degree of integration, as measured by the number of cointegrating vectors, varies. For example, the Asian currencies are cointegrated before the Mexican crisis of 1994/5 but are not found to be cointegrated again until the Russian crisis of 1998/9.

The Granger-causality tests also revealed instability in linkages. During the crisis in that area, causality was found between countries with weak trading links and at a great distance from the Asian region. This may suggest relationships that can be related to the contagion rather than interaction that would provoke normal co-

movements. Given the level of inter and intra regional interaction indicated by either Granger-causality or cointegration, AuYong *et al*. suggest diversification on an international basis may be undermined particularly when they find that (real) trade links do not adequately explain causality relationships.

Masih and Masih (1997, 2004) examine the impact of the stock exchange crash of October 1987. They find cointegration among six major stock markets (1997) and the five monthly European stock market indices (2004) both before and after the crisis. They find only one vector in each period. In the 2004 paper, oddly, cointegration is not found across the entire period but this is not investigated in the 1997 paper. Also in the 1997 paper, vector loadings are investigated. Only the French index appears to have a zero loading in the long run vector.

The Granger-causality results suggest that most links were altered. In the 1997 paper there were no significant links before the crash, which conflicts with the 2004 paper. Only the bond between Germany causing France was consistent across both eras in the 2004 paper. Thus, the crash is found to have altered the bonds between many markets.

Financial Crises and Contagion

In their review of contagious financial events, Kaminsky *et al.* (2003) highlight three common themes: first, an abrupt reversal of capital flows; second, an unanticipated announcement that sets off a readjustment of portfolios; and third, leveraged common creditors, such as commercial banks, help propagate the crisis across national borders. All three appear evident in the credit crunch of 2007.

Kaminsky *et al.* (2003) identify three groups of theories to explain contagion. The first, herding, concerns an information-cascade, where individuals observe the

behaviour of those 'in front of them' and, without regard to their own information, follow that. Indeed, where investors in portfolios face information asymmetries, the costs of correcting these may outweigh the benefits, so herding is rational. Mimicking the market portfolio is a prediction of the Capital Asset Pricing Model, so if other investors are divesting themselves of a country specific investment, so should you.

The second, trade linkages, can be seen in a regional system of countries in a fixed exchange rate system with strong trade linkages among sub-group and one of these devalues. The change in relative prices will put pressure on others in the sub-group to follow suit, such as the Portuguese Escudo devalued with the Spanish Peseta during the ERM crisis of 1992.

The third explanation of contagion is financial linkages. Rational investors with non-performing assets in country-diversified portfolio may rebalance it by selling assets. As the assets that will be sold are unlikely to be the country where asset prices have collapse, the rebalancing will depress asset prices in other countries. Banks play an important role in this process as they call in loans in markets that are, as yet, unaffected by the contagion, in an effort to shore-up positions in their home market.

Pericoli and Sbracia (2003) present five definitions of contagions; the fifth, (shift) contagion, is relevant for the approach taken here. Shift contagion entails an intensification or change in the transmission of shocks between markets. This is a variant on the third and fourth definitions, which relate to an intensification of the co-movement of assets across markets. Shift contagion implies a structural break and the identification of a tranquil, pre-event period. The key concern about contagion is that it undermines the very assumptions of portfolio analysis. Markets that were assumed (estimated to be) weakly associated before the event are subsequently found to be

strongly associated, so that diversification across these markets fails to shield the investor from unsystematic risk.

A Macroeconomic Perspective

As a group in 2006, the EU-8 had relatively low rates of household debt to income. However, the period from 2000-2006 had seen a high rate of growth of credit in Latvia and Estonia compared with the others whereas in Slovakia and the Czech Republic it had fallen. Moreover, the external debt of banks and enterprises in Latvia and Estonia was also out of line with the others. But this difference may reflect macro targets. The Czech Republic, Hungary, Poland and Slovakia pursue variants of inflation targeting, whereas Latvia targets exchange rate stability.

