Terhi Jokipii

Forecasting market crashes: further international evidence

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Forecasting market crashes: further international evidence

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Abstract

This paper studies the extent to which market crashes are predictable for a set of six countries, focusing in particular on possible differences between transition economies (The Czech Republic, Hungary and Poland) and mature markets (UK, US and EU). We estimate a set of individual country and pooled specifications to find that market crashes, in the broader sense, are predictable for all countries analysed. We additionally investigate the role that investor heterogeneity, proxied by trading volume, plays in this predictability and find some varying results between countries. For the Central and Eastern European Countries (CE3), an increase in trading volume relative to trend appears to have great predictive power, a result that is supportive of the theory of investor heterogeneity outlined in the relevant background studies. For the more mature markets (G5), on the other hand, market crashes appear more likely to follow a period of increased stock prices and returns, a result fitting a number of traditional theories, in particular the stochastic bubble model. Further analysis, allowing for time-varying coefficients, confirms the volume-crash relationship for the CE3 and provides preliminary evidence that macro news releases may additionally contribute to the predictability of market crashes.

Key words: aggregate market returns, skewness, trading volume, market crash

JEL classification numbers: C14, G12, G15

Voiko markkinoiden romahduksia ennustaa? Lisänäyttöä kansainvälisestä osakemarkkina-aineistosta

Suomen Pankin tutkimus
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Terhi Jokipii
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Tässä työssä tutkitaan markkinoiden romahdusten ennustettavuutta kuudessa ennalta valitussa maassa. Erityisesti keskitytään siirtymätalouksien (Tšekki, Unkari ja Puola) ja kehittyneiden markkinoiden (Iso-Britannia, Yhdysvallat ja euroalue) välisiin mahdollisiin eroihin. Tutkimuksen empiirisessä osassa kunkin yksittäisen maan aineistosta sekä kaikki maat kattavasta paneeliaineistosta estimoidaan osakemarkkinoiden tuottojakauman vinoudelle malli, jonka estimaattien perusteella romahdusten ennustettavuutta pyritään arvioimaan. Estimointien yhteydessä tarkastellaan myös sijoittajien heterogeenisuuden merkitystä markkinanotkahdusten kannalta. Heterogeenisuutta mitataan kaupankäynnin volyymilla. Tulosten mukaan kaupankäynnin volyymin suhteellisella kasvulla pitkän aikavälin trendiin nähden on ennustevoimaa keskisen ja itäisen Euroopan (CE3) maissa. Tältä osin tulokset ovat sopusoinnussa sijoittajien heterogeenisuuden vaikutuksia käsittelevien teorioiden kanssa. Kehittyneissä talouksissa osakemarkkinoiden romahdukset näyttäisivät sen sijaan seuraavan osakemarkkinahintojen ja -tuottojen nousujaksoja, mikä on sopusoinnussa joidenkin perinteisten teoreettisten hypoteesien, kuten stokastisten arvostuskuplien, kanssa. Alustavat lisätarkastelut, joissa kaupankäynnin volyymin vaikutusten sallitaan vaihdella ajassa, vahvistavat myös käsitystä, että kokonaistaloudellisten uutisten julkaiseminen parantaa markkinoiden romahdusten ennustettavuutta.

Avainsanat: osakemarkkinoiden tuotot, vinous, kaupankäynnin määrä, markkinoiden romahdus

JEL-luokittelu: C14, G12, G15

Contents

1 Introduction

In recent decades, asset booms and busts have been important factors in macro economic fluctuations in both mature as well as in developing countries. In light of this experience, despite their focus on maintaining price stability, there is a growing belief that central banks should additionally monitor asset price developments more closely.[1]

The importance of studying the properties of asset returns is manifold since asset prices serve multiple roles in a modern economy. Asset prices have the potential to affect aggregate demand, either through the net worth of consumer wealth or alternatively through its effect on business balance sheets. Furthermore, asset prices have the ability to lead to financial fragility via the impending growth of asset price bubbles and their subsequent bursting. Ultimately however, asset price volatility is capable of leading to excessive lending and risk-taking, eventually evolving into asset price booms and subsequent busts. Financial institutions in particular are vulnerable to asset price collapses, firstly because of the decline in the value of collateral they hold, but also due to the general increase in uncertainty that may lead to a flight to quality and to a widespread reduction in lending that could affect even the most solvent institution. Literature has subsequently highlighted the importance of asset price declines in triggering banking crises (see among others Diamond and Dybvig, 1983; Mishkin, 1994; Allen and Gale, 1998b; Marshall, 1998) emphasising the importance of determining the degree to which markets are crash-prone, and the key economic mechanisms driving this phenomenon.

It is possible to think of the riskiness of any asset as essentially being made up of at least three different elements: its standard deviation (the overall dispersion in possible outcomes); its skewness (the relative probability of a positive or negative surprise); and its kurtosis (the probability of an extreme outcome). While the standard deviation or variance measures the spread of possible returns, skewness adds a further richness to this picture by measuring the concentration of the probability in downside or upside returns. On the one hand, positive skewness resembles a large probability of a small loss offset by a small probability of a large gain, while negative skewness, on the other hand, represents a small probability of a large loss offset by a large probability of a small gain. Therefore, the more negatively skewed the distribution of a set of assets, the greater the chance of the return being below rather than above expected returns. If the degree of negative skewness falls, then it may be suggested that market expectations are changing and that a tendency towards a diminished expectation of sharp falls in share prices exists. The degree to which market returns are negatively skewed

[1] See for example Gertler et al (1998), Bernanke and Gertler (1999), Greenspan (1999), Vickers (1999).

therefore serves as an indication of the perception of downside risk to a set of assets, additionally acting as an indicator of the extent to which these markets are crash-prone.

While much work has investigated the nature, extent and persistence of asymmetry in asset returns, only very recently has the focus shifted towards understanding the role of trading volume in this relationship. Key papers in addressing this area are Chen, Hong and Stein (2001); Hong and Stein (2003); Hueng and Brooks (2003); Charoenrook and Daouk (2004). Using a variety of datasets, they generally find that while relationships do exist between the risk, return and levels of prices and of volume, these relationships are complex and subtle. Much of the work has however focussed primarily on estimating the determinants of asymmetries in the US (see among others Cutler, Poterba and Summers, 1989; Chen, Hong and Stein, 2001; Hong and Stein, 2003; and Hueng and Brooks, 2003), in particular concentrating on daily returns of individual stocks. Cross-country evidence together with a concrete understanding of aggregate market asymmetries is however lacking.

In this paper, we address these outstanding issues and analyse the degree to which market crashes are predictable in six international markets; the Czech Republic (CZ), Hungary (HU), Poland (PL), the United States (US), United Kingdom (UK) and European Union (EU). Following Hong and Stein (2003), we consider a 'crash' to encompass three distinct elements: 1. an unusually large movement in stock prices; 2. that this movement is negative; and 3. that the effect is a contagious market-wide phenomenon.[2] In particular, we focus our investigation on understanding differences that exist between the Central European countries (CE3) and more mature (G5)[3] markets in this respect. We estimate a set of individual country equations, as well as panel regressions and find that market crashes *are* predictable for all countries in our sample. Our estimations further allow us to analyse the role that trading volume takes on in this predictability. We find that for the CE3, crashes appear more likely in markets that have experienced an increase in trading volume relative to trend. This finding is in line with the theoretical underpinnings of this paper. Regarding the G5 however, market crashes appear to be more pronounced in markets that have recently experienced an increase in stock prices and returns. This finding is congruent with some of the more traditional investor theories. In particular, the stochastic bubble model put forward by Blanchard and Watson (1982). The uncovered discrepancies are further explored though the implementation of a state space model, allowing for the investigation of time varying coefficients. In

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[2] The 'crash' involves an abrupt highly correlated decline in the prices of an entire class of stocks rather than in just a single stock.

[3] We consider these markets as the G5, as they comprise five of the seven G7 countries, namely, the US, UK, Italy, France and Germany. They subsequently represent a sample of wealthier or more mature markets.

addition to addressing the gaps in the literature, our findings raise two further issues which have not yet been addressed in this previous literature. We experiment with different time-horizons for measuring skewness and discover that the choice of time horizon does have a notable impact on statistical power. Moreover we briefly explore the extent to which the release of macro news affects trading volume and its subsequent impact on predicting market crashes. We conclude that this relationship deserves further investigation.

The remainder of this paper is organised as follows: Section 2 reviews the theoretical literature put forward to explain return asymmetries and outlines the theoretical model motivating our empirical estimations. Section 3 describes the data adopted for our analysis. Section 4 presents our empirical specification and results. Section 5 briefly concludes.

2 The asymmetry of market returns

Research in finance has shown that that the assumption of the normality of price variations in financial markets inadequately represents the short-term returns of financial assets and that negative asymmetries in stock returns do exist. While this asymmetry of returns is generally not disputed, the underlying effects driving this phenomenon are less clear. Two main lines of theoretical research have emerged to explain this: the first, typified by Black (1976); Blanchard and Watson (1982); French, Schwert and Stambaugh (1987); Schwert (1989) and Campbell and Hentschel (1992) suggests, from a variety of perspectives, that the role of representative investors may change as markets move. This line of reasoning is based on understanding the underlying economic mechanisms reflected, and focuses on representative investor theories of asymmetry including the 'leverage effect', stochastic bubble models as well as the 'volatility feedback' mechanism.

Probably the most reputable of the representative investor theories for asymmetry in stock prices is based on the 'leverage effect' (Black, 1976; Christie, 1982) which considers that a drop in prices raise both operating and financial leverage, in turn reducing the volatility of subsequent returns. In this case, leverage is reduced after an increase in price causing the skewness of returns to become more negative after a period of price return decline. Black (1976) reported that implied and historical volatilities of individual stocks go up when the stock prices go down, however it has since been argued that the leverage effect is too small to account for this phenomenon (Christie, 1982; Schwert, 1989). An alternative theory typified by Blanchard and Watson (1982), models stochastic bubbles which imply the existence of two distinct regimes in generating stock returns; one where the bubble collapses and one where it survives. Rational investors take this into consideration when deciding whether to invest in an asset.

