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A spillover analysis of shocks from US, UK and China on African financial markets☆

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Abstract

Emerging African financial markets have been recently put forward as an interesting and profitable alternative to diversify risk for international investors. At the same time, they became more integrated with developed financial markets, so that, despite claims that Africa would be sheltered by outside shocks because at the margin of the globalization process, they have been hit by the 2008–09 crisis. This paper analyses the relationships among mature financial markets (US and UK), China, some South Saharan African emerging markets (Botswana, Kenya, Nigeria and South Africa) and two North African countries (Egypt and Tunisia) over the period 2005–2012, focusing on the role of financial markets' volatility. We study, with the help of a Multiplicative Error fully inter-dependent model (MEM), the dynamics of the financial market volatility (risk), and the interactions with other markets. We present impulse-response functions with a time dependent profile to describe how a volatility shock from one market may propagate to other markets, increasing the fragility of African infant financial markets. Finally, we summarise the role of different markets in propagating risk in the area using a synthetic index (Volatility Spillover Balance) that distinguishes between volatility "creators" and "absorbers". Our results show that South Africa and US shocks significantly affect African financial markets, and China has recently become more interconnected. Furthermore, while US, Kenya and Tunisia are "net creators" of volatility spillovers, South Africa and China turn out to be net "absorbers".

Keywords: Financial markets volatility; Multiplicative Error Models (MEM); Impulse-response functions; African financial markets

1. Introduction

In recent decades, international financial markets have been characterised by increasing degrees of integration. However, Sub Saharan Africa has been lagging behind. Its financial markets have been considered fairly independent, so that, just before the start of the subprime crisis, *The Economist* characterised Africa as the final frontier of globalisation for international investors (29/7/07), suggesting to "Buy Africa"' (19/2/2008) to diversify their risk. Indeed, before the global financial meltdown, African financial markets had experienced a large expansion in a very short time. The number of operating stock exchanges in Africa rose from just eight in 1989, to 23 in 2007, reaching a total market capitalisation of over $2.1 billion. While small size and low liquidity remain an aspect to be further investigated, during the last few years, many African markets offered very large returns to investors. There has been at least one African stock market in the top 10 best-performing markets in the world every year since 1995. In 2004, for example, six African countries (Ghana, Uganda, Kenya, Egypt, Mauritius and Nigeria) were among the world's 10 best-performing stock markets, while in 2005, Egypt, Uganda and Zambia were in the top five. The global financial crisis has nevertheless reached Africa, hitting some of the drivers of African countries' development. In 2008, foreign direct investment (FDI) and portfolio equity flows slowed dramatically. The Nigeria stock exchange, for example, fell by 46%, becoming the world's worst performing market.

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This paper contributes to the scarce literature on the effects of the crises on African markets by investigating the relationships among volatility in some mature and emerging financial markets, such as US UK and China, and volatility in Sub-Saharan Africa (Botswana, Kenya, Nigeria and South Africa) and North Africa (Egypt and Tunisia), over the period 2005–2012. Our aim is to test whether, and in case how, the financial turmoil originated in the US in 2008 spilled over into the African market. To this task, we use a volatility model (Multiplicative Error Model; Engle, 2002) that allows us to estimate and forecast the interactions and spillover effects among several markets with a fully interconnected model. Then, we use a graphical representation of the spillover effects and report impulse response functions (Engle et al., 2012).[1]

The paper is structured as follows. Section 2 briefly surveys the literature, both theoretical and empirical, on financial markets recent developments with a special focus on the few African markets. Section 3 describes the African markets during the expansion and the recent turmoil. Section 4 introduces the model, and Section 5 discusses the results. Section 6 concludes.

2. A brief literature review

Equity market integration plays a crucial role in development. Finance theory suggests that an integrated stock market is more efficient than segmented national capital markets. Asset-pricing models also predict that integrated markets tend to respond more to global events than to local factors, although the reverse might also happen (Errunza and Losq, 1985). Evidence shows that, by dismantling investment restrictions, integration allows for international risk sharing, which can affect long-term economic growth by altering resource allocation and savings rates (Obstfeld, 1995; Bracker et al., 1999). Bekeart (1995) and Kim and Singal (2000) argue that a higher degree of market segmentation increases the level of risk, and this inevitably affects the local cost of capital, with ramifications for company financing and, in the long run, economic growth.

Capital markets in Sub-Saharan Africa were highly regulated in the past. Recently several countries have however undergone financial sector reforms, relaxed control on Foreign Direct Investments and portfolio flows and liberalised capital accounts (Irving, 2005). Several recent studies focus on the repercussions of financial crises on developed and underdeveloped world (Beck et al., 2011; Kasekende et al., 2009; Macias and Massa, 2009). Well before the financial and economic crisis of 2008–2009, the world economy had experienced global downturn during which developing countries have been hurt. After decades of high growth, developing Asia was badly hit by the 1997–1998 crisis. Active policies and effective governments combined with openness to foreign trade and substantial investments in technology helped Asian countries to successfully overcome the crisis. Latin Americas countries in 80s and Argentina in 2000 as well as Russia have gone through deep crises that altered their path to growth. But, unlike financial crises such as the Latin American debt crises of the 1980s and the Asian financial crisis of 1997–1998, the global crisis of 2008–2009 originated in the advanced economies. As a result, the global crisis hit the advanced economies first and harder than the developing countries. The first wave of the crisis originated in the US subprime mortgage market (2008) and spread to Europe due to the heavy exposure of European banks to US subprime assets, with effects and transmission mechanisms not yet understood, especially on developing countries. The second wave hit just a few years after (2011) and directly affected the Eurozone sovereign debt. The crisis is rooted in the uneven growth performance of the Euro countries, the unsustainable large public debts of some EU countries, and the European banks' exposure to such debt. From the viewpoint of developing countries, both crises represent major external shocks from advanced economies. The magnitude of the global crisis poses the question of the potential effect of this twin crisis on developing countries.