Czech Republic, Hungary, Poland and Slovakia were members of the Central European Free Trade Area until 2004, which should foster relatively strong trading bonds. In an exercise to examine financial stability in Europe and a single market in banking, Garcia and Nieto (2007) estimate cross border bank asset holdings in the European Economic Area. They find that the large western economies generally hold a low level – certainly less than 25%. By contrast, of EU-8 analysed, the lowest proportion is just below 60% and Estonia is estimated at 100%. Clearly, the scope for financial contagion is greater in the EU-8 as a result. Moreover, Lithuania and Estonia in 2004 and Latvia and Slovakia in 2005 joined the so-called ERM11, the precursor to joining the Euro. In a speech given by Otmar Issing, Member of the Executive Board of the ECB, in April 2005 suggested that ERM11, by requiring the adoption of a consistent monetary and economic policy framework, fosters policy discipline towards stability. It can help establish a stable macroeconomic environment and can act as a catalyst of structural reforms. Second, it can enhance policy credibility and

help guide expectations. The central parity of a currency against the Euro provides guidance to foreign exchange markets and should contribute to greater exchange rate stability. Furthermore, this should constrain inflationary expectations, accelerating disinflation and reduce inflation volatility. ERM11 should foster another link among the currencies.

Daianu and Lungu (2007) review the impact of inflation targeting on the Central European economies of Czech Republic, Hungary, Poland and Slovakia and the Baltic states of Latvia, Estonia and Lithuania. The cost of accession to the EU in 2004 has, Daianu and Lungu argue, pushed up inflation. Karam *et al.* (2008) might argue that this is a price worth paying, as smaller states are subject to more volatility than larger ones. The problems of conflicting government goals and uncertainty about the future making forecasting [and hence targeting] inflation challenging could breed uncertainty among speculators. This would undermine confidence in the central bank (Daianu and Lungu, 2007). Indeed, targeting both low inflation and exchange rate stability (as part of ERM11) implies a conflict of goals if the same instrument is used.

One would anticipate that, among the group, there would be at least one cointegrating vector, possibly, given the extent of the common borders and history, there would be more. Moreover, given the banking linkages, bonds with Europe and the accession to the Euro criteria, there is likely to be some contagion leading to more bonding as measured by cointegration and Granger-causality after the [news] event of 9 8 08. Furthermore, it is anticipated that the foreign exchange rates (*FX* rates) are led, in the long run (Jones and Leishman) and short run (Granger-causality sense), by the Euro.

Data for the Czech Koruna, Estonian Kroon, Hungarian Forint, Lithuanian Litas, Latvian Lats, Polish Zloty, Slovakian Koruna and Euro, all measured in US

Dollars, is taken from the Bank of England's statistics website for the period 15 7 05 to 28 10 08. This covers 835 daily *FX* rates, with the break occurring at 9 8 07. Plots of the logged series (unlabelled) are displayed in Figure 1. There may be a slow drift downwards in the levels of the data but this may not be significant. In generally, the lower two (Czech Koruna and Estonian Kroon) appear almost flat, whilst the rest appear to drift very much in line.