Here, the popping of the bubble- a low probability event produces large negative returns resulting in negative skewness following the end of period sustained return increases. Formally however, this bubble is essentially argued to be incomplete (Spotton and Rowley, 1998). Finally, the 'volatility feedback' mechanism (Pindyck, 1984; French, Schwert and Stambaugh, 1987; Campbell and Hentschel, 1992) recognises that an increase in the volatility of returns exacerbates price decline, therefore causing the distribution to become more negatively skewed. When a large piece of good news hits the market, the positive news will tend to be followed by other large pieces of news (volatility persistence) subsequently increasing future expected volatility. As a result, the required rate of return rises causing a fall in the stock price and hence dampening the positive impact of the news. Poterba and Summers (1986) however, point out that shocks to market volatility are short-lived and therefore cannot be expected to have a large impact on risk premiums.

In contrast, an alternate and more recent line of research can be stylized by the heterogeneity of investor beliefs about the future course of market returns. This theory has its roots in the belief that investors differ in their opinion about the fundamental value of stocks, which subsequently affects both the volatility and the volume of returns. Deriving in large part from Epps and Epps (1976) who measure the amount of disagreement among investors based on the arrival of new information in the market, this research has generally provided support for the relationship between trading volume and dispersion (and thus indirectly the mean level) of returns. Research has subsequently shown that trading volume can proxy for the intensity of disagreement. (See among others Kim and Verrecchia, 1991a, 1991b; Harris and Raviv, 1993; Shalen, 1993; and Kandel and Pearson, 1995) When disagreement (trading volume) is high, it is more likely that the information held by bearish investors is incompletely revealed in prices, setting the stage for negative skewness of returns in subsequent rounds of trade. This reasoning follows that accumulated 'hidden' information tends to come out during market declines supporting the view that returns are negatively skewed.

Since our paper is concerned with understanding differences between countries of varying degrees of development, we focus our empirical analysis on testing whether differences in opinion about the fundamental value of stocks differs between these countries. We might expect to find a larger degree of divergence for the CE3 countries than for the G5, particularly in the early part of the 1990s when these countries were far less stable than their more mature counterparts. Each of the three CE3s analysed here underwent significant market developments, policy initiatives as well as crises during this time.

2.1 Theoretical model: heterogeneity of investor beliefs

The empirical investigation in this paper addresses the question of whether stock markets may be vulnerable to crashes. As outlined in the introduction, our definition of a ‘crash’ encompasses three distinct elements each grounded in a set of robust empirical facts.[4]

The Hong and Stein model (H-S) encompasses all the three empirical regularities covered, focussing in particular on the consequences of differences of opinion among investors. The model predicts that negative skewness in returns will be most pronounced around periods of heavy trading volume since, like many other models with differences of opinion, trading volumes proxy for the intensity of investor disagreement. (See Varian, 1989; Harris and Raviv, 1993; Kandel and Pearson, 1995; and Odean, 1998a).

Difference of opinions is modelled by assuming that two investors, A and B each receive a private signal about a stocks terminal payoff. Investors are assumed to be overconfident and therefore concentrate on their own private information in order to make inferences about the value of a stock. Even if information regarding investor A’s (B) private information is revealed via prices, investor B (A) concentrates on his/her own signal. Such an assumption maintains a level of divergence in opinion between investors and preserves varying valuations for the asset.

Additional traders in the form of fully rational, risk-neutral arbitrageurs enter the model. The arbitrageurs recognize that the best estimate of the stocks true value is formed by averaging the signals of A and B. Due to the fact that investors A and B face short-sales constraints, the arbitrageurs will not always get to see both signals. It is important to note that arbitrageurs are not short-sale constrained and can therefore take infinitely large positive or negative positions at zero cost. The market in which these traders operate is fully efficient in that there is no predictability of returns. This comes about from the presence of the arbitrageurs who are assumed to be rational, risk-neutral and unconstrained. Only one stock is traded which can be thought to be the market portfolio.

Trading takes place on two dates, t_1 and t_2 after the individual signals are revealed. The first two elements of our definition of a crash are captured by the model since it is evident that the price movement at t_2 may be completely out of proportion to the signal revealed at this time as it may additionally reflect the impact of a previously hidden signal. Essentially, here the trading process can cause the endogenous exposure of built-up private information, and can lead to large price changes based only on small observable contemporaneous news events.[5] The fundamental asymmetry in the model is introduced via the notion

[4] See Hong and Stein (2003) for a detailed description of the definition adopted here.
[5] For a more detailed explanation of this model see Hong and Stein (2003).

that more total information comes out when the market is falling rather than rising, essentially stating that the biggest observed price movements are more likely to be declines, a phenomenon corresponding closely to historical facts (see among others Cutler, Poterba and Summers, 1989).

The final element of the definition relates to the inherent contagion or increased correlation of stocks during a downturn. For this purpose, the model considers a portfolio of stocks, whereby the possibility of a sell-off in one stock causes the release of pent-up information that is not only relevant for pricing stock i, but also for pricing stock k. Resultantly, the release of bad news tends to heighten the correlation among stocks, having the potential to affect the price of j despite the lack of contemporaneous news relating to its own fundamentals.

In addition to governing the degree of negative skewness, The H-S model further shows that the ex ante divergence of opinions additionally determines the level of trading volume. In particular, when the difference of opinion is great, trading volume is unusually great at both t_1 and t_2. This increase in trading volume is associated with the likelihood of investor B moving out of the market at time t_1, and into the market at t_2, exactly the effect that drives negative skewness. The comparative statistics of the H-S model with respect to the difference of opinion, hence predict that stock returns will be more negatively skewed following an increase in trading volume. To show this more clearly, we consider a situation where the heterogeneity of opinions (H) > the variance of the news received by investors (V). At time 0, both investors A and B have no initial endowment of the stock and prices are consequently set by the arbitrageurs who all agree on the stocks worth ex ante. Once the signals are revealed, trading volume will be proportional to the extent to which A's and B's signals differ from one another: $\frac{|S_A - S_B|}{2}$. This is the case since if at t_2, A has the higher valuation, trading volume will be proportional to $(S_A - P_2)$. Conversely, if B has the higher valuation, trading volume will be proportional to $(S_B - P_2)$.[6] The implications for skewness follow since short-horizon skewness monotonically decreases in H for H > V therefore implying that for H > V, the degree of short-horizon returns is increasing in trading volume.

3 Data description

As our Table 3.1 indicates, market returns for the six international markets in our sample, namely the Czech Republic, Hungary, Poland, the US, UK and EU, all exhibit a degree of negative asymmetry. In particular, we see that the extent to which asymmetry persists is notably higher for the CE3 (from –0.81 in Hungary

[6] For a formal proof see Hong and Stein (2003).

to –0.58 in Poland) countries when compared to more mature G5 (from –0.13 in the US to –0.30 in the EU) markets. A simple test of normality is based on the assumption that a normal probability density function has skewness equal to zero and kurtosis equal to three. The statistics here clearly indicate the rejection of normality for all market indices. The *Jarque-Bera* test examines the difference of the skewness and kurtosis of the series with those of the normal distribution. We see that this test is rejected at all levels of significance which consequently confirms the clear rejection of normality.[7]

Table 3.1 **Total sample descriptive statistics**

Daily data: April 1994 to December 2004

	CZ	**PL**	**HU**	**UK**	**US**	**EU**
Mean	0.00	0.01	0.05	0.03	0.04	0.03
Maximum	5.20	9.26	11.27	4.75	5.36	4.71
Minimum	-7.25	-11.01	-17.68	-4.72	-7.03	-5.31
Std. Dev.	1.29	1.90	1.75	0.99	1.11	0.95
Skewness	-0.64	-0.58	-0.81	-0.21	-0.13	-0.30
Kurtosis	4.99	6.07	14.39	5.30	6.56	5.60
Jarque-Bera	478.87	1070.90	15056.88	623.45	1450.42	813.17
Probability	0.00	0.00	0.00	0.00	0.00	0.00
Observations	2806	2805	2728	2806	2806	2806

Sample

To construct or variables, we make use of 10 years of daily aggregate market return and trading volume data for the Czech Republic, Hungary, and Poland, the US, UK and EU.[8] Our sample begins on April 1st 1994[9] and spans till the end of December 2004. All of the data is obtained from *DataStream International*.

Both the daily price index and volume data are aggregated on a non-overlapping 20, 15 and 10-day basis. The choice of horizon is admittedly subjective; however the H-S model gives no guidance on this issue. Since much of the empirical literature in this field have adopted varying time frames for calculating observations of skewness we experiment by calculating skewness over 20, 15 and 10-day periods respectively. The motivation for concentrating on smaller rather than longer time frames[10] stems from our adoption of market rather than individual stock returns, reducing the risk of having outliers strongly influence the data. Since the results obtained for each of the time frames are

[7] The reported probability represents the likelihood that the Jarque-Bera statistic exceeds (in absolute value) the observed value under the null hypothesis. A small probability value leads to the rejection of the null hypothesis of a normal distribution.

[8] All EU series were created by combining data for Germany before 1999 with EU data after 1999.

[9] This is the first date for which trading volume data was available for all countries of interest.

[10] Cheng, Hong and Sein (2001) calculate skewness over six-month periods. Charoenrook and Daouk (2004) obtaine skewness observations for one month intervals.

broadly similar, we present only those obtained for the 10-day period, since these returned the most significant results. Our sample therefore consists of a total of 280 observations for each variable.

Dependant and explanatory variables

To measure the degree of negative skewness, we follow Chen, Hong and Stein (2001) and consider two varying approaches. The first is calculated by taking the negative of the third moment of daily returns and dividing it by the standard deviation of daily returns raised to the third power. Scaling the raw central third moment by the standard deviation is standard practice in skewness statistics, allowing for the comparison of returns with different variances (Greene, 1993). Thus for any index i over any 10-day period t, we have:

$$SKW_{it} = (-1) * \left[\frac{n(n-1)^{3/2} \sum R_{it}^{3}}{(n-1)(n-2)\left(\sum (R_{it}^{2})\right)^{3/2}} \right] \tag{4.1}$$

Where R_{it} represents the average sequence of daily returns and n, the number of observations in each of the10-day periods. Here the negative coefficient forces the measure to increase as negative skewness increases. The desirability of this definition as a measure of skewness is discussed extensively in Chen, Hong and Stein (2001) and in Kearney and Lynch (2004b).