Only recently, the empirical literature on financial integration[2] started analyzing the potential effects on developing countries, whether there are areas more exposed to risk and whether/how the risk is spread out from mature to developing markets (Ncube, 2012; Allen and Giovannetti, 2009; Overseas Development Institute, 2009). To study these potential effects required an adaptation of the literature on volatility transmission and contagion (Forbes and Rigobon, 2002; Ehrmann et al., 2011). Aizenman et al. (2012), for instance, estimate the responsiveness of equity and bond markets in developing countries (Emerging Asia, Latin America, Eastern Europe, Middle East and Africa) to global crisis news and euro crisis news. They apply the event study methodology to test for financial contagion from the EU to developing countries, finding that whereas "global crisis news" had a consistently negative effect on returns of equity and bond markets in developing countries, the effect of euro crisis news was more mixed and limited. Neaime (2012), on the other hand, focuses on the financial linkages between Middle East and North Africa region (MENA countries) and the US and EU, analyzing also the intra-regional financial linkages between the oil and non-oil producing MENA financial markets. Neaime uses GARCH-family models, the T-ARCH, ARCH-M models, and VAR analysis to model conditional volatilities in these stock markets. Agyei-Ampomah (2011) examines the linkages among African stock markets (10 African countries over the period 1998–2007), decomposing the volatility of the domestic stock market index into three components: the contribution of the regional index, the contribution of the global and that of the unsystematic component. Their results show that African stock markets are segmented and separated from global

[1] In this paper, we aim at focusing on the risk associated with financial markets, modelling the dynamics of the expected volatility of one market (the risk associated to that market), including in this model the interactions with the past volatility from other markets (risk transmission effects from other markets). Based on the model' results, we draw impulse-response functions that allow us to describe how a shock in one market propagates, if at all, to other markets, and how long the effect is expected to last.

[2] For an extended discussion on financial integration and shocks transmission, see Bekaert et al. (2005).

markets despite recent structural adjustments; furthermore, the local index volatility is largely country-specific.

3. A short description of African financial markets

The US and European' crisis and credit downgrade have caused a significant increase of stock markets' volatility across the world, the effects of which are difficult to be fully understood. After a long period in which African stock markets have been perceived as the last secure investment to diversify the risk of international investors, they have been hit by the crisis and now are not "out of danger" (Yartey, 2008). For instance, due to their higher level of integration with the global economy, some of the most interesting emerging financial markets in Africa (South Africa, Nigeria and Egypt) saw their stock markets plunging by 6.9%, 5.5% and 10.6%, respectively, in the first three days of trading following the US credit downgrade. During the 2008/2009 crises stock markets in Nigeria, Egypt and South Africa plunged more than 50%, showing the sensitivity of African stock markets to external shocks. Many other markets in Africa witnessed a sharp reversal in portfolio flows during the financial crisis when portfolio investment to Africa fell from USD 6.9 billion in 2007 to negative USD 6.2 billion in 2008. These shocks may have particularly depressing effects for some African countries, such as South Africa, relying on financial inflows in order to finance their current account deficits (African Development Bank, 2011). Still focusing on the increased risk for African markets associated to the recent crisis, we may mention the fact that since the beginning of August 2011, foreign investors have sold as much as 5.9 billion of South African stocks. Bonds for a value of 4.7 billion were bought during the same period but at higher risk premium, showing the real and risky effects of the crisis on these emerging and fragile markets. Volatile market conditions generate unstable movements in currency market increasing the risk premium for investors. For example, the risk premium on South Africa's four-year bonds has increased to 6.13% points from 5.11% points on 5 January 2011.

Tables 1 and 2 present some descriptive evidence for African emerging financial markets characterised by, on average, a low number of listed companies, tiny volume and value traded. However, there was a significant improvement between 2000 and 2009 (and according to anedoctical evidence also beyond 2009): most countries for which data are available experienced a financial deepening with an increase of ratios of volumes traded, number of companies listed and capitalization,; for instance, Ghana and Nigeria experienced a large boom in 2011 (+120%, respectively, 30% in market capitalisation as a percentage of their GDP), but other markets were also expanding (see also Beck et al., 2011).

Using data from DATASTREAM, for selected SSA and North-African countries, as well as for UK, US and China in the period 2005–2012, we focussed on the performance of their financial markets. In Tables 3 and 4, returns and absolute returns (our volatility proxy) are reported for the period in question (1 January 2005–10 May 2012). Figs. 1 and 2 show the behaviour of our six markets over the same period stressing the effect of the boom and the recent crisis. Data show the standard characteristics of financial time series: not Normally distributed returns with zero mean, asymmetry and high kurtosis. Prices non stationarity is summarised in Fig. 1 while evidence of fat tails, leptocurtosis and, thus, volatility clustering can be seen in Fig. 2 for squared returns. This simply means that investing in these markets gives a higher probability of either positive or negative returns than expected under the assumption of Normality. Also, volatility clustering reminds us to the fact that high volatility periods follow low volatility periods for all markets, implying different levels of risk for investors. This characteristic is especially relevant during crisis because it points at increasing risk for investors in African markets (notice the peaks in volatility in Fig. 2, corresponding to the 2008 first wave of crisis that affected almost all markets).

4. The model

The following analysis focuses on the volatility of some SSA and Mediterranean financial markets and their relationships to mature markets and China to identify the possible volatility links and their directions. To this aim, we model the volatility of market i using its own past values and positive and negative news from other markets (Engle et al., 2012; Cipollini et al., 2009). From model estimation on the whole sample, we derive that SSA markets are interdependent and also depend on more financially developed markets to varying degrees. The detected relationships show how African countries, contrary to some views, are not independent from the global turmoil and help us to highlight the financial channels of transmission in Africa.

ME Models are a generalisation of GARCH-type models estimated on non-negative valued processes (Engle, 2002); the model we use in this paper is based upon Engle et al. (2012).

Conditional on the information set I_{t-1}, the Multiplicative Error Model for market i is:

$$sr_{i,t}|I_{t-1} = \mu_{i,t}\varepsilon_{i,t},$$

$$\varepsilon_{i,t}|I_{t-1} : Gamma(\phi_i, 1/\phi_i)$$

Given the unit expectation of the innovation term, $\mu_{i,t}$ is the conditional expectation of $sr_{i,t}$, where $sr_{i,t}$ is a volatility proxy (range, squared returns, absolute returns, etc.). Its simplest specification is a base MEM(1,1):

$$\mu_{i,t} = \omega_i + \beta_i\mu_{i,t-1} + \alpha_{i,i}sr_{i,t-1}. \quad (1)$$

This base specification can include other terms, like cross links from other markets, volumes or characteristics of a specific market as well as country's specific holidays or calendar anomalies, if present. The possibility of introducing theoretically an infinite number of variables and information, gives a very flexible model that easily include asymmetries and shocks coming from other markets.

In this paper, we proxy volatility ($sr_{i,t}$) using the squared returns and include in the ME models:

Table 1
Financial indicators for selected African financial markets (2011).