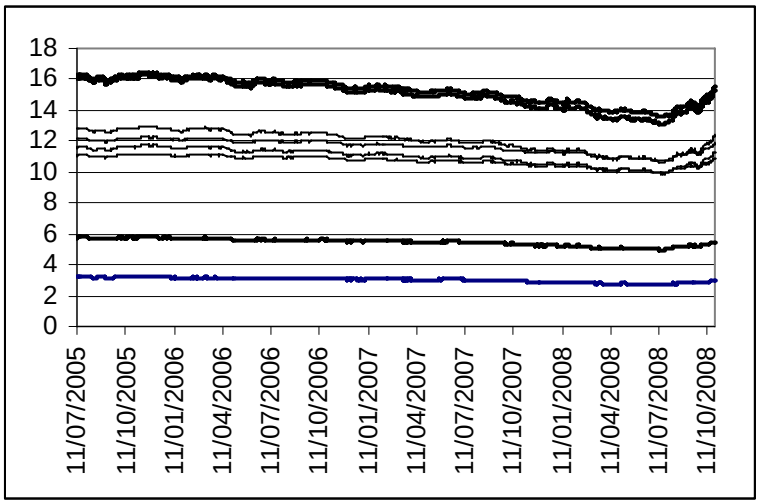

Figure 1 Exchange Rates vs US Dollar

The autocorrelation functions (ACF) of the exchange rate data are considered. All exhibit a slow decline in the ACF pattern and a single spike at lag 1 on the Partial ACF of around 1, indicative of unit root. The data is differenced and the ACFs are re-estimated. The results of this exercise, displayed in Table 1, show a common spike at lag 4, implying a periodicy of 4 days. Despite this, a Box-Ljung test (with 4 lags) indicates that the Latvian Lats and the Slovak Koruna follow random walks.

Table 1 Autocorrelation Function Coefficients of the Data Differenced

Lag	Czech	Estonia	Hungary	Lithuania	Latvia	Poland	Slovakia	Euro
1	.011	.009	.064	.009	.003	.093	.032	.008
2	.068	.058	-.007	.058	.055	.109	.039	.059
3	.023	.029	.067	.029	.035	.031	.012	.029
4	.118	.089	.159	.088	.076	.141	.079	.088
5	.012	-.009	.057	-.008	-.012	.025	-.014	-.009
6	-.003	-.006	-.076	-.006	-.010	-.051	-.023	-.006
7	.015	-.040	.065	-.040	-.033	-.001	-.005	-.040
8	.017	.005	.057	.004	.009	.065	.040	.004
9	-.038	-.043	-.023	-.043	-.043	-.024	-.015	-.042
10	-.036	-.028	-.007	-.028	-.017	.014	-.025	-.028
11	-.018	.016	.035	.016	.023	-.040	.006	.016
12	.089	.037	.092	.037	.046	.100	.055	.037
13	.035	.035	.043	.035	.045	.028	.071	.035
14	.025	.066	.031	.066	.065	.025	.035	.067
15	.070	.072	.061	.072	.065	.070	.017	.072
16	.005	-.025	-.036	-.026	-.020	.007	-.024	-.026

Critical Value 0.07

Using the Akaike lag selection criterion, the data from the eight *FX* rate series will be considered for unit roots. The Augmented Dickey-Fuller (ADF) test involves the expression,

$$\Delta x_t = \alpha_{10} + (\rho_1 - 1)x_{t-1} + \beta t + \sum_{j=1}^{p} \alpha_{1j}\Delta x_{t-j} + \varepsilon_{1t}$$

where p is the order of the lag polynomial, $\varepsilon_{1t} \sim$ iid(0, σ_ε^2) and t is a time trend. The unit root test results for the eight currencies used subdivided by the two sub periods are reported in Table 2. The lag order (p) = 0 unless indicated. The results are for an ADF with a linear trend (critical value –3.4175) and without a linear trend (critical value –2.8654). The unit root tests suggest that all the series are difference-stationary. Given the discussion above the results entailing the intercept but no trend are more likely to reflect the data generating mechanism.

Table 2 Unit Root Test Results

	Before Aug 2007		After Aug 2007	
	a	*b*	*a*	*b*
Czech	-1.1512	-2.9758	-1.4503 (4)	1.3986
Estonia	-.72230	-3.0272	-.18490 (4)	1.6434
Hungary	-.69179	-1.9306	-.27336 (7)	1.7436 (7)
Lithuania	-.72207	-3.0265	-.43831 (4)	1.6438
Latvia	-.76062	-3.0103	-.15072 (4)	1.7467
Poland	-1.1586	-3.3366 (1)	-.68712 (4)	2.3436 (6)
Slovakia	-.11696	-2.5055	-1.2509 (4)	1.6214
Euro	-.72156	-3.0275	-.43793 (4)	1.6450

a intercept but not a trend *b* an intercept and a linear trend
Lag(0) unless indicated