In addition to SKW_{it}, we calculate an additional measure, $DUVOL_{it}$, which does not involve third moments and is hence less likely to be overly influenced by extreme events. This measure considers 'down-to-up-volatility' whereby for any index i, over any 10-day period, t we distinguish between those that have returns below the period mean R_{itDOWN} from those that have returns above the mean r_{itUP}. The standard deviations of each of these sub-samples are then estimated separately.

The ratio of the standard deviation of 'down' days to the standard deviation of 'up' days is computed as:

$$DUVOL_{it} = \log \frac{\left((n_u - 1) * \Sigma R_{itDOWN}^{2}\right)}{\left((n_d - 1) * \Sigma R_{itUP}^{2}\right)} \tag{4.2}$$

Where n_u and n_d are the number of up and down days respectively. As with the previous measure presented in (4.1), the convention here is that a higher value of $DUVOL_{it}$ corresponds to a more negatively skewed distribution.

In addition to the skewness measures outlined above, our baseline specification includes several additional explanatory variables which are relatively straightforward and do not require much explanation. For both volume and return variables, we additionally calculate the mean and standard deviations for each 10-day period. Summary statistics of the aggregated data are presented in Table 3.2. The means of the series are broadly uniform in size, with the figures for Hungary and Poland demonstrating slightly negative values. The variance measures are again largely unvarying, ranging between 0.09 in the Czech Republic, to 0.03 in the US, the UK and the EU. The Skewness statistics are negatively signed for all markets and are notably larger for the CE3 countries than for the G5.

Table 3.2 **Descriptive statistics for international market returns**

Aggregated data: April 1994 to December 2004

	CZ	PL	HU	UK	US	EU
Returns						
Mean	0.00	-0.03	-0.02	0.04	0.02	0.02
Maximum	0.77	0.45	0.66	0.58	0.51	0.47
Minimum	-1.16	-1.11	-1.17	-1.06	-1.09	-0.98
Std. Dev.	0.09	0.06	0.04	0.03	0.03	0.03
Skewness	-2.88	-1.44	-1.21	-1.09	-0.72	-0.65
Kurtosis	4.15	3.04	3.88	4.09	3.17	2.59
StDev of Returns						
Mean	1.08	1.22	0.99	0.80	0.98	0.96
Maximum	2.34	3.22	4.55	3.97	5.35	4.24
Minimum	0.29	0.28	0.31	0.34	0.35	0.24
Std. Dev.	0.01	0.01	0.01	0.01	0.01	0.01
Skewness	1.89	2.11	2.45	2.66	2.37	3.01
Kurtosis	9.66	7.37	24.55	35.75	2.44	28.59
Sample Skewness						
Mean	0.08	0.06	-0.25	-0.09	-0.03	-0.01
Maximum	2.62	3.68	3.57	2.35	2.45	2.37
Minimum	-3.06	-1.67	-3.16	-1.89	-3.56	-2.06
Std. Dev.	0.77	0.61	0.34	0.89	0.67	0.58
Kurtosis	4.18	2.47	2.53	3.08	3.11	2.86
SKW						
Mean	-0.11	-0.18	-0.20	-0.21	-0.56	-0.26
Maximum	17.68	22.34	12.13	10.39	56.66	54.72
Minimum	-15.25	-39.11	-18.66	-22.55	-45.24	-23.25
DUVOL						
Mean	-0.04	-0.09	-0.11	-0.02	-0.03	-0.05
Maximum	0.68	0.52	0.62	0.78	0.41	0.74
Minimum	-0.66	-0.78	-0.56	-0.51	-0.71	-0.48

Note: These statistics are calculated on 10-day periods of returns aggregated from daily price indices. SKW is defined according to equation (4.4)

Control variables

Empirical work by Bekaert and Harvey (2000) and Henry (2000), has provided significant evidence in favour of a substantial effect that liberalization has on both liquidity as well as on volatility. In our study, each of the CE3 countries considered experienced periods of market development during much of our sample period. Included in this were events of both financial sector as well as stock market liberalization. We consequently include several measures to act as a control against these effects.

To capture financial market liberalization, we consider four distinct events as important; *Bank ownership*: a move towards privatization, *Interest rates*: date of liberalization; *Credit control*: elimination of controls; *Deposits*: the date when deposits in foreign currencies are allowed. Here the dummy series moves from 0 to 1 in the period where the event took place. A similar dummy is created for the date of stock market liberalization in each of the CE3 countries. The dates capturing the events of interest are presented in Table 3.3.

Table 3.3 **Financial and stock market liberalization: event dates**

	CZ	HU	PL
Financial liberalization			
Bank ownership	Privatization of state owned banks late 1991.	01.01.95: Bank privatization beings. (creation of ÁPV Rt)	In 1993 Bank privatization begins.
Interest rates	Liberalization of interest rates in 1992.	Liberalization of interest rates in 1987 for enterprises and in 1992 for households.	Liberalization of interest rates starting with 1990.
Credit control	01.04.97: Removal of credit control.	01.01.00: Liberalization of foreign currency denominated credits to non-residents from OECD countries. 01.06.01: The Ministry of Finance and the MNB lifted all remaining restrictions on foreign-exchange transactions for residents and non-residents.	01.01.98: Required permission needed for short-term credit to non-residents lifted. Short term financial credit from residents to non-residents prohibited above a given limit.
Deposits	01.01.01: Foreign deposits no longer require pre-approval.	01.07.00: Residents allowed to deposit securities and earnings abroad.	In 1990 deposits an foreign accounts allowed with limit
Stock market liberalization			
	06.04.93: Stock exchange trading begins. 14.06.01: Foreign securities allowed.	01.06.90: Stock Exchange established. 01.01.97: Foreigners allowed trading on derivatives market.	01.08.91: Stock Exchange re-opened. 14.10.03: First foreign company listed.

Source: National Central Bank and National Supervisory Authority.

4 Empirical specification and results

4.1 Predictability of skewness: individual countries

Traditional investor theories of asymmetry explain why the skewness of returns may be predictable. The leverage effect and the volatility feedback effect imply that returns should be more negatively skewed following a stock price decline. The stochastic bubble model on the other hand implies that the distribution of returns should be more negatively skewed following a period of a stock price run up constituting a subsequent positive relationship between negative skewness and lagged returns. What we are predominantly interested in however, is the role that the heterogeneity of investor beliefs takes on here. This theory predicts that negative skewness will be more pronounced, and market crashes more likely, following periods of heaving trading volume.

In order to test the predictability of market crashes and subsequently the role that trading volume takes on in this predictability, we develop a baseline regression specification as below

$$SK_{it} = \alpha_{i,0} + \sum_{j=1}^{5} \alpha_{ij} SK_{it-j} + \sum_{j=0}^{5} \beta_{ij} \sigma_{it-j} + \sum_{j=0}^{5} \delta_{ij} R_{it-j} \sum_{j=0}^{5} \varepsilon_{ij} V_{it-j} + \sum_{j=0}^{5} \phi_{ij} SDV_{it-j} + \sum_{j=0}^{5} \varphi_{ij} SKV_{it-j} + \zeta_{ij} \qquad (4.1)$$

Here SK_{it} denotes market return skewness in country i over any 10-day period t measured using both the SKW_{it} and the $DUVOL_{it}$ measures of skewness outlined in the previous section. σ_i represents the standard deviations of returns; and R_i, excess returns; V_i represents trading volumes; SDV_i, the standard deviation of trading volumes; and SKV_i (or $DUVOLV_i$), the skewness of trading volumes. Each regression additionally includes the control dummies defined in Section 4.1. A number of lags of past returns are included on the right hand side of the regression since the empirical model tries to isolate the predictive power that trading volume has on the incidence of negative skewness. It is therefore essential to control for the fact that past returns are known to be naturally correlated with trading volumes and that in addition, they can serve as predictors of skewness. (See Shefrin and Statman, 1985; Lakonishok and Smidt, 1986; Odean, 1998b).

Results: individual country analysis

Our results are presented in Table 4.1 and Table 4.2 for the CE3 and the G5 countries respectively. The model diagnostics for all countries can be seen in

Table 4.1 **Determinants of skewness in CE3 total market returns**

	α	β	δ	ε	ϕ	φ	**Financial liberalization**		**Stock mkt liberalization**
							Credit control	Deposit control	
Czech Republic									
0		-1.71 *(0.56)*	35.07 *(2.06)***	0.08 *(0.49)*	-0.00 *(0.27)*	0.16 *(0.53)*	0.03 *(0.51)*	-0.00 *(0.05)*	-0.06 *(0.58)*
1	0.01 *(0.14)*	2.24 *(0.73)*	2.82 *(0.49)*	0.12 *(2.48)****	-0.00 *(0.21)*	-0.08 *(0.51)*			
2	0.17 *(1.38)***	-5.76 *(1.48)**	10.37 *(1.39)**	0.15 *(1.99)***	-0.00 *(7.34)****	-0.52 *(2.64)****			
3	-0.00 *(0.12)*	2.43 *(0.86)*	-0.53 *(0.15)*	0.11 *(2.45)***	-0.0 *(1.31)**	0.19 *(3.96)****			
4	-0.03 *(0.53)*	4.22 *(1.23)*	1.19 *(0.38)*	0.09 *(2.14)***	-0.00 *(2.08)***	-0.00 *(2.01)***			
5	0.02 *(0.39)*	-0.93 *(0.32)*	-0.76 *(0.21)*	0.05 *(2.31)***	0.00 *(1.91)***	0.26 *(2.43)***			
Hungary									
0		-49.08 *(1.41)**	-1.05 *(0.55)*	0.00 *(0.22)*	0.00 *(1.03)*	0.11 *(0.65)*	0.04 *(0.41)*	-0.09 *(0.79)*	-0.07 *(1.42)**
1	-0.05 *(0.68)*	1.46 *(0.34)*	-1.18 *(0.58)*	0.08 *(8.53)****	0.00 *(1.70)**	-0.09 *(0.62)*			
2	-0.03 *(0.48)*	-3.55 *(0.93)*	1.98 *(0.91)*	0.12 *(3.31)****	9. 29e^{-05}*(3.19)***	-0.05 *(0.43)*			
3	0.01 *(0.19)*	-3.12 *(0.81)*	0.11 *(0.06)*	0.06 *(2.16)***	3. 54e^{-06}*(4.01)****	-0.09 *(2.67)****			
4	0.08 *(1.28)**	0.13 *(0.03)*	0.19 *(0.11)*	4.57e^{-05}*(0.08)*	2.54e^{-05}*(1.95)***	-0.07 *(2.37)***			
5	0.07 *(1.29)**	-0.20 *(0.05)*	-1.44 *(0.91)*	7. 96e^{-05}*(0.16)*	-0.00 *(0.74)*	0.21 *(1.39)**			
Poland									
0		-2.65 *(0.87)*	48.68 *(1.28)**	0.00 *(0.98)*	0.00 *(1.21)*	0.02 *(0.09)*	-0.10 *(2.27)****		-0.04 *(0.58)*
1	0.05 *(0.07)*	2.06 *(0.86)*	2.99 *(0.72)*	0.12 *(2.66)****	-0.00 *(0.94)*	-0.14 *(0.48)*			
2	-0.05 *(0.70)*	3.68 *(1.23)*	8.36 *(2.21)**	0.11 *(1.36)**	0.00 *(0.27)*	0.38 *(1.42)**			
3	0.03 *(0.55)*	-6.57 *(1.37)**	1.78 *(0.52)*	0.09 *(1.57)***	-0.00 *(1.37)**	*-0.56 (2.57)****			
4	0.01 *(0.24)*	2.92 *(0.80)*	1.75 *(0.50)*	0.05 *(2.35)****	0.00 *(2.30)****	0.11 *(2.29)***			
5	-011 *(1.72)**	-6.07 *(1.46)**	7.79 *(1.92)**	6.97 e^{-05}*(1.29)**	-0.00 *(2.57)***	0.12 *(2.18)***			