Exchanges	Value traded US$	Volume traded	Market cap US$	Turnover ratio (%)	# of listed companies	Market cap as % of GDP
Botswana SE	193,450,500	667,891,882	58,888,770,000	3.300	37	25.050
Bourse de Tunis	1,130,428,000	254,869,295	9,641,350,000	12.000	57	21.140
BRVM	150,713,600	19,799,503	7,670,831,000	0.000	67	0.000
Dar Es Salaam SE	32,854,400	133,403,198	7,389,640,000	0.440	17	30.200
Ghana SE	269,010,000	252,870,000	28,522,430,000	0.010	34	120.370
JSE Ltd.	407,370,000,000	71,463,833,873	856,242,000,000	0.000	406	0.000
Lusaka SE	149,102,000	1,148,269,144	9,409,000,000	1.590	21	63.540
Nairobi SE	6,268,647,000	5,721,831,529	10,000,000,000	8.870	58	34.480
Namibian SE	560,735,700	344,765,582	137,857,900,000	0.000	32	0.000
Nigerian SE	4,181,930,000	89,576,608,901	67,681,100,000	8.360	198	30.280
Randa SE	35,274,460	118,134,400	1,589,300,000	2.200	4	26.000
Mauritius SE	559,140,500	347,394,601	7,681,570,000	7.280	87	70.900
Uganda SE	16,372,900	46,139,325	4,031,000,000	0.410	14	30.160
Zimbabwe SE	477,524,000	4,610,008,413	3,690,000,000	12.950	77	45.670

Source: Data for Year 2011. From African Securities Exchanges Association (www.africansea.org/).

Table 2
Financial indicators for selected markets.

Country	Year	Financial system deposits/GDP	Stock market capitalization/GDP	Stock market turnover ratio	No. of listed companies per 10k of population	Remittance inflows/GDP	Stock market total value traded/GDP
Botswana	2009	0.573	0.876	0.019	0.093	0.009	0.020
Botswana	2000	0.239	0.165	0.048	0.093	0.004	0.008
China	2009				0.013	0.006	
China	2000		0.381	1.242	0.009	0.005	0.602
Egypt, Arab Rep.	2009	0.755	1.140	0.223	0.028	0.039	0.366
Egypt, Arab Rep.	2000	0.611	0.311	0.387	0.162	0.029	0.111
Ghana	2009		0.171		0.013	0.004	
Ghana	2000	0.143	0.144	0.020	0.011	0.006	0.002
Kenya	2009	0.296	0.496	0.069	0.013	0.034	0.026
Kenya	2000	0.318	0.108	0.037	0.018	0.043	0.004
Nigeria	2009	0.253			0.015	0.016	
Nigeria	2000	0.126	0.078	0.062	0.016	0.030	0.006
South Africa	2009	0.672	3.382	0.705	0.099	0.001	2.592
South Africa	2000	0.501	1.774	0.378	0.140	0.003	0.583
Tunisia	2009	0.532	0.196	0.133	0.052	0.045	0.024
Tunisia	2000	0.465	0.143	0.221	0.046	0.041	0.032
United Kingdom	2009	1.634	1.322		0.325	0.003	
United Kingdom	2000	0.989	1.924	0.712	0.323	0.003	1.272
United States	2009	0.821	1.523	3.509	0.167	0.000	4.841
United States	2000	0.637	1.637	2.110	0.267	0.000	3.263

Source: Data for Years 2009 and 2000. From Financial Development and Structure Database (World Bank, http://econ.worldbank.org/programes/finance).

Table 3
Descriptive statistics for returns in selected markets (1 January 2005–10 May 2012).

	Botswana	China	Egypt	Ghana	Kenya	Nigeria	SouthAfrica	Tunisia	UK	US
Mean	0.045	0.034	0.037	−0.002	0.010	−0.003	0.051	0.070	0.009	0.006
Median	0.000	0.011	0.000	0.001	0.000	0.000	0.053	0.034	0.010	0.054
Max	5.506	9.034	6.930	6.403	6.948	3.843	6.834	4.109	8.811	10.957
Min	−4.775	−9.256	−11.117	−8.754	−5.234	−4.747	−7.581	−5.004	−8.710	−9.470
Std. Dev.	0.502	1.772	1.800	0.779	0.911	1.025	1.371	0.603	1.282	1.409
Skewness	1.543	−0.336	−0.637	−0.937	0.415	−0.011	−0.181	−0.611	−0.192	−0.298
Kurtosis	35.195	6.393	6.617	26.601	11.127	5.336	6.404	14.973	10.116	12.727

Source: Authors' elaboration on data extracted from Data Stream.

Table 4
Descriptive Statistics for absolute returns in selected markets (1 January 2005–10 May, 2012).

	Botswana	China	Egypt	Ghana	Kenya	Nigeria	South Africa	Tunisia	UK	US
Mean	0.254	3.14	3.238	0.606	0.829	1.05	1.881	0.368	1.643	1.985
Median	0.008	0.715	0.802	0.005	0.154	0.217	0.525	0.063	0.338	0.294
Max	30.312	85.675	123.587	76.633	48.27	22.537	57.467	25.037	77.629	120.06
Min	0	0	0	0	0	0	0	0	0	0
Std. dev.	1.486	7.274	7.64	3.067	2.642	2.188	4.36	1.347	4.959	6.797
Skewness	13.19	5.65	6.387	13.114	9.105	4.078	6.08	9.444	8.829	9.587
Kurtosis	214.292	45.936	64.655	249.21	116.6	25.439	53.88	118.452	106.20	125.30

Source: Authors' elaboration on data extracted from Data Stream.