Analytical Approach

The non-stationary data is tested for cointegration using the Johansen (1988) method. The Johansen approach is based on full information maximum likelihood estimation and is primarily applied to $I(1)$ data. Let $\boldsymbol{x}_t$ be an $n \times 1$ vector, with a p^{th} order vector error correction (VECM) format expressed as,

$$\Delta \boldsymbol{x}_t = \boldsymbol{\mu} + \sum_{j=1}^{p-1} \boldsymbol{\Phi}_j \, \Delta \boldsymbol{x}_{t-j} + \boldsymbol{\Pi} \boldsymbol{x}_{t-p} + \boldsymbol{e}_t , \qquad \boldsymbol{e}_t \sim \text{iid}\,(\boldsymbol{0}, \boldsymbol{\Omega}_e),$$

where $\boldsymbol{\mu}$ is a vector of constants, $\boldsymbol{x}_t$ vector of the n *FX* rate variables, $\boldsymbol{e}_t$ is vector of residuals and $\boldsymbol{\Phi}$ and $\boldsymbol{\Pi}$ are $n \times n$ matrices of parameters. The long-term relationship parameter matrix, $\boldsymbol{\Pi}$ is assessed for its rank. If the rank of $\boldsymbol{\Pi} = r$, where $0 < r < n$, then some or all the variables in $\boldsymbol{x}_t$ are cointegrated with r cointegrating vectors. Defining $\boldsymbol{\Pi} = \boldsymbol{\alpha}\boldsymbol{\beta}'$, where both $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are $n \times r$ matrices, the columns of $\boldsymbol{\beta}$ form r distinct cointegrating vectors and $\boldsymbol{\alpha}$, the corresponding weights. The Johansen estimation procedure offers two options for testing the number of cointegrating relations. The one used here, known as the Trace test, entails the likelihood ratio

$$\lambda_{trace} = -T \sum_{j=r+1}^{n} ln(1 - \hat{\lambda}_j) \quad \text{(Johansen, 1995 p.93).}$$

The Trace test is preferred to the alternative, the Maximal Eigenvalue, as it is more robust to both residual skewness and kurtosis (Cheung and Lai, 1993). Silvapulle and

Podivinsky (2000) report that, when using Johansen's technique, researchers should not be overly concerned by small departures from normality, even in finite samples. They examine the impact of skew and leptokurtic errors and find they represent a mild problem. They also report that tests for restrictions on cointegrating vector values appear to be robust to both problem areas.

The Number of Cointegrating Vectors

The Johansen MLE can produce as many as $n - 1$ cointegrating vectors from n variables. Dickey *et al.* (1991) suggest that each vector represents a constraint on a system of variables, restricting their deviations from the long-run relationship to be within certain boundaries. The greater the number of cointegrating relations, the more stable the model.

As a cointegrating vector is a stationary linear combination of non-stationary variables it is possible for a sub-set to be stationary. Davidson (2000) argues that a cointegrating relation with k ($< n - 1$) variables may be *reducible*, implying a sub-set of $k - j$ variables may be cointegrated. A cointegrating relation with k variables is only *irreducible* if dropping any one of them leaves the set not cointegrated. Thus, "it is legitimate to check for cointegrating relationships in sub-sets." (Dickey and Rossana, 1994, p.342). This translates in to, with r cointegrating vectors among the n *FX* rates from Central Europe, the series are closely bonded with $r = n - 1$ and weakly bonded if $r = 1$ and not bonded in the long run if $r = 0$. Jones and Leishman (2006) go one step further revealing a leading housing region by considering whether the addition of that region to a group of others that are cointegrated results in an increase in the number of cointegrating vectors. This translates in to, with r cointegrating vectors among the n *FX* rates from Central Europe, where $n > r > 0$, if it

is a leading currency in the Jones and Leishman sense, the addition of the Euro to this group should be associated with $r + 1$ vectors from $n + 1$ currencies.