Note: The estimates above are the results from estimating equation (4.1). *, ** and *** denote significance at the ten, five and one per cent levels respectively. Absolute value of the t-statistic is presented in parenthesis. Column 1 indicates the number of lags.

Table 4.2 **Determinants of skewness in G5 total market returns**

	α	β	δ	ε	ϕ	φ
EU						
0		13.86 *(2.51)****	76.22 *(13.47)****	0.00 *(0.46)*	-0.00 *(1.02)*	0.05*(0.16)*
1	-0.09 *(1.41)**	1.27 *(0.23)*	14.07 *(1.67)***	5.74 e^{-05} *(0.16)*	-0.00 *(0.69)*	0.17 *(0.49)*
2	-0.06 *(0.82)*	5.07 *(1.96)***	4.43 *(2.23)***	0.00 *(1.19)*	1.49e^{-05} *(0.02)*	0.16 *(0.41)*
3	-0.11 *(1.54)**	6.55 *(1.26)**	9.81 *(1.31)**	0.00 *(0.88)*	-0.0 *(1.14)*	-0.54 *(1.41)**
4	-0.00 *(0.07)*	7.77 *(1.44)**	8.69 *(1.41)**	-0.00 *(1.44)**	7.98e^{-06} *(0.01)*	0.25 *(0.82)*
5	-0.03*(0.37)*	-3.97 *(0.85)*	0.42 *(0.06)*	0.00 *(2.26)***	-0.00 *(1.33)**	-0.22 *(0.66)*
UK						
0		-3.17 *(0.74)*	64.62 *(14.65)****	10.12 *(2.03)***	-0.00 *(0.35)*	-0.49 *(1.32)**
1	-0.09 *(1.39)**	2.41 *(0.61)*	11.83 *(2.23)***	-0.00 *(0.62)*	-0.00 *(0.89)*	0.14 *(0.39)*
2	-0.04 *(0.67)*	-0.87 *(1.31)**	0.76 *(2.32)***	0.00 *(1.14)*	0.00 *(0.34)*	-0.00 *(0.00)*
3	0.07 *(1.55)***	6.65 *(1.94)***	3.25 *(0.56)*	-0.00 *(1.54)**	-0.00 *(0.56)*	-0.08 *(0.23)*
4	0.12 *(1.80)**	1.32 *(2.40)***	0.19 *(0.11)*	0.00 *(0.72)*	0.00 *(0.29)*	-0.03 *(0.10)*
5	0.11*(1.72)**	3.72 *(1.06)*	14.66 *(2.30)**	-3.18e^{-05}*(0.05)*	0.00 *(1.96)**	0.54 *(1.35)**
US						
0		9.08 *(2.07)*	69.94 *(14.39)****	-0.00 *(1.66)*	-0.00 *(1.25)**	-0.66 *(0.54)*
1	0.02 *(0.25)*	-3.51 *(1.30)**	2.16 *(3.38)****	0.00 *(0.31)*	0.00 *(1.89)**	0.42 *(0.34)*
2	0.07 *(1.13)*	1.37 *(1.35)***	7.13 *(2.21)***	-0.00 *(0.75)*	0.00 *(0.93)*	1.92 *(1.74)**
3	-0.05 *(0.73)*	-0.06 *(1.44)**	6.18 *(1.31)**	0.00 *(2.49)****	-0.00 *(0.89)*	-2.07 *(1.66)**
4	0.04 *(0.58)***	7.90 *(1.89)**	2.48 *(0.43)*	0.00 *(2.20)***	-0.00 *(0.77)*	0.24 *(0.23)*
5	0.06 *(1.11)***	-12.15 *(3.05)****	8.33 *(1.71)**	-0.00*(0.52)*	0.00 *(1.07)*	1.32 *(1.00)*

Note: The estimates above are the results from estimating equation (4.1).
*, ** and *** denote significance at the ten, five and one per cent levels respectively.
Absolute value of the t-statistic is presented in parenthesis. Column one indicates the number of lags.

Table 4.3. We include five lags of both the dependent and each of the independent variables respectively and correct for autocorrelation and heteroskedasticity in the residual term. The constant terms are all negative, none however are statistically significant. Results obtained under the SKV_{it} and the $DUVOL_{it}$ measures of skewness are very similar. We therefore chose to report those for SKW_{it} to allow for a comparison with previous studies in this field.

Table 4.3 **Estimation summary statistics**

	R^2	MDV	SEE	DW	Q-Statistic	# OBS
Czech Republic	0.52	-0.02	0.32	2.00	0.94 (0.86)	254
Hungary	0.62	-0.07	0.25	1.98	1.27 (0.95)	266
Poland	0.55	-0.05	0.27	2.03	0.76 (0.98)	255
US	0.57	-0.07	0.25	2.02	1.19 (0.95)	266
UK	0.43	-0.07	0.26	1.98	0.78 (0.98)	266
EU	0.45	-0.07	0.25	2.01	0.42 (0.99)	266

Note: MDV, SEE and DW represent mean dependent variable, standard error of the estimation and Durbin-Watson statistic respectively.

Central and Eastern European countries (CE3)

Looking first at Table 4.1, we find that all three moments of the price return variables are broadly insignificant for the CE3 countries. In particular, the sign of the coefficient of both the contemporaneous and the lagged returns variable, R_i vary throughout time, and across countries. The significant effect uncovered however, appears to be positive for all three countries. This would tend to indicate that when a relationship does exist between lagged return and the incidence of negative skewness, it is more likely to be positive. This finding is in line with the previous literature. Harvey and Siddique (2000) and Cheng, Hong and Stein (2001) both find that for daily stock prices and monthly trading volume for all NYSE and AMEX firms past return terms are always positive. The cross country study by Charoenrook and Daok (2004) investigates conditional skewness in aggregate market returns and unveils a similar result. Comparing their findings for the Czech Republic, Hungary and Poland to ours, we find that the evidence uncovered is largely similar. Since the coefficients are significant only at the 10 percent level, it is impossible for us to draw any meaningful conclusions from these results.

The volume variables returned on the other hand provide far more statistically significant results. We find that the lagged trading volume variable, V_i is significant at the one percent level for all three countries. The coefficients are uniformly positive both through time and across countries, indicating that stocks making up the indices being analysed are, everything else being equal, are more crash-prone following a surge in trading volume relative to trend. That is, market crashes in these countries appear to be more likely to follow a surge in trading volume. These results are in line with previous studies in the field. Both Chen, Hong and Stein (2001) and Charoenrook and Daouk (2004) provide strong evidence that lagged trading volumes are directly associated with subsequent negative returns in the aggregate returns.

The control variables in general are not significant, though we do find that the liberalization of credit controls in Poland, in 1998, which came in the form of eradicating the need to seek permission to extend short-term credit to non-residents, appears to be significant at the one percent level.

Generally, the results for the CE3 countries indicate that trading volume does have a highly significant impact on the incidence of negative skewness. In particular, the result shows that an increase in trading volume relative to trend would result in a pronounced prevalence of negative skewness in these countries. This finding is consistent with the theoretical model adopted in this paper which predicts that there should be a stronger negative relationship between lagged trading volume and skewness in countries where short selling is constrained.

The US, UK and EU (G5)

Turning then to the results for the G5 countries presented in Table 4.2, we see that the price return variables appear to be positive and highly significant for all countries. The negative relationship for the US, UK and EU are in line with the results of Harvey and Siddique (2000) and Cheng, Hong and Stein (2001). Moreover, the finding is in line with the study by Charoenrook and Daouk (2004) who also uncover a significant positive relationship between negative skewness and lagged returns for these countries. This result tends to suggest that markets to have recently experienced high levels of past returns are predicted to have more negative skewness, or all else equal, are more prone to collapse.

The contemporaneous and lagged volume variables on the other hand are only marginally significant for all three countries and in each case, the coefficient is very small. The signs and of the coefficients additionally vary throughout time and across countries. We generally find that the effect appears to be positive on the whole for these countries, however since the marginal level of significance is only ten percent, it is impossible to infer anything concrete from these findings. This result corresponds to that of Cheng, Hong and Stein (2001) who uncover a positive relationship between the volume variable and the incidence of negative skewness. They however, are unable to find any significant effects. It is possible that this difference in the significance could stem from the time horizon adopted in the calculation of the skewness observations, since our estimations with a longer time frame had a far more limited statistical power than those with shorter horizons. Similarly, Charoenrook and Daouk (2004) find weak evidence of trading volume as a predictor of negative skewness.