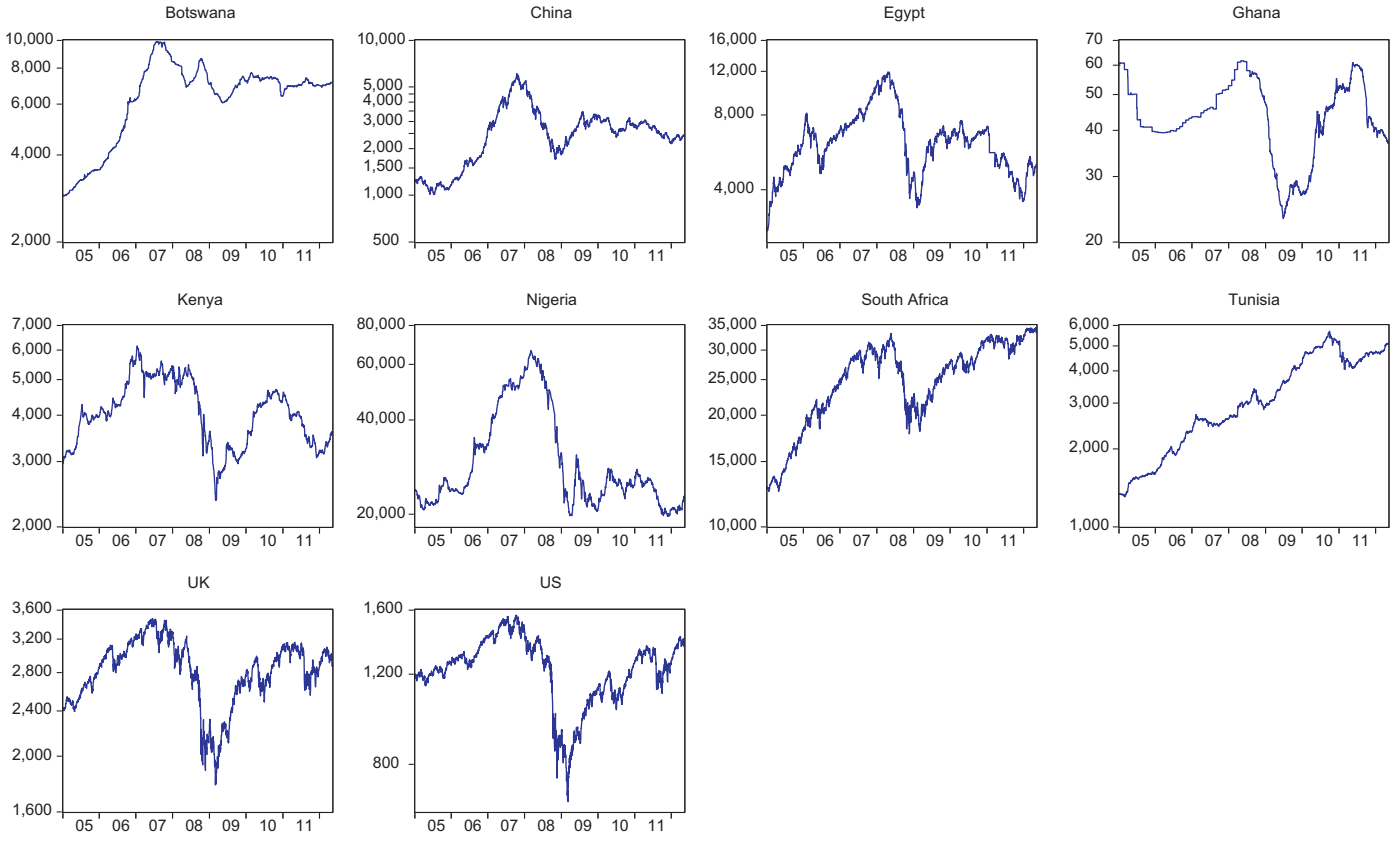

Fig. 1. Stock indices – January 2005–May 2012 – (log-scale).
Source: authors' elaboration on data extracted from Data Stream.

1) the lagged daily squared returns observed in other markets to link together different markets $sr_{j,t-1}, j \neq i$ (j represents developed markets: NYSE, FTSE and Shangai market);
2) asymmetric effects in which the impact from own lagged volatility is split into two terms according to whether the lagged market returns ($r_{i,t-1}$) are negative and, respectively, positive (corresponding to dummy variables, respectively).

The estimated models at previous step are then used to analyse volatility shock propagation in what could be seen as a scenario analysis (Engle et al., 2012). For each market, we use impulse response functions to describe how a shock in one market (an one-standard-deviation shock) may propagate to others. We report a graphical representation in which time (days since the shock hit the market) is on the horizontal axis and the volatility response (relative difference between a baseline and the response after the shock) is on the vertical axis.[3] When a shock hits market i, the graph shows the market volatility responses to the shock originating in that market; on average, the response of market i at time 0 to a shock in its own market will be higher than other markets' response, given the volatility persistence in the market. The graph shows the dynamic reactions (volatility spillovers) of markets to single positive or negative shocks that may hit market i in a given day. Hence, the profiles turn out to be time dependent and may change as the

[3] For a detailed discussion on the impulse response functions developed in this context, see Engle et al. (2012).

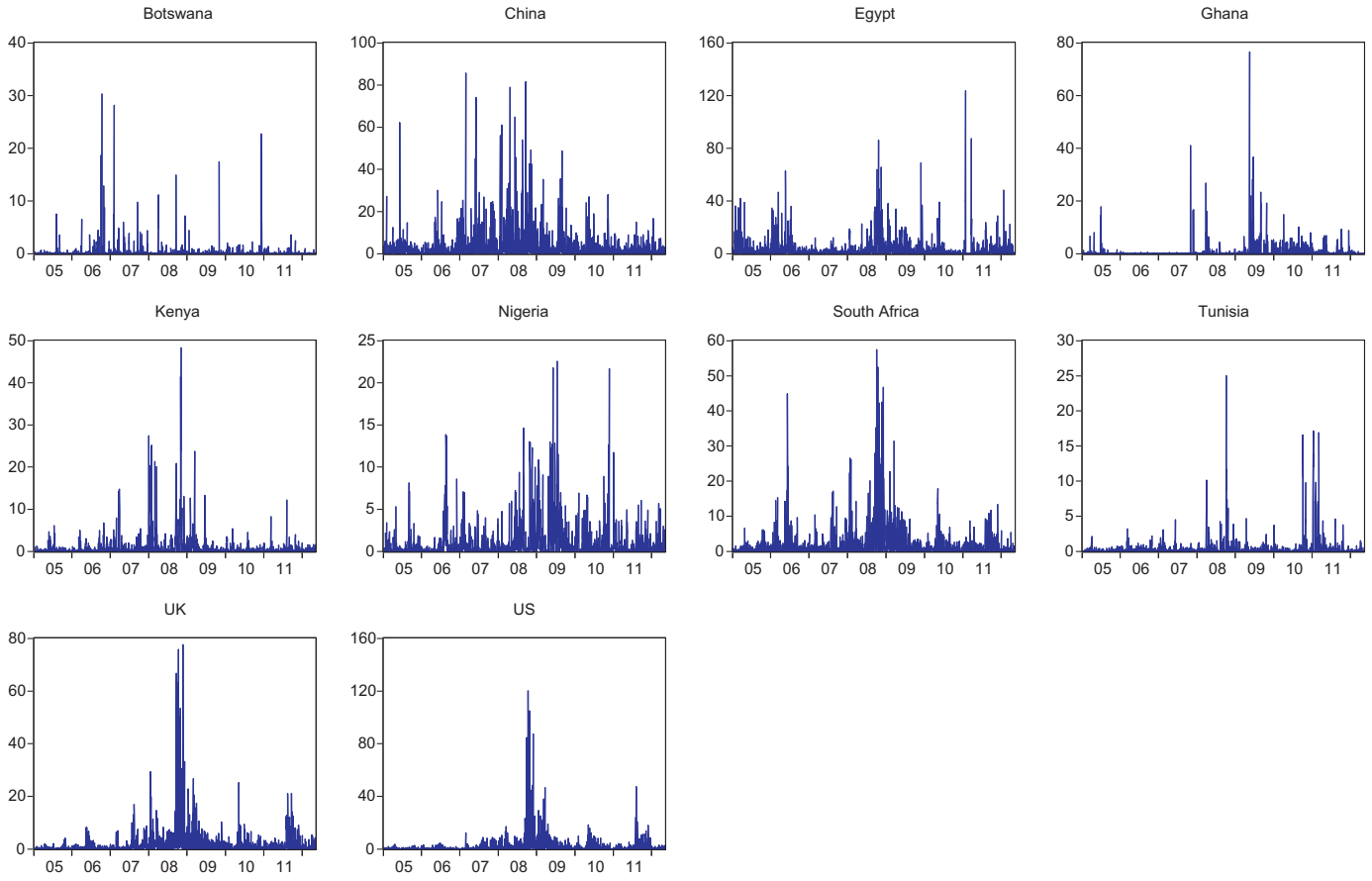

Fig. 2. Squared returns – 1 January 2005, 10 May 2012.
Source: authors' elaboration on data extracted from Data Stream.

originating market (the market which is shocked) and time (different shocks) vary.