Granger-causality

In an n-dimensional multivariate vector error correction model of lag order (p) (VECM(p)) for $\ln FX_1$, the logged foreign exchange rate for country 1, can be represented as

$$\Delta \ln FX_{1t} = \mu_1 + \sum_{j=1}^{p-1} \phi_{1j} \Delta \ln FX_{1t-j} + \sum_{j=1}^{p-1} \phi_{2j} \Delta \ln FX_{2t-j} + .. + \sum_{j=1}^{p-1} \phi_{nj} \Delta \ln FX_{nt-j} + \sum_{j=1}^{r} \alpha_{1j} z_{jt-p} + e_{1t}$$

where

$z_{jt} = \mu_1 + \beta_{j1} \ln FX_{1t} + \beta_{j2} \ln FX_{2t} + \beta_{j3} \ln FX_{3t} + \ldots + \beta_{jn} \ln FX_{nt}$

$e_{1t} \sim$ iid $(0, \sigma_{1e}^2)$,

μ_1 is the intercept capturing rate of drift *or* is the mean of the levels of the data.

Changes in currency market 2 are said to Granger-causality changes in currency market 1 if $\phi_{2j} \neq 0$ for all j, with the possibility of Granger-causality in both directions (feedback). Granger-causality and cointegration have been used to identify unified spatially-distinct markets and to delineate leading markets/ spillover/ contagion.

Finding they are difference stationary suggests the *FX* rate series could be cointegrated. Using an Akaike lag selection criterion, a lag length of four for pre and post event structures is used. Two formats are considered for the VECM; the intercept could be in the long run relations or in the short run expression. The results for the number of cointegrating vectors and Granger-causality were almost identical but the

constant in the short run relations was found to be zero in all cases, whereas the intercept in the long was found to be different from zero (see Table 4).

Cointegration

The cointegration results for the pre and post August 2007 periods are reported in Table 3. In the period up to the crisis the group of seven currencies exhibit one cointegrating vector at the 5% level. Thus, there is a long run relation among the group. As the period considered does not involve a currency crisis, it will be assumed that this reveals normal currency relations. There is only a weak link between them but the follow common trends. In the period after August 2007, the period after the western banking crisis began to unfurl, the group of seven currencies exhibit two cointegrating vectors. Thus, in the crisis period, the bonds between the currencies appear to have increased. On this measure, there appears to be evidence of shift contagion in the fifth definition sense of Pericoli and Sbracia (2003).

Table 3 Cointegration Test Results

Hypothesis		Trace Statistic		Critical Value	
Null	Alt.	Before Aug 07	After Aug 07	95%	90%
$r = 0$	$r \geq 1$	170.8125*	199.4739*	132.45	127.24
$r \leq 1$	$r \geq 2$	72.8146	107.3032*	102.56	97.87
$r \leq 2$	$r \geq 3$	47.3969	56.7754	75.98	71.81
$r \leq 3$	$r \geq 4$	29.8898	33.6794	53.48	49.95
$r \leq 4$	$r \geq 5$	15.5490	19.9048	34.87	31.93
$r \leq 5$	$r \geq 6$	7.0134	10.0085	20.18	17.88
$r \leq 6$	$r \geq 7$	2.1309	4.1934	9.16	7.53

* significant at the 5% level

Factor Loadings

Next, there is a consideration of the factor loading in the cointegrating vector(s). The null that the factor loading for currency *j* is zero is not rejected in the cases of Czech

Koruna, Hungarian Forint, Latvian Lats, Polish Zloty and Slovakian Koruna in the pre August period. Indeed, the test results in Table 4 indicate two of the Baltic States appear cointegrated only. This suggests that these currencies are weakly bound at best.

By contrast the post-August considerations paint a different picture. Only the Slovakian Koruna appears to have a zero weighting. Thus, there again appears to be a significant change in the level of interaction among the currencies of Central Europe. Again, on this measure, there appears to be evidence of shift contagion.