Our results for the G5 countries are contrary to those uncovered for the CE3. Here we see that negative skewness tends to be most pronounced in stocks that exhibit positive lagged returns. While this finding does not relate to the predictions made by the model adopted in this paper, it is in line with a number of other theories, notably, the stochastic bubble model of Blanchard and Watson (1982) which predicts that negative skewness in returns following a period of a stock price run up.

4.2 Predictability of skewness: panel analysis

In order to shed some further light on the findings uncovered via the individual country estimations, we pool the data together into sub-samples by countries and estimate as series of panel regressions. We use pooled data in order to analyse common relationships across countries since it allows for the identification of country-specific effects that control for missing or unobservable variables. The motivation behind this segregated analysis is such that we wish to shed some light on the significant differences that were uncovered by via the individual country regressions.

Since our estimation includes as one of the regressors the lagged dependent variable SK_{it-j} we estimate a dynamic fixed-effects model taking the following form

$$SK_{it} = \alpha + \sum_{j=1}^{5} \gamma SK_{it-j} + \sum_{j=0}^{5} \chi_{it}^{'} \beta_j + \eta_i + \varepsilon_{it} \tag{4.2}$$

Where η_i is a fixed-effect, χ_{it} is a $((T_1 + T_2 + ... T_k)*K)$ vector of exogenous regressors (the same as those used in equation (4.1)), and $\varepsilon_{it} \approx N(0, \sigma_\varepsilon^2)$.

As before, SK_{it} denotes market return skewness in country i over any 10-day period t, measured using either the SKW_i or the $DUVOLV_i$ approach.

We assume

$$\sigma_\varepsilon^2 \geq 0, \tag{4.3}$$

$$E(\varepsilon_{it}, \varepsilon_{ks}) = 0 \text{ and } i \neq k \text{ or } t \neq s$$
$$E(\eta_i, \varepsilon_{kt}) = 0 \;\; \forall i, k, t$$
$$E(\chi_{it}, \varepsilon_{ks}) = 0 \;\; \forall i, k, t, s$$

Equation (4.2) is estimated, using the least squares dummy variable approach, separately for three sub-groups. We consider a CE3 group; where we include the

Czech Republic, Poland and Hungary, a more mature markets group (G5); which is comprised of the UK, US and the EU and a total sample group with considers all countries together. Our panel specification for the CE3 group additionally includes dummies for both financial and stock market liberalization outlined in Section 3.

Results: panel analysis

Results for the panel analysis are reported in Table 4.4. As for the previous estimations, we report only results obtained under the SKW_{it} estimate of skewness. Between groups, the results vary substantially. Lagged trading volume appears to be a strong predictor of market crashes for the CE3, with four out of the five lags returning highly significant results. The sign of the effect remains positive and constant through time, providing confirmation for the findings obtained under the individual country estimations. This result uncovers further evidence in favour of the theoretical underpinnings of the model adopted in our paper. Essentially, providing support for the notion that periods of heavy trading, proxying the heterogeneity of investor beliefs, does have a significant impact on the distribution of returns in the CE3.

Table 4.4 **Determinants of skewness in market returns: panel analysis**

	0	1	2	3	4	5
Total sample						
SK_i		-0.01 *(0.37)*	-0.08 *(3.03)****	0.14 *(5.76)****	-0.06 *(2.38)****	0.00 *(0.01)*
σ_i	-12.83 *(0.57)*	6.02 *(0.25)*	-11.22 *(0.46)*	0.65 *(0.03)*	-7.14 *(0.29)*	-0.47 *(2.82)***
R_i	28.49 *(2.40)***	-8.82 *(0.31)*	-1.96 *(3.07)****	-19.09 *(1.67)**	-10.12 *(0.35)*	-1.69 *(2.66)***
V_i	0.55 *(1.27)**	0.16 *(2.33)***	0.55 *(3.16)****	-0.17 *(0.36)*	-0.58 *(1.25)*	0.27 *(0.64)*
SDV_i	0.37 *(0.52)*	-0.55 *(1.77)**	-0.18 *(0.26)*	-0.49 *(0.69)*	0.34 *(0.48)*	-0.27 *(0.39)*
SKV_i	$-4.27e^{-11}$ *(0.01)*	$3.32e^{-10}$ *(0.10)*	$6.85e^{-10}$ *(0.20)*	$5.10e^{-10}$ *(0.15)*	$3.48e^{-10}$ *(0.10)*	$-2.03e^{-10}$ *(0.05)*
CE3						
SK_i		0.13 *(3.48)****	-0.03 *(0.76)*	0.18 *(0.46)*	0.09 *(2.24)***	-0.10 *(2.55)****
σ_i	8.51 *(0.63)*	2.21 *(0.16)*	-8.43 *(0.59)*	4.89 *(0.34)*	1.67 *(0.12)*	1.80 *(0.13)*
R_i	28.01 *(1.74)*	6.62 *(0.39)*	13.81 *(0.83)*	7.80 *(0.49)*	-5.02 *(0.32)*	2.59 *(0.16)*
V_i	0.05 *(0.05)*	0.15 *(3.14)****	0.89 *(3.82)****	0.31 *(2.28)***	0.55 *(1.46)*	1.21 *(3.16)****
SDV_i	0.19 *(1.40)**	-0.95 *(2.01)*	-0.12 *(2.26)***	0.18 *(2.31)***	0.53 *(1.11)*	-0.04 *(0.75)*
SKV_i	$-2.11e^{-10}$ *(0.12)*	$3.16e^{-10}$ *(0.17)*	$-1.35e^{-10}$ *(0.07)*	$-7.11e^{-10}$ *(0.04)*	$3.77e^{-10}$ *(0.35)*	$-1.07e^{-10}$ *(0.05)*
G5						
SK_i		0.17 *(0.48)*	-0.09 *(2.53)****	0.17 *(4.72)****	-0.04 *(2.98)****	0.01 *(0.39)*
σ_i	81.74 *(1.24)*	20.07 *(1.99)***	28.58 *(0.38)*	-23.16 *(0.31)*	42.34 *(0.57)*	-3.92 *(0.01)*
R_i	134.72 *(0.52)*	44.26 *(2.12)***	80.53 *(4.21)****	99.47 *(3.71)****	59.42 *(4.16)****	103.99 *(2.56)***
V_i	0.48 *(0.76)*	-0.05 *(0.07)*	0.30 *(0.43)*	-0.83 *(1.22)*	-0.92 *(1.37)**	0.23 *(0.39)*
SDV_i	0.91 *(0.56)*	0.05 *(0.03)*	-0.81 *(0.48)*	-1.62 *(0.97)*	-0.23 *(0.14)*	0.28 *(0.17)*
SKV_i	$-2.83e^{-06}$ *(0.21)*	$4.34e^{-06}$ *(0.32)*	$4.25e^{-08}$ *(0.89)*	$2.43e^{-08}$ *(0.53)*	$5.35e^{-09}$ *(0.11)*	$3.61e^{-09}$ *(0.08)*

Note: Absolute value of the t-statistic is presented in parenthesis. *, **, *** denote significance at the ten, five and one per cent levels respectively.

For the G5 countries on the other hand, we find that market crashes are generally preceded by movements in the price return variables. In particular, lagged price returns, R_i, uncover a consistently highly positive significant result through time, again confirming our individual country findings. Again, this finding tends to support the rendition of stock-price bubbles in existence within the G5 countries. Moreover, this result is in contrast to both the leverage and volatility feedback effects whereby the return distributions of stocks become more negatively skewed after a stock price decline. The 'leverage effect' theory particularly has been shown to have very little quantitative importance in explaining data, particularly high frequency data (Schwert, 1989; Bekaert and Wu, 2000), and while the volatility feedback effect is in some ways more attractive than the leverage-effect theory, its ability to explain data is also questioned (Poterba and Summers, 1986).

Finally, including the total sample in the panel regression, we find that lagged dependent variable dominates as a predictor of market crashes in international market returns. The coefficients for the lagged skewness variables are varied however as the sign for these coefficients changes notably through time. We do however find some evidence in favour of relationships in existence between most of the independent variables and negative skewness of returns. This evidence is rather mixed and insubstantial.

Table 4.5 **Panel estimation summary statistics**

	R^2	MDV	SEE	DW	# OBS
Total sample	0.44	0.43	1.53	1.99	1518
CE3	0.41	-0.13	1.36	2.03	698
G5	0.39	0.49	0.87	1.90	819

Note: MDV, SEE and DW represent mean dependent variable, standard error of the estimation and Durbin-Watson statistic respectively.

4.3 Volume-return relationships explored

Since both the individual and the panel estimations returned some striking results relating to the role of volumes in predicting market crashes, we try to shed some further light on this through and extensive investigation between the types of relationships that exist between all the variables in the model. We therefore estimate a series of Vector Autoregressive models (VARs) enabling us to conduct a *Granger Causality / Box Exogeneity Wald* test to unravel the extent of the relationships that exist between each of the variables in the country vectors below