5. Volatility spillovers in selected African financial markets

In this section we present and discuss the main results of the estimated models according to the specification presented in the previous section. Table 5 summarises the estimates from models fully reported in Table A1.[4] It shows the overall (significant/non significant) cross average effects of financial markets included in the analysis; in particular, for each market in row the average effect of other markets (in column) can be read. Note that the South African market is the most affected, since all markets, but the Nigerian, enter directly its specification and significantly affect its volatility. As expected, each market depends mostly on its own performance (see the magnitude and significance level on the main diagonal). On average, the role of western financial markets, when significant, is very strong.[5] This means that there's a large channel of transmission of any shock from UK and US to South Saharan African markets which will quickly react with amplified volatility. From the table, we can see that there are negatively interconnected markets like Ghana and Egypt or China and South Africa and Tunisia (significant links but small magnitudes). This means that these markets mitigate the volatility of markets they enter. For instance, any shock in China (either positive or negative) on average tends to reduce the volatility in South African or Tunisian market. This may due to the Chinese investments in natural resources and row materials of the area.

Comparing these results to a previous similar analysis run on a smaller set of countries until 2009 (Giovannetti and Velucchi, 2011), we notice that the role of western markets (US and UK) has increased while China confirms its leading role in Africa. In particular, these results show that China and US are strongly interconnected to African markets while UK shows lower links to these emerging markets. Chinese financial market volatility, in particular, depends on several African markets (Egypt, Ghana, Kenya and South Africa), confirming that its investments have, as a consequence, also a reverted effect in terms of volatility

[4] Appendix A reports the estimates of the fully inter-dependent MEMs on three SSA financial markets (Kenya, Nigeria, South Africa), two North African countries (Egypt and Tunisia), China and two mature western financial markets (UK, US) for the whole period (1 January 2005–10 May 2012). We separate positive and negative shocks, since they are likely to spread out differently.

[5] The effect of UK and US volatility performance on the South African performance is respectively 0.1017 and 0.1787.

Table 5
Estimated cross country effects (based on estimated coefficients reported in Table A1). Statistically significant links in bold (5%).

To	From									
	BO	CH	EG	GH	KE	NI	SA	TU	UK	US
BO	0.06959	0.000316	**−0.0029**	**−0.00217**	0.002603	−0.00133	−0.0016	−0.00029	**−0.00233**	0.000805
CH	−0.04187	**0.561059**	**−0.02717**	**0.047226**	**0.211074**	0.002085	**0.094415**	0.003166	0.016301	**0.04681**
EG	−0.03854	−0.00205	**0.667891**	**−0.03117**	−0.01838	0.012533	0.015591	−0.05559	0.00224	0.003264
GH	−0.0046	−0.00249	−0.00083	**0.166279**	−0.01294	0.001937	−0.00393	0.00147	**0.000789**	−0.00277
KE	**−0.00395**	−0.00062	−0.00065	**−0.00059**	**0.90655**	−0.00078	0.011234	**0.000259**	**0.006961**	0.00231
NI	0.005821	0.000872	**−8.4E−06**	0.008835	0.000429	**0.903527**	0.003874	0.023961	**−0.01638**	**0.02845**
SA	**0.013732**	**−0.00284**	**0.03**	**−0.01856**	**0.096692**	−0.00859	**0.453239**	**−0.02175**	**0.101742**	**0.178716**
TU	0.003029	**−0.00042**	0.000809	0.003865	**−0.0015**	0.001404	0.002926	**0.932647**	**−0.00473**	**0.004372**
UK	−0.01997	0.009752	**0.043629**	**−0.00961**	0.056506	−0.03864	0.030129	**0.047157**	**0.160742**	0.047324
US	**−0.01935**	**0.000809**	**−0.00313**	**0.033258**	**0.04608**	**−0.02196**	**0.053275**	−0.01712	**0.189724**	**0.683329**

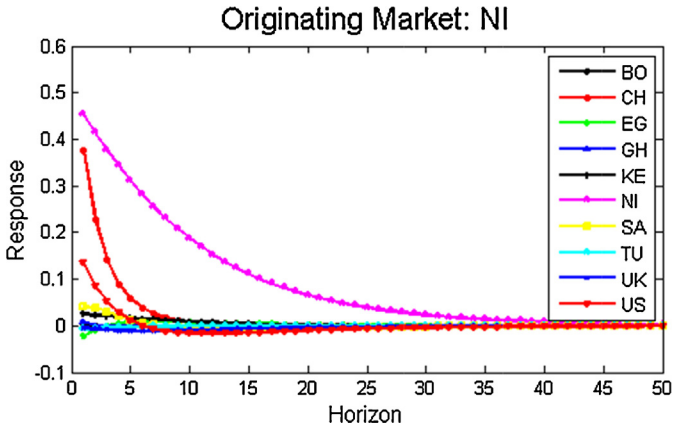

Fig. 3. Impulse response functions on a quiet day (25 March 2008).

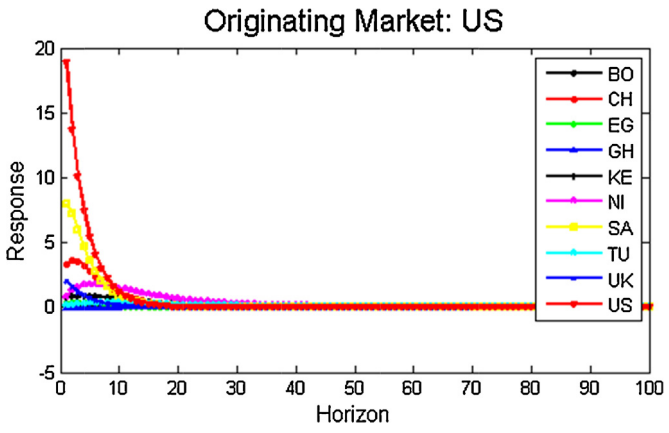

Fig. 5. Impulse response functions. Each line shows markets response to the shock originating in the US (15 September 2008).

in both markets: if China invests in Africa and influences the African markets, then they will somehow dependent on each other. Among the SSA countries, South Africa and Kenya are the most influential markets – they are the bigger and most developed markets, indeed – while some markets like Botswana remain relatively independent of the others, maybe due to their relatively small size. The Nigerian market, highly dependent on natural resources and oil, is relatively independent of other African markets but strictly related to the US market. This result is particularly interesting, given its good performance during the crisis: it suggests that Nigeria could have been an "escape" to the crisis for US.