Table 4 Tests for Zero Loadings

	Before Aug 2007	After Aug 2007
Czech	1.2502[.264]	17.8387[.000]**
Estonia	72.5458[.000]**	68.8259[.000]**
Hungary	1.2260[.268]	28.2844[.000]**
Lithuania	72.5415[.000]**	68.8029[.000]**
Latvia	.062087[.803]	7.9128[.019]*
Poland	.55444[.457]	23.2970[.000] **
Slovakia	2.9708[.085]	3.1801[.204]
Intercept	72.5518[.000]**	68.8309[.000]**

Granger-causality

The short run links are revealed by Granger-causality tests based on the Vector Error Correction Models. The models, in general, exhibit errors that are independent over time. Where heteroscedasticity was evident, a Newey-West adjustment was made entailing 14 lags. As one might anticipate, this was needed more for the post than the pre August 2007 period. The errors appear leptokurtic, which is common in financial data and Silvapulle and Podivinsky (2000) view this as a minor problem.

The Wald tests, displayed in Table 5 for the period before the crisis, suggest that there were no short run links among the Central European currencies. By contrast, the Granger-causality test show, in Table 6, that Poland exhibits a leading role in short run currency changes. The test results may also point to a secondary

effect through Hungary. Moreover, Latvian Lats leads the Slovakian Koruna and feeds-back with the Hungarian Forint. Overall, evidence suggests no currency is independent of all others in the post August 2007 period. Yet again, on this measure, there appears to be evidence of shift contagion in the fifth definition sense of Pericoli and Sbracia (2003).

Table 5 Granger-causality Test Results Before August 2007

	Czech	Estonia	Hungary	Lithuania	Latvia	Poland	Slovakia
Czech		1.8539	1.6908	1.8489	2.8452	2.9254	2.9527
		[.603]	[.639]	[.604]	[.416]	[.403]	[.399]
Estonia	1.2044		2.2688	1.0096	.94050	.49685	2.8030
	[.752]		[.519]	[.799]	[.816]	[.920]	[.423]
Hungary	.78230	.88191		.88164	1.1665	1.4176	2.1412
	[.854]	[.830]		[.830]	[.761]	[.701]	[.544]
Lithuania	1.2248	1.0707	2.2530		.98893	.56249	2.9046
	[.747]	[.784]	[.522]		[.804]	[.905]	[.407]
Latvia	1.3820	2.8198	1.0188	2.8340		1.0966	4.8385
	[.710]	[.420]	[.797]	[.418]		[.778]	[.184]
Poland	1.4911	3.2083	.52402	3.2005	3.7684		4.4050
	[.684]	[.361]	[.914]	[.362]	[.288]		[.221]
Slovakia	.43537	.60089	.88433	.59335	.69252	.97703	
	[.933]	[.896]	[.829]	[.898]	[.875]	[.807]	

Table 6 Granger-causality Test Results After August 2007

	Czech	Estonia	Hungary	Lithuania	Latvia	Poland	Slovakia
Czech		2.7313	4.0821	2.7753	2.8212	1.7559	.88978
		[.435]	[.253]	[.428]	[.420]	[.625]	[.828]
Estonia	1.0834		1.0094	1.5713	1.2790	2.2536	3.4446
	[.781]		[.799]	[.666]	[.734]	[.521]	[.328]
Hungary	15.8094	7.9671		7.9879	8.4145	3.1606	8.5535
	[.001]**	[.047]*		[.046]*	[.038]*	[.368]	[.036]*
Lithuania	1.0378	1.5872	.94656		1.3467	2.1941	3.4470
	[.792]	[.662]	[.814]		[.718]	[.533]	[.328]
Latvia	2.2096	5.3731	9.0821	5.3359		7.8126	8.8606
	[.530]	[.146]	[.028]*	[.149]		[.050]	[.031]*
Poland	10.6085	12.9904	24.0237	12.9300	12.4727		9.3072
	[.014]*	[.005]**	[.000]**	[.005]**	[.006]**		[.025]*
Slovakia	1.0070	2.4606	1.9017	2.4342	2.5242	.26459	
	[.800]	[.482]	[.593]	[.487]	[.471]	[.967]	

*sig. at the 5% level, **sig. at the 1% level

The Leading Role of the Euro

The leading role of the Euro is considered in two ways: first, following Jones and Leishman (2006) the Euro should add an extra cointegrating vector if added to the group of seven currencies considered for cointegration; second, the Euro could Granger-cause change in other currencies.