$$x_t = (SK_{it}, \sigma_{it}, R_{it}, V_{it}, SDV_{it}, SKV_{it}) \tag{4.4}$$

Table 4.6 **Block exogeneity test**

	α	β	δ	ε	ϕ	φ
Czech Republic						
α	14.40 *(0.15)*	1.59 *(0.44)*	0.06 *(0.97)*	0.38 *(0.02)***	0.38 *(0.82)*	2.53 *(0.04)***
β	0.69 *(0.71)*	8.62 *(0.56)*	0.11 *(0.95)*	0.41 *(0.81)*	0.16 *(0.95)*	1.29 *(0.53)*
δ	2.51 *(0.23)*	5.31 *(0.07)**	11.57 *(0.31)*	0.68 *(0.71)*	1.05 *(0.09)**	2.46 *(0.52)*
ε	3.31 *(0.29)*	1.79 *(0.71)*	0.06 *(0.31)*	6.72 *(0.75)*	19.01 *(0.00)****	3.52 *(0.17)*
ϕ	3.09 *(0.21)*	0.72 *(0.69)*	0.59 *(0.74)*	2.89 *(0.25)*	35.55 *(0.00)****	3.34 *(0.18)*
φ	4.92 *(0.28)*	0.69 *(0.73)*	8.13 *(0.31)*	1.23 *(0.57)*	1.69 *(0.43)*	10.51 *(0.39)*
Hungary						
α	5.00 *(0.89)*	5.19 *(0.07)*	2.42 *(0.29)*	5.31 *(0.07)**	2.79 *(0.25)*	5.73 *(0.05)***
β	1.07 *(0.58)*	14.35 *(0.16)*	4.48 *(0.11)*	6.90 *(0.03)***	8.86 *(0.01)***	2.12 *(0.35)*
δ	2.41 *(0.29)*	6.25 *(0.04)***	9.21 *(0.51)*	4.32 *(0.12)*	3.08 *(0.22)*	2.49 *(0.28)*
ε	0.04 *(0.41)*	2.08 *(0.03)*	1.49 *(0.47)*	22.08 *(0.11)*	33.83 *(0.00)****	0.36 *(0.84)*
ϕ	0.20 *(0.90)*	3.45 *(0.00)*	1.01 *(0.60)*	6.12 *(0.04)***	70.67 *(0.00)****	0.40 *(0.82)*
φ	0.46 *(0.79)*	2.90 *(0.23)*	0.54 *(0.56)*	0.09 *(0.96)*	0.37 *(0.82)*	20.31 *(0.02)***
Poland						
α	14.65 *(0.14)*	0.64 *(0.58)*	0.18 *(0.91)*	1.11 *(0.57)*	2.78 *(0.25)*	4.33 *(0.09)**
β	1.59 *(0.75)*	19.77 *(0.03)***	2.29 *(0.32)*	7.91 *(0.01)***	4.86 *(0.28)*	2.64 *(0.26)*
δ	2.49 *(0.29)*	0.18 *(0.91)*	12.42 *(0.25)*	2.01 *(0.35)*	2.35 *(0.31)*	1.92 *(0.38)*
ε	3.63 *(0.63)*	1.38 *(0.07)**	5.05 *(0.26)*	14.83 *(0.14)*	24.06 *(0.00)****	0.79 *(0.68)*
ϕ	0.98 *(0.61)*	0.48 *(0.34)*	1.39 *(0.49)*	7.34 *(0.02)***	57.28 *(0.00)****	0.48 *(0.79)*
φ	3.85 *(0.15)*	0.12 *(0.94)*	1.64 *(0.17)*	3.06 *(0.22)*	1.27 *(0.53)*	10.84 *(0.37)*
US						
α	15.02 *(0.13)*	6.95 *(0.03)***	0.72 *(0.69)*	3.99 *(0.12)*	4.24 *(0.12)*	2.41 *(0.30)*
β	0.01 *(0.99)*	41.13 *(0.00)****	1.21 *(0.54)*	3.87 *(0.14)*	0.78 *(0.67)*	1.04 *(0.59)*
δ	3.96 *(0.14)*	20.42 *(0.00)****	7.43 *(0.68)*	12.63 *(0.00)****	1.13 *(0.00)****	5.28 *(0.07)**
ε	3.52 *(0.17)*	8.07 *(0.02)***	3.26 *(0.19)*	51.95 *(0.00)****	13.68 *(0.00)****	1.43 *(0.48)*
ϕ	4.10 *(0.12)*	0.02 *(0.99)*	1.68 *(0.43)*	18.32 *(0.00)****	68.89 *(0.00)****	0.70 *(0.70)*
φ	3.26 *(0.19)*	0.76 *(0.68)*	0.77 *(0.67)*	8.07 *(0.01)***	0.07 *(0.92)*	7.94 *(0.63)*
UK						
α	6.35 *(0.78)*	3.53 *(0.17)*	0.72 *(0.70)*	0.87 *(0.65)*	0.25 *(0.88)*	0.23 *(0.89)*
β	0.00 *(0.99)*	45.91 *(0.00)****	0.09 *(0.95)*	6.49 *(0.33)*	3.64 *(0.16)*	1.31 *(0.52)*
δ	0.45 *(0.79)*	26.49 *(0.00)****	4.63 *(0.92)*	2.99 *(0.22)*	0.39 *(0.82)*	1.57 *(0.46)*
ε	4.27 *(0.12)*	3.18 *(0.20)*	2.79 *(0.25)*	20.85 *(0.02)***	40.77 *(0.00)****	1.61 *(0.45)*
ϕ	2.75 *(0.25)*	2.20 *(0.33)*	2.57 *(0.07)**	8.02 *(0.01)***	84.80 *(0.00)****	3.13 *(0.21)*
φ	2.78 *(0.25)*	0.77 *(0.68)*	3.36 *(0.19)*	3.95 *(0.14)*	8.99 *(0.01)***	14.32 *(0.15)*
EU						
α	5.89 *(0.82)*	10.54 *(0.00)****	1.21 *(0.55)*	1.53 *(0.46)*	0.19 *(0.91)*	1.12 *(0.57)*
β	0.10 *(0.95)*	60.01 *(0.00)****	0.97 *(0.62)*	5.67 *(0.05)***	3.67 *(0.16)*	0.82 *(0.66)*
δ	0.65 *(0.73)*	45.83 *(0.00)****	9.07 *(0.52)*	1.35 *(0.51)*	0.42 *(0.81)*	1.69 *(0.43)*
ε	0.79 *(0.67)*	1.14 *(0.56)*	1.28 *(0.53)*	53.19 *(0.00)****	30.64 *(0.00)****	16.14 *(0.00)****
ϕ	3.11 *(0.21)*	2.78 *(0.34)*	2.65 *(0.26)*	35.63 *(0.00)****	37.68 *(0.00)****	15.01 *(0.00)****
φ	1.61 *(0.45)*	0.51 *(0.77)*	5.50 *(0.06)**	2.86 *(0.21)*	3.24 *(0.19)*	30.00 *(0.00)****

Note: The table presents the χ^2 statistic for the block exogeneity test. The marginal significance level is presented in brackets. *, ** and *** denote significance at the ten, five and one per cent levels respectively. Variables on the left hand side represent the excluded variables, while the horizontal variables are the dependent variables.

Table 4.7 **Total market volume and return relationships**

The effect of volume on returns
Czech Republic: $V_i \rightarrow SK_i$; $SDV_i \rightarrow R_i$; $SDV_i \rightarrow V_i \rightarrow SK_i$
Hungary: $V_i \rightarrow SK_i ; V_i \rightarrow \sigma_i \rightarrow R_i ; V_i \rightarrow SDV_i \rightarrow \sigma_i \rightarrow R_i ; SDV_i \rightarrow SK_i$
Poland: $V_i \rightarrow \sigma_i ; SDV_i \rightarrow V_i \rightarrow \sigma_i ; SKV_i \rightarrow SK_i$
US: $V_i \rightarrow R_i ; V_i \rightarrow \sigma_i \rightarrow R_i ; V_i \rightarrow SK_i \rightarrow R_i$
UK:
EU: $V_i \rightarrow \sigma_i \rightarrow SK_i ; V_i \rightarrow \sigma_i \rightarrow R_i$
The effect of returns on volume
Czech Republic:
Hungary:
Poland: $\sigma_i \rightarrow V_i \rightarrow SDV_i$
US: $\sigma_i \rightarrow V_i \rightarrow SDV_i ; \sigma_i \rightarrow V_i \rightarrow SKV_i$
UK: $\sigma_i \rightarrow R_i \rightarrow SDV_i \rightarrow V_i ; \sigma_i \rightarrow R_i \rightarrow SDV_i \rightarrow SKV_i$
EU: $\sigma_i \rightarrow R_i \rightarrow SKV_i$

Note: This table provides a summary of Table 4.7 above. SK_i, σ_i and R_i denote skewness, standard deviation and excess returns of price return variables respectively. V_i, SKV_i, SDV_i denote trading volumes, skewness of trading volume and standard deviation of trading volumes respectively.

The results are presented in Table 4.6. Here we present the χ^2 statistic together with the marginal significance level in brackets. Table 4.7 summarizes the findings in Table 4.6, presenting both the direct and the indirect relationships that exist between variables.

Results: the effect of volumes on returns

We first look at the influence of the volume variables on returns. For the Czech Republic and Hungary, the level of trading volume appears to have a direct relationship on the skewness of returns, a finding that is in line with both our single country and our panel regressions. Trading volume further directly impacts on the standard deviation of returns in both the Hungary and Poland. We are further able to infer that trading volume has an effect on price returns through its impact on volatility in Hungary. The standard deviation of volumes directly affects price returns in the Czech Republic, and the skewness of returns in Hungary. Furthermore, volatility of trading volumes indirectly affects the skewness of returns through its affect on trading volumes in the Czech Republic. Moreover, trading volume volatility affects the volatility of return through its impact on trading volumes. Finally, a direct relationship is apparent between the skewness of volumes and the skewness of returns in Poland.

For the US, we find that trading volumes directly affect returns, while in the EU, returns are indirectly affected by trading volumes through its impact on volatility. A further indirect effect is evident between trading volumes and the skewness of returns via price return volatility.

Results: the effect of volumes on returns

Looking at the impact of returns on trading volume, we find that the volatility of returns indirectly affects the standard deviation of volumes via the relationship with trading volumes. No other significant effects are evident for the CE3 countries.

In the US, we find that the volatility of trading volumes is indirectly affected by the volatility of returns via trading volumes. Similarly, the volatility-volume relationship affects the skewness of volumes in the US. In the UK, the volatility of returns has an indirect effect on the standard deviation of trading volumes through its relationship with price returns. Similarly the volatility-price return relationship affects both trading volumes as well as the skewness of trading volumes. In the EU, the volatility of returns affects the skewness of volatility through price returns.

These estimations further allow us to consider the volume-volatility-skewness relationship suggested recently in the literature by Hueng and Brooks (2003) and Charoenrook and Daouk (2004). We find that for four of the six markets, (Poland, Hungary, the US and the UK) volumes lead volatility. Similarly, in four of the six markets, (Poland, the US, the UK, and the EU) we are able to identify effects from volatility to volume. These results are interesting. Kearney and Lynch (2004b) also find evidence of an important relation in existence between volume and volatility operating through the third moment of price returns. At a country level however, their results differ somewhat. They find significant effects of volume leading volatility for the UK and Germany while we find no evidence of this. Furthermore, they find that feedback effects from volatility to volume are significant for the UK, a result our data is unable to confirm.