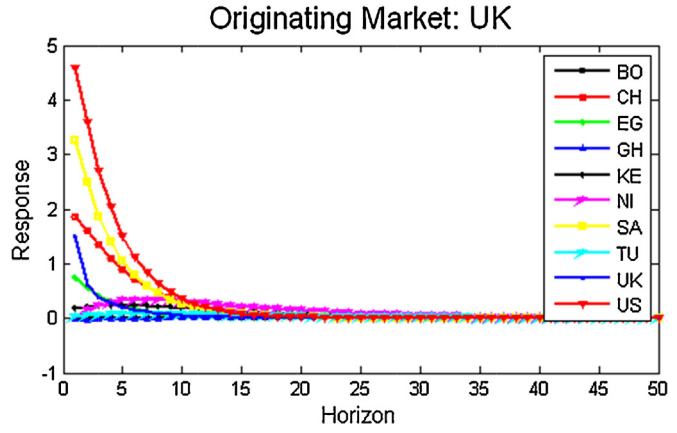

Fig. 4. Impulse response functions. Each line shows markets response to the shock originating in the UK (21 January 2008).

Figs. 3–5 report the impulse-response functions, which are an interesting representation of how markets' j volatility respond to a (one standard deviation) shock in another market, say market i.[6] The representation uses the model estimates to derive a time-dependent profile that describes how one market, hit by a shock (either positive or negative), spreads its volatility to other markets. For ease of readability and to allow comparison among different market conditions, Fig. 3 reports the situation of a "standard day", a quiet day where all markets in our sample have low volatilities, and no negative or positive shocks hit any market. As expected, all responses are very low and no particular behaviour is detected over time.

In contrast, Figs. 4 and 5 show the reaction in days of turmoil (as opposed to the quiet of 29 June) according to the estimation results reported in Table 4. Fig. 4 represents an example of

[6] It is important to distinguish the statistical relationships identified in the models (reported in Table 5) from volatility responses to a single shock identified in the impulse-response analysis, reported in Figures 3–5 (see Engle et al., 2012). Indeed, although a statistically significant relationship between market i and market j is detected by the model, the volatility response of market j to a volatility shock in market i at time t may be small relatively to other markets responses.

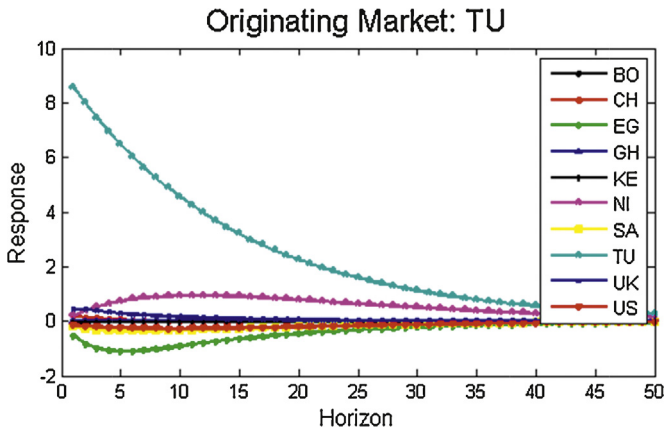

Fig. 6. Impulse response functions. Each line shows markets response to the shock originating in Tunisia (7 March 2011).

impulse-response representation to a shock: on 21 January 2008, international stock markets suffered their biggest falls since 11 September 2001 due to a crash in the British financial market, due to recession fears.[7] The shock originated in the UK market, and then propagated to markets all around the world; behind the UK reaction, which is obviously the highest, the US, China and South Africa over-reacted to the initial shock. Unexpectedly, their volatility response (thus the risk associated to these markets) became higher and larger than the UK volatility response to its own shock. Botswana reaction, instead, low at the very beginning, has a cumulated effect and becomes larger than others markets reaction in 10 days and lasts more. This means that, due to this shock originated in UK, investing in Botswana became much riskier than investing in UK and the risk associated to this market has been steadily higher than investing in the UK for a while. However, this shock, though large and clearly felt by most countries, is reabsorbed by the most of them in few days. In Fig. 5, we show how the collapse of Lehman Brothers on 15 September 2008 spills over from the US to all markets.[8] It clearly emerges that this shock has a more relevant impact for all markets involved: the scale of the impulse response is, indeed, almost five times that of the previous example (20 versus 5). The figure shows that South Africa, China and Nigeria all receive an immediate, large impact from the Lehman Brothers shock; Nigeria, in particular, has also a long memory and, after 10 days, when the shock was going to be absorbed by almost all markets, its volatility response (thus the risk associated to this market) is well above others. A further characteristic of the Lehman Brothers shock is that it is strongly persistent: after a month, it has not yet been re-absorbed and the curves are well above zero. This is particularly evident in the case of South Africa and Nigeria, more interconnected than the other countries to the US market, where the whole effect of the shock still persists after this period.

Analysing the impact of Arab Spring on the African and Western countries financial markets, in Fig. 6, we report markets response to a volatility shock in Tunisia during the 2011 "Jasmine Revolution" (the maximum has been reached on March 7). This shock turns out to be substantially less influential than the Lehman Brothers global crash but it shows a large peak for Tunisia. From the figure, we can notice that this shock has a strong local effect: African countries turn out to be hit while western countries seem to be less involved. When Tunisia is hit by the shock, Nigeria and Egypt, in particular, strongly react but while Nigerian volatility (and risk) increases, Egyptian volatility slightly decreases. This may depend on the fact that the turmoil spilling over Tunisia is positively perceived by Egypt as a new possibility of growth and change. The Nigerian market, instead, well developed market and highly based on oil production and trade, may consider these as source of instability for the area. Thus, after these shocks the Nigerian volatility increases.Since the graphical representations provided in Figs. 3–5 are date (and shock) specific, we use an averaged index for all markets and all days in sample to get a better picture. To this aim, Table 6 reports a synthetic index (Volatility Spillover Balance, VSB from now), described in Engle et al. (2012) as the ratio of the average responses 'from' to the average response 'to' (excluding one's own):

$$\xi_i = \frac{\sum_{j \neq i} \sum_{t:1}^{T} \phi_t^{ji}}{\sum_{j \neq i} \sum_{t:1}^{T} \phi_t^{ji}}$$

where

$$\phi_t^{ji} = \sum_{T:1}^{k} \rho_{t,T}^{ji}$$

is the whole effect by a shock from market i to market j. A value of VSB bigger than one means that the market is a "net creator" of volatility spillovers.[9] Values lower than one define "absorbers" of volatility spillovers, countries that receive shocks but do not contribute (or contribute little) to propagate them. This representation helps us to understand the possible channels for propagating the crisis in Africa. However, it has to be read together with the significant links in the model results. Indeed, it may happen that the net creator of volatility does not have many links in the area, so it may propagate the crisis but its role in affecting other markets turns out to be limited. That seems to be the case of Tunisia in our results: based on the VSB results, Tunisia is a net creator of volatility spillovers (maybe due to the turmoil after the Arab Spring in that area) but the magnitude of its effects is limited (see Table 5 and model estimates

[7] See the Guardian article on 22 January 2008 for a full and detailed description of the events that brought to the FTSE100 black Monday: http://www.guardian.co.uk/business/2008/jan/22/marketturmoil.equities.