Having found one cointegrating vector among the seven currencies before and two after August 2007, the null the addition of the Euro to the pre August 07 period produces one or fewer vectors is rejected. A likelihood ratio statistic of 171, reported in Table 7 > critical value of 132 indicates there are two vectors (but not three, 72 < 102). The inference is that the Euro leads the other seven currencies in the long run. The same can be said of the post August period, where the null of two vectors is rejected in favour of three (105 > 102). Finding the Euro is a leading currency both before and after August 07 is consistent with Syriopoulos (2007) and suggests a stable relation that may be one through which contagion could be transmitted.

Table 7 Tests for Additional Cointegrating Vectors with the Euro

	1 CV	2 CV	3CV
To Aug 07	320.3746	171.2067	72.4633
After Aug 07	284.0970	186.6748	105.8222
Critical Values	166.1200	132.4500	102.5600

By contrast with the long run, the short run reveals no leading role of the Euro. The Wald tests, reported in Table 8 fail to reveal any Granger-causality from the Euro to a single currency.

Table 8 Granger-causality Test Results with the Euro

	Czech	Estonia	Hungary	Lithuania	Latvia	Poland	Slovakia
To Aug	4.6533	3.2911	5.3368	3.2995	3.3799	4.3660	4.6148
07	[.199]	[.349]	[.149]	[.348]	[.337]	[.225]	[.202]
After Aug	3.3223	2.5787	1.4758	2.5923	3.1544	2.8674	3.1077
07	[.345]	[.461]	[.688]	[.459]	[.368]	[.413]	[.375]

The leading role of the Euro is confined to the long run. Unlike among the seven Central European currencies, the Euro's influence on the region appears stable. These results are out of line with Gilmore and McManus (2002) who find no cointegration.

Although Syriopoulos (2007) finds one cointegrating vector this remains the case after the schism. This does not demonstrate contagion. Serwa and Bohl (2005) do not find contagion either across Eastern European markets. However, given the inclusion of two developed economy indices, Syriopoulos may have revealed a stable leading role of the Dax and S&P500. His short run results does not indicate an increase in the links between markets, and so not evidence of shift contagion in the fifth definition sense of Pericoli and Sbracia (2003).

Conclusion

The findings suggests that despite not being of the region directly concerned, the EU-8 were subject to financial contagion, perhaps as a result of a banking sector that had strong cross-border links and possibly based on lack of information about EU-8 markets. The assessment of shift contagion in the fifth definition sense of Pericoli and Sbracia (2003) was revealed both in the long and short runs when comparing the pre and post August 2007 periods. Given the volatility among currencies of smaller economies, the increased bonding, and targeting of the Euro, the scope for deflecting shocks through exchange rate adjustments was much reduced. The protected 2 year period of displaying financial rectitude via targeting the Euro before accession is considered may now appear a burden that the IMF is supporting indirectly. Perhaps, in the light of the regular crises that beset financial markets and how contagion appears to undermine the hope of self determination of a small economy, the EU should reconsider the entry requirements for the EU-8 still not approved to join the Euro.

At the end of the study period the Slovakian Koruna was revalued and then granted permission to join the Euro in 2009 whilst the Forint was facing sustained

speculative pressure. Following offering an emergency package to Hungary of $25bn, the IMF set up a $100bn fund to support emerging economies weather the global credit crunch. If the EU continues to require convergence of economy with emerging markets to the standards expected of developed economies before currency accession to monetary union, research is needed explore how a record of financial rectitude can be demonstrated whilst recognising that contagion is more likely to affect those emerging markets with information deficiencies.

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