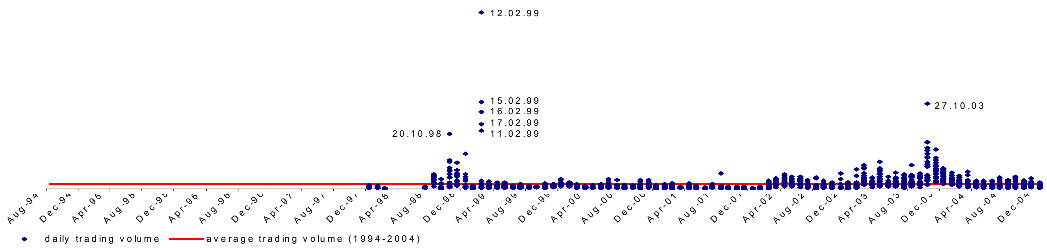
4.4 Further investigation

Results obtained under both the single country and the panel estimations highlight a distinct difference between the role of trading volume in forecasting crashes for the CE3 and G5. These findings were further confirmed via the *Granger Causality / Box Exogeneity Wald* test which explored the direction of causality between the volume-return relationships. While these findings are somewhat unsurprising considering the varying degrees of development and stability between countries during our sample period, it is essential to delve deeper into these results in order to decipher the root of the discrepancy. In essence we wish to understand whether it is in fact an increase in trading volume, or the existence of the heterogeneity of investor beliefs, predicting market crashes, or whether it is some other institutional effect underlying the Central European countries that merely creates an illusion.

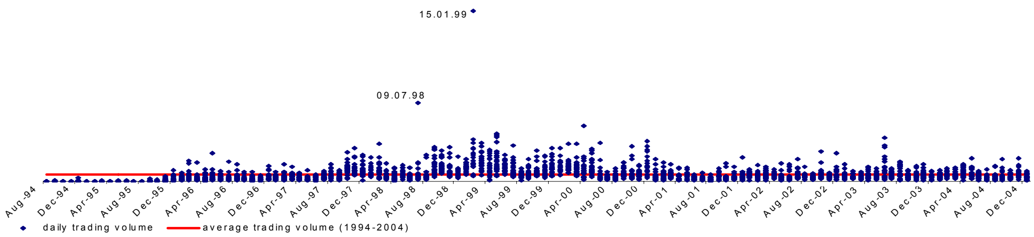
We with simple graphical analysis of daily trading volume for each country as presented in Figure 4.1. The individual country graphs presented depict the number of trades that occurs daily, and additionally includes a measure of average trading volume over the ten year period, illustrated by a bold red line. From the individual country graphs we see that no obvious pattern of trading volume for the CE3, either pre or post transition phase, is evident as we may have expected. Rather, when compared to the G5 we the striking difference is the existence of extreme dates of trading volume relative to trend. For the G5, trading volume is much more consistent through time, with 'extreme' trading volume never drifting far beyond the average.

Figure 4.1 **Daily trading volume**

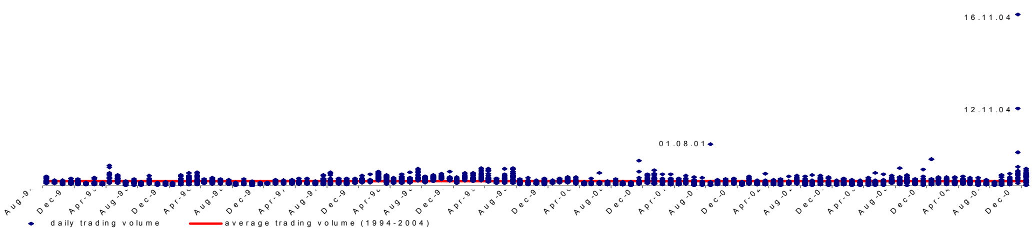
Czech Republic



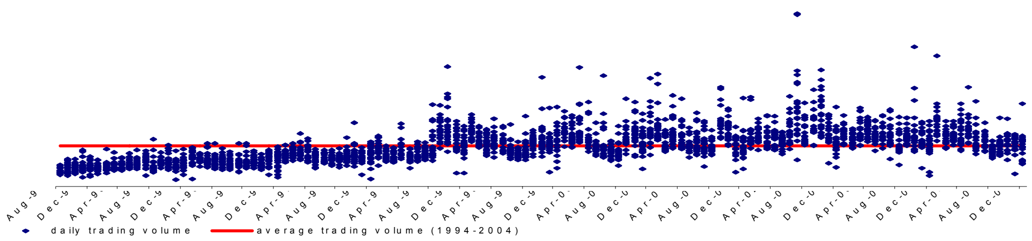
Hungary



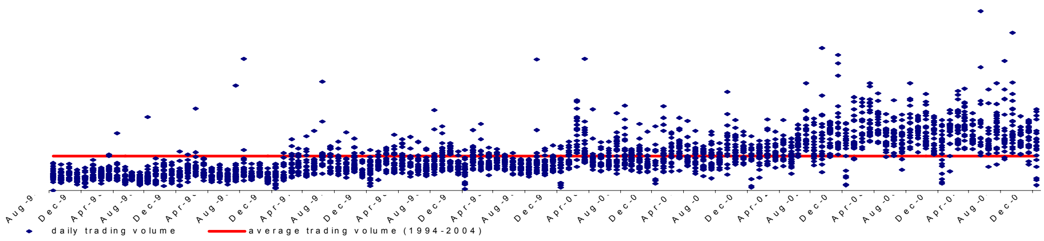
Poland



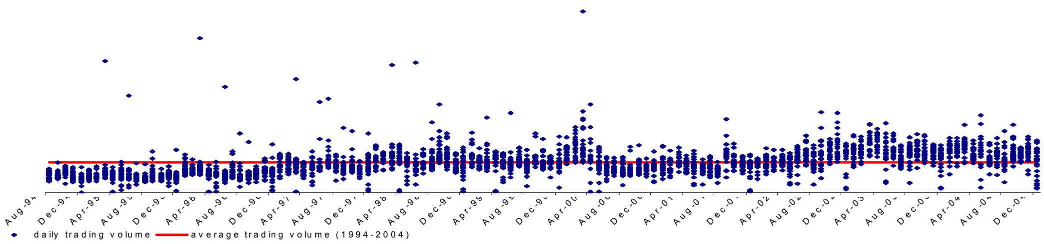
US



UK



EU



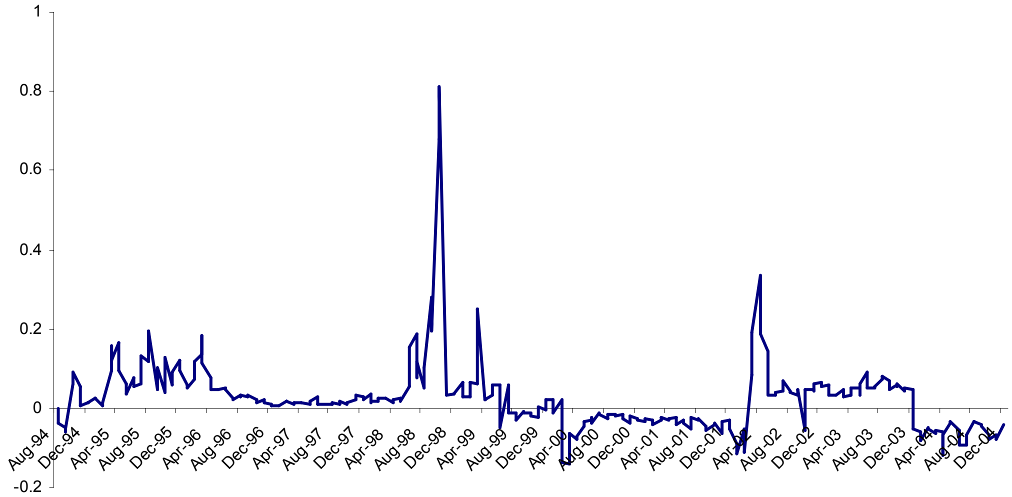
In order to test whether extreme trading volume does in fact drive the volume-skewness effect that our results have returned to date, we allow for the possibility of time-varying coefficients, that is, we estimate a state space model and plot the evolution of these coefficients over time. Essentially the estimation can be presented as follows

$$\begin{aligned} SK_t &= c_t + \alpha_t V_t + \varepsilon_t \\ \alpha_{t+1} &= d + \alpha_t T_t + v_t \\ c_t &= c_{t-1} + \varepsilon_t \end{aligned} \tag{4.5}$$

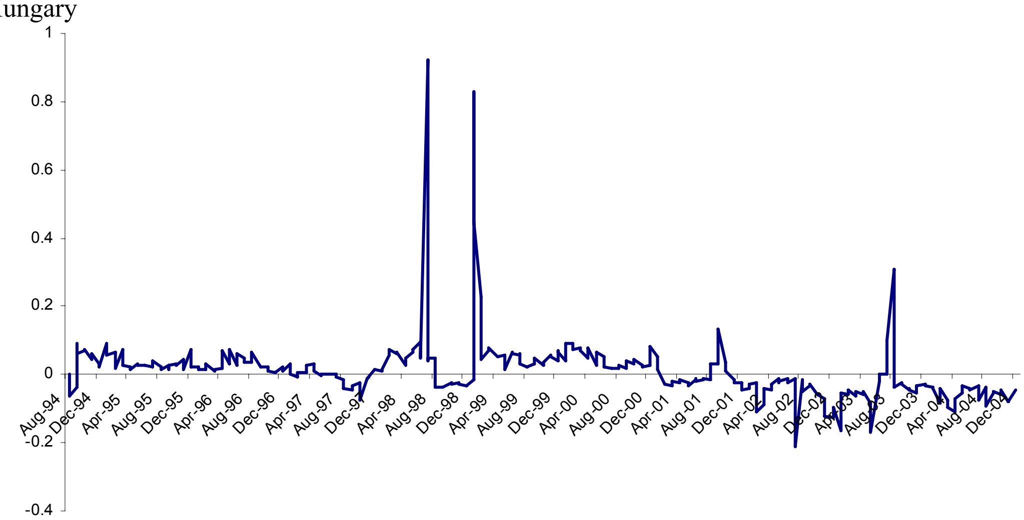
Where α_t is an m*1 vector of possibly unobserved state variables, c_t, V_t, d_t and T_t are conformable vectors and matrices, and where ε_t and v_t are vectors of mean zero, Gaussian disturbances. Note that the unobserved state vector is assumed to move over time as a first-order vector autoregression.