[8] On 15 September 2008, Lehman Brothers went bankrupt. This was a shock for the United States but also undermined the credibility of financial markets and soon the shock propagated so that all the integrated international financial markets suffered enormous losses.

[9] If the risk that a country "exports" (column) is less than that it "imports" (row), then it is classified ad "volatility creator". Otherwise, it is defined as "volatility absorber".

Table 6
Summary of the volatility impacts to a one standard deviation shock to the market in the column heading. Last row is the Volatility Spillover Balance index.

To	From									
	BO	CH	EG	GH	KE	NI	SA	TU	UK	US
BO	0.7949	−0.7504	1.1413	2.6058	4.3812	−0.3976	1.8151	34.5038	0.5821	5.4524
CH	0.1797	2.2389	3.0283	2.673	10.1783	0.3045	2.6904	30.5552	3.3405	7.402
EG	0.3001	−0.8778	8.4577	2.4649	−0.1084	1.009	2.2577	35.8072	1.0675	7.1221
GH	0.3636	−0.7751	1.8025	8.2997	3.9783	0.4139	1.3898	33.9227	−0.0762	4.824
KE	0.1053	−0.5737	3.6562	1.955	23.7922	−0.1047	2.8255	27.4837	4.4895	7.038
NI	0.4016	−0.6291	2.9889	3.7704	3.2179	8.8534	2.6325	36.7939	1.9551	9.7413
SA	0.1445	−0.4088	4.7659	1.8583	13.253	0.3733	3.5983	25.122	5.7854	7.794
TU	0.6661	−1.3131	3.507	5.0672	−0.0276	0.8827	3.1121	64.7788	−0.351	9.6996
UK	0.266	−0.5415	4.351	2.5551	5.2747	0.3305	2.479	34.7893	5.0511	7.5758
US	0.1352	−0.4132	4.0635	2.5666	9.1826	0.3395	2.7181	29.4872	6.113	10.0409
VSB	0.0519	−0.1041	0.5975	0.5566	1.0524	0.0518	0.3735	13.5793	0.4013	1.2299

in Table A1). Other two important volatility creators are US, as expected, and Kenya (one of the most important markets for raw materials in Africa) which are highly interconnected with the SSA markets. Interestingly, the South African market is a "volatility absorber". However, Table 6 also suggests that South Africa is strictly linked to all markets in the area (column corresponding to South Africa): it is the most open market receiving shocks and propagating them.[10] The Nigerian market, confirming the model results and the impulse-response graphical representation, is almost independent of shocks coming from other markets.

6. Concluding remarks

Recent years have been characterised by major integration of international financial markets. African markets, on the one hand, seem to have lagged behind this process, but, on the other, have maintained a fairly stable growth during and after the 2008 global crisis. The channels of transmission of the shocks are not as strong as within developed markets, where interconnection is very high. Despite this, the recent global financial crisis has reached Africa too, hitting some of the drivers of stock market development.

In this paper, we focused on some emerging SSA financial markets (Kenya, Nigeria, South Africa) and two north African countries (Egypt and Tunisia) volatility relationships with some developed markets (the UK and the US, as well as with China,) using a Multiplicative Error approach to model and describe whether (and how) volatility spills over from one market to another. We proxied market volatility with squared returns and we modelled the dynamics of the expected volatility in a market including interactions with the past squared returns of other markets. In doing so, we use a fully inter-dependent model that allows us to describe the relationships among the market volatilities. To highlight whether a shock originating in one market affects (and how) other markets, we use impulse response functions. The results show that South Africa, the US and China all play a key role in all African markets, while the influence of events in the UK is less relevant. Indeed, the impulse response representation shows that the African financial markets volatility response to a shock in either the UK or the US had cumulative effects that took time to be fully developed and understood, thereby worsening their fragile economic conditions. Shocks from the Arab Spring, instead, seem to be less global and directly involve only North-African countries. Interesting enough, China turns out to be relatively independent of the UK but not of the US. Finally, we use an index to highlight the role of volatility "creators" and "absorbers": markets that receive shocks and propagate (creators) or receive and absorb (absorbers) them. This index suggests that US and Kenya are "volatility creators" while South Africa and China are "volatility absorbers". Tunisia, during the Jasmine revolution, has been a big volatility creator but it has low links with SSA markets, thus the domestic crisis had very little effect in the area.

[10] Results on South Africa are interesting because they show a market which receives and propagates shocks but the magnitude of propagation is lower than that of shocks it receives, so on average it is a net absorber.

Appendix A.

Table A1
Estimated coefficients based on the full model described in Section 3. *t*-Stats in brackets, statistically significant links in bold. Diagnostic tests include log likelihood Akaike and Bic criteria, LB (12 lags) test and White test on heteroskedasticity (4 lags).

	Botswana	China	Egypt	Ghana	Kenya	Nigeria	South Africa	Tunisia	UK	US
Ω	**0.272**	**1.008**	**1.182**	**0.601**	**0.045**	**0.071**	**0.385**	**0.016**	**1.138**	**0.176**
	[1.323]	**[11.190]**	**[2.117]**	**[3.078]**	**[4.543]**	**[4.769]**	**[6.326]**	**[2.994]**	**[4.193]**	**[9.537]**
Mt−1	0.063	**0.432**	**0.658**	0.164	**0.682**	**0.564**	**0.402**	**0.731**	0.018	**0.527**
	[0.092]	**[9.029]**	**[4.017]**	[0.646]	**[10.902]**	**[15.231]**	**[5.226]**	**[14.774]**	[0.104]	**[22.575]**
bo+	0.007	−0.056	−0.022	−0.009	0.000	0.012	**−0.03**	0.005	**−0.034**	**−0.017**
	[0.281]	[−1.367]	[−0.326]	[−0.410]	[−0.065]	[0.748]	**[−6.757]**	[0.732]	**[−4.910]**	**[−2.599]**
bo−	0.006	−0.028	−0.055	−0.001	**−0.007**	0.000	0.057	0.001	−0.006	**−0.022**
	[0.056]	[−0.219]	[−1.100]	[−0.013]	**[−2.873]**	[−0.003]	[1.119]	[0.267]	[−0.165]	**[−1.979]**
ch+	0.000	**0.071**	−0.011	−0.005	0.002	−0.002	**−0.011**	−0.001	0.001	−0.003
	[0.105]	**[4.159]**	[−0.565]	[−1.576]	[0.556]	[−1.006]	**[−11.57]**	[−1.088]	[0.089]	[−0.859]
ch−	0.000	**0.187**	0.007	0.000	−0.003	0.004	0.006	**0.00001**	0.018	0.005
	[0.100]	**[5.582]**	[0.368]	[0.046]	[−1.436]	[1.094]	[0.792]	**[62.596]**	[1.428]	[0.784]
eg+	**−0.005**	**−0.039**	0.01	−0.002	−0.001	0.001	**0.021**	0.000	0.035	**−0.008**
	[−3.107]	**[−19.156]**	[0.375]	[−0.186]	[−0.206]	[0.374]	**[2.023]**	[0.375]	[0.970]	**[−3.522]**
eg−	−0.001	**−0.015**	0.01	0.000	−0.001	**−0.001**	**0.043**	0.001	0.052	0.001
	[−0.730]	**[−24.799]**	[0.198]	[0.024]	[−0.430]	**[−2.930]**	**[2.517]**	[0.977]	[1.716]	[0.466]
gh+	−0.001	0.126	**−0.067**	0.003	0.003	−0.007	**−0.033**	0.009	−0.031	0.001
	[−0.087]	[1.753]	**[−3.900]**	[0.032]	[0.480]	[−1.131]	**[−4.390]**	[1.586]	[−1.706]	[0.074]
gh−	**−0.003**	**−0.031**	0.005	0.001	**−0.004**	0.024	−0.004	−0.002	0.012	**0.065**
	[−6.975]	**[−2.001]**	[0.147]	[0.008]	**[−2.664]**	[1.250]	[−0.339]	[−1.244]	[0.457]	**[2.391]**
ke+	0.003	0.038	−0.019	−0.001	**0.216**	0.004	−0.01	−0.001	0.046	−0.013
	[0.355]	[0.941]	[−0.704]	[−0.044]	**[4.791]**	[0.360]	[−0.680]	[−0.374]	[0.708]	[−1.054]
ke−	0.002	**0.384**	−0.018	**−0.025**	**0.233**	−0.003	**0.203**	**−0.002**	0.067	**0.105**
	[0.195]	**[4.762]**	[−0.303]	**[−9.698]**	**[3.664]**	[−0.455]	**[2.511]**	**[−2.280]**	[1.031]	**[3.061]**
ni+	0.002	0.024	0.023	0.002	0.001	**0.349**	−0.003	0.002	−0.054	**−0.024**
	[0.057]	[0.854]	[0.449]	[0.056]	[0.230]	**[7.201]**	[−0.152]	[0.831]	[−1.260]	**[−101.09]**
ni−	−0.004	−0.02	0.002	0.002	−0.003	**0.331**	−0.015	0.001	−0.024	**−0.02**
	[−0.684]	[−1.085]	[0.040]	[0.078]	[−0.531]	**[7.321]**	[−0.898]	[0.241]	[−1.185]	**[−9.046]**
sa+	−0.003	0.039	0.021	−0.004	−0.002	0.006	0.003	0.000	0.008	**0.065**
	[−0.756]	[1.650]	[0.370]	[−0.584]	[−0.230]	[0.982]	[0.100]	[−0.066]	[0.157]	**[3.856]**
sa−	0.000	**0.15**	0.01	−0.004	0.025	0.001	**0.1**	0.006	0.053	0.042
	[0.017]	**[2.679]**	[0.082]	[−0.692]	[1.023]	[0.218]	**[2.067]**	[1.575]	[0.842]	[1.346]
tu+	0.003	0.052	−0.073	0.005	0.011	0.013	−0.014	**0.155**	**−0.072**	−0.023
	[0.057]	[0.730]	[−1.509]	[0.053]	[1.024]	[0.864]	[−0.627]	**[4.264]**	**[−8.936]**	[−1.364]
tu−	−0.003	−0.046	−0.038	−0.002	**−0.01**	0.035	**−0.03**	**0.248**	0.166	−0.011
	[−0.638]	[−0.991]	[−0.301]	[−0.136]	**[−2.868]**	[1.018]	**[−6.818]**	**[3.575]**	[0.486]	[−1.318]
uk+	−0.002	0.016	−0.002	0.001	**0.021**	**−0.031**	0.064	0.000	0.042	**0.139**
	[−0.822]	[0.455]	[−0.024]	[0.119]	**[1.987]**	**[−3.915]**	[1.392]	[0.053]	[0.530]	**[3.739]**
uk−	**−0.003**	0.017	0.007	−0.004	−0.007	−0.002	0.139	**−0.01**	**0.244**	**0.24**
	[−2.153]	[0.245]	[0.055]	[−0.877]	[−0.333]	[−0.206]	[1.664]	**[−2.207]**	**[1.981]**	**[5.324]**
us+	0.000	**−0.045**	−0.002	−0.003	−0.004	**0.04**	**0.13**	0.000	0.068	**0.054**
	[−0.231]	**[−1.996]**	[−0.022]	[−0.885]	[−0.408]	**[3.635]**	**[2.504]**	[0.019]	[0.726]	**[1.971]**
us−	0.002	**0.139**	0.008	−0.003	0.009	**0.017**	**0.227**	**0.009**	0.027	**0.258**
	[0.227]	**[2.757]**	[0.093]	[−0.729]	[0.735]	**[1.986]**	**[3.262]**	**[2.106]**	[0.176]	**[5.596]**
Diagnostic tests										
loglik	−1367.26	−3685.37	−3804.47	−2211.29	−2115.0	−2390.6	−3039.38	−1327.71	−2991.3	−2840.97
aic	1.517	3.932	4.056	2.394	2.293	2.581	3.258	1.472	3.208	3.051
bic	1.450	3.868	3.992	2.330	2.230	2.517	3.194	1.408	3.144	2.987
LB	2.838	3.150	2.880	1.070	1.299	17.114	1.110	1.900	1.250	1.100
	[0.550]	[0.230]	[0.770]	[0.150]	[0.178]	[0.145]	[0.190]	[0.200]	[0.190]	[0.300]
Arch	4.850	1.904	4.317	19.862	0.809	8.808	5.464	3.648	3.100	13.821
	[0.260]	[1.000]	[0.130]	[0.070]	[1.000]	[0.719]	[0.870]	[0.989]	[0.950]	[0.312]

Note: *t*-Stat in parenthesis, significant coefficients (5%) in bold. Sample: 1 January 2005–10 May 2012. Data source: DATASTREAM.

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