Figure 4.2 **Time-varying effect of lagged trading volume on skewness**

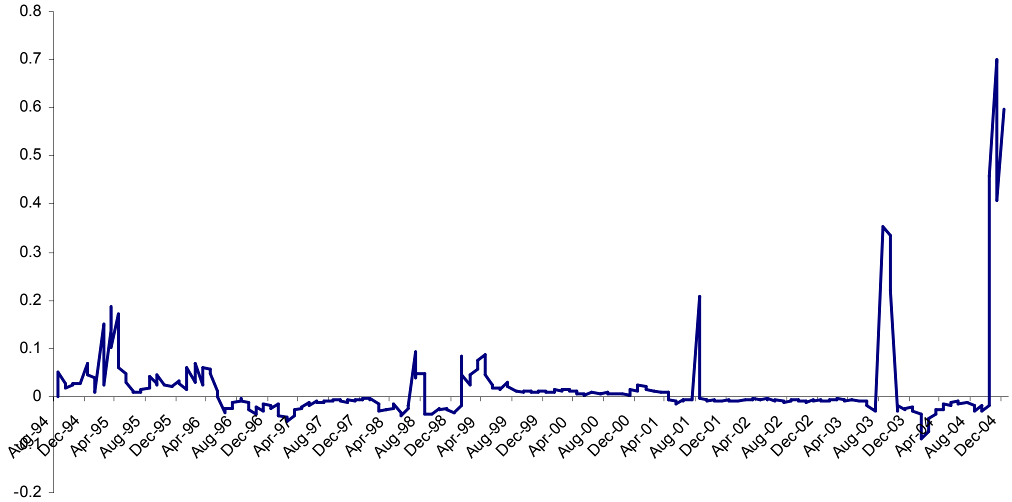
Czech Republic



Hungary



Poland



The results are presented in Figure 4.2. They appear to provide strong evidence in favour of a varying effect of trading volume on market crashes through time. Essentially our findings indicate that lagged trading volume in each of the three CE3 countries predicts negative skewness. Moreover, they highlight that this effect is dominated by only very few extreme periods.

One aspect of our definition of a 'crash' requires that the unusually large movement in stock prices occurs without a correspondingly large public news event. Despite the fact that many authors have shown that large asset price movements are many times very difficult to explain with tangible public information (see Roll 1984, 1988; Cutler, Poterba and Summers, 1989), we try to determine whether any of the extreme trading days are attributable to the release of information, or the occurrence of a significant event. We start by considering only the 10 largest incidence of negative skewness in each country and identify the time period during which it took place. Furthermore, making use of *Lexis Nexis* news databank we investigate whether any significant macro news was released during that 10-day period. This information is presented in Table 4.8.

Interestingly, we find that when we compare the dates of extreme trading volume (from Figure 4.1) to those of extreme negative skewness (presented in Table 4.8), for each country there is at least one occasion where we are able to detect a direct lagged relationship between the two variables. Considering the case of the Czech Republic, as seen in Figure 4.1, the largest incidence of negative skewness (March 1999) could possibly correspond to a significant spike in trading volume that took place in February 1999. A comparable spike in trading volume is evident in October 1998 and October 2003 with an occasion of extreme negative skewness apparent in November of each of those years respectively. A similar pattern of behaviour is observed for Poland and Hungary with the possibly related dates highlighted in red in Table 4.8. From this simple analysis, it appears that negative macro news, released on the date extreme negative skewness, could be anticipated in the days preceding. Further analysis into this relationship is however hindered by the necessity to aggregate data into 10-day periods for the calculation of a measure of negative skewness. Research in this field would therefore benefit from the estimation of a probabilistic model allowing for the daily analysis of changes in the incidence of negative skewness. A daily measure of negative skewness would allow for an in depth analysis of the extent to which a macro news-trading volume relationship affects the predictability of market crashes.

Table 4.8 **Negative skewness and new releases**

	DATE	SKEW	ANNOUNCEMENT #	*Date*	*Corresponding LexisNexis event*
CZ					
1	12.03.99	-17.49	**5**	**12.03.99**	**unemployment increases**
				11.03.99	**interest rates rise**
				10.03.99	**privatization of large banks postponed by one year**
				10.03.99	**current account deficit increases**
				08.03.99	**consumer price index falls**
2	05.11.98	-0.65	**1**	**23.10.98**	**Moody's lowers banks' ratings**
3	16.10.03	-0.61	2	06.10.03	current account deficit increases
				07.10.03	unemployment increases
4	13.11.03	-0.28	**2**	**10.11.03**	**consumer price index rises**
				12.11.03	**current account deficit falls**
5	20.03.03	-0.16	2	17.03.03	Czech Republics government debt grows
				20.03.03	GDP figures show a decline in growth
6	07.06.96	-0.12	2	07.06.96	unemployment decreases
				10.06.96	consumer price index increases
7	21.02.02	-0.10	1	08.02.02	unemployment figures rise
8	13.05.94	-0.09	2	08.08.01	unemployment figures rise
				09.08.01	Nomura sues Czech state for kc40bn compensation for IPB
9	27.03.96	-0.08	2	20.03.96	GDP figures show signs of economic growth
				26.03.96	improvement in the terms of trade
10	30.12.96	-0.08	3	22.11.96	current account deficit increases
				25.11.96	unemployment increases
HU					
1	11.02.99	-11.26	**2**	**02.02.99**	**unemployment figures rise**
				11.02.99	**consumer price index rises**
2	14.01.99	-8.32	1	06.01.99	unemployment figures rise
3	01.08.99	-1.93	2	04.08.99	unemployment increases
				11.08.99	consumer price index rises
4	20.02.00	-1.45	3	10.02.00	unemployment figures rise
				11.02.00	consumer price index rises
				18.02.00	short term interest rates rise
5	19.08.94	-1.45	0		
6	14.04.03	-1.42	2	10.04.03	EU announces EU13million in funding for candidate countries
				11.04.03	consumer price index rises
7	15.12.97	-1.36	1	11.12.97	consumer price index rises
8	23.10.03	-1.14	1	14.10.03	consumer price index rises
9	30.05.96	-0.89	1	30.05.96	consumer price index rises
10	26.06.03	-0.74	1	24.06.03	Latest macro reports suggest fragile signs of recovery

	DATE	SKEW	ANNOUNCEMENT #	Date	Corresponding LexisNexis event
PL					
1	08.09.00	-29.61	2	08.09.00	increase in the consumer price index
				08.09.00	improvement in the terms of trade
2	28.07.00	-19.94	2	25.07.00	unemployment decreases
				01.08.00	current account deficit increases
3	16.11.04	-15.14	**2**	**16.11.04**	**consumer price index rises**
				16.11.04	**unemployment decreases**
4	16.08.01	-14.96	**1**	**13.08.01**	**consumer price index falls**
5	02.06.00	-14.57	1	02.06.00	current account deficit decreases
6	19.03.04	-14.44	1	23.03.04	GDP figures show signs of economic growth
7	05.05.99	-14.24	1	05.05.99	current account deficit increases
8	20.11.03	-11.66	0		
9	13.05.02	-11.58	1	08.05.02	Nordea Banking Group to Take Over LG Petro Bank
10	04.04.02	-11.01	1	04.04.02	DZ Bank Takeover Bid for AmerBank

5 Comments and conclusions

Motivated by the difference of opinion theory outlined by Hong and Stein (2003), this paper conducts an empirical investigation addressing the question of why stock markets may be vulnerable to crashes. In particular, considering aggregate market returns of six countries; the Czech Republic, Hungary, Poland, the US, UK and EU we analyse whether differences exist between countries that have been in transition during much of the sample period when compared to more mature markets.

Adopting two different measures of skewness for our analysis, we estimate a series of single country regression equations. Our findings tend to indicate that for all countries in the sample, market crashes *are* predictable. Moreover, relating to the role that trading volume takes on in this predictability, our results uncover some distinct differences between countries. For the CE3, our estimations provide evidence in favour of the investor heterogeneity theory whereby market crashes appear more likely in countries to have recently experienced an increase in trading volume relative to the trend. This finding is in line with the theoretical predictions of the model motivating the empirical estimations in this paper. For the G5 however, we determine that market crashes appears most prominent after a period of increased prices and returns. A finding that is more in line with traditional representative investor theories, in particular the stochastic bubble model put forward by Blanchard and Watson (1982). While these findings are broadly in line with the literature in this field, their comparability is restricted. Due to restricted statistical power, these studies have focussed on analysing individual stocks rather than aggregate market returns. Experimenting with different time-horizons for calculating skewness, our study finds that the length of the horizon does affect the statistical power of results. Literature in this field may therefore benefit from more research into the optimal time-horizon for calculating skewness observations.

Estimating a set of panel equations, we are able to confirm that volume variables appear significantly more important for forecasting crashes in the CE3, while in lagged skewness appears to be the driving force in the G5 markets. We further explore the relationships between all volume and return variables by conducting a *Granger Causalit / Box Exogeneity Wald* test. The results provide further confirmation of our previous results.

Allowing for time-varying effects we delve deeper into these findings. Graphical analysis of our findings show that lagged trading volume in each of the CE3 countries seems to predict market crashes. Moreover it shows that the results obtained under the single country and panel estimations are dominated by only very few extreme periods. We assess whether these incidents of extreme trading volume are attributable to the release of macro news, and while we find that a relationship does appear to exist, further investigation is hindered by the necessity to aggregate data into 10-day periods for the calculation of a measure of negative skewness. This field of study would therefore benefit greatly from the development of a probabilistic model for estimating daily skewness observations. A high frequency measure of negative skewness would allow for a deeper analysis into the extent to which macro news releases affect trading volume and subsequently the predictability of market crashes.

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