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Spillovers in Sub-Saharan Africa's sovereign eurobond yields *

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Abstract

This paper investigates the possibility of spillovers among Sub-Saharan African (SSA) eurobonds. Twelve SSA countries are examined from January 1, 2015 to June 30, 2017. Following the methodology of Diebold and Yilmaz (2012), we proceed as in Antonakakis and Vergos (2013) to compute both the overall and time-varying total spillover index and directional spillovers using secondary market daily yields. Ours results indicate significant contagion effects among these bonds as, on average, 66.37% of the forecast error variance in our model come from spillovers. The results of the time-varying analysis shows that the total spillover index has been sensitive to major economic events and news announcements over this period. More important, they suggest that less resilient economies transmit more to and receive less from their peers, but that this relationship is not linear: cases of extreme fragility such as that of Mozambique do no translate into higher spillovers to peers. This non-linear relationship between countries' macroeconomic performance and spillover levels confirms to some extent the *market discipline hypothesis* in the case of SSA eurobonds as markets have proven able to factor-in and discriminate against issuers' salient abnormal behaviors.

Keywords: Spillover index, VAR models, Sub-Saharan Africa, Eurobonds

JEL: C33, E44, G15, H63

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1 Introduction

The year 2016 seems to have marked the end of the SSA eurobond spree with a drastic shrink in the number as well as the amount of eurobonds issued by SSA countries to collected financial resources through international markets. From annual total record of over US$ 6 billion collected in 2014 and 2015, the total amount mobilized by these countries in 2016 dropped to less than US$ 1.5 billion by only Ghana (US$ 750 million) and Mozambique (US$ 727 million), and until June 2017, only Nigeria has been able to raise US$ one billion using eurobonds. The decline in SSA eurobond issuance is believed to have been driven by the negative impact of low commodity prices on the economy of many of these countries, and the resumption of economic growth in the developed world, events that lowered the risk appetite of investors for SSA eurobonds and thus pushing up yields to dramatic levels that were by no means attractive for these countries to issue new eurobonds.

Beyond the influence of global economic factors, empirical studies have also underscored the role of country-specific factors such as the quality of macroeconomic management and the degree of vulnerability to global economic shocks in the determination and evolution of SSA eurobond yields (see Gevorkyan and Kvangraven, 2016; Senga et al., 2018). The experience of SSA eurobonds suggests that markets seems to have been able to sanction countries with erratic economic management behavior such as the absence of economic diversification and over-reliance on a limited number of commodities that exacerbates the vulnerability to global shocks, and loose public finance and debt management that put pressure on the countries' macroeconomic stability and ability to service their foreign debt (Senga et al., 2018). A case in point is the recent history of Mozambique where, in addition to allegations of eurobond proceeds misallocation, the scandal of hidden debts in end last year has irked these countries' creditors and donors as well as multilateral institutions thus creating nervousness around the performance of the Ematum eurobond on international markets. Likewise, cases of alarming government budget deficits and macroeconomic framework instability have been documented in Angola, Ghana and Zambia in 2014-15 and 2016 respectively with noticeable consequences on both their primary and secondary market eurobond yields.

However, while there seems to be a consensus on the influence of global and country-specific factors on SSA eurobond yields, little is still known about the possibility and extent of contagion among these assets. In fact, despite their intrinsic heterogeneity, these assets have in common that they all belong to the frontier market category and may therefore be put in the same basket from the investor's perspective.

The geographic proximity of borrowers facing in most cases similar political and economic challenges, coupled with their shared history of cases of poor economic performance and debt management, raises the possibility of investors adjusting their expectations about the whole class of these assets based on unanticipated moves in the performance of one of these assets. This is for instance more likely in the case of the asset's negative performance regardless of the probability of the triggering event to spread across the whole group.

The issue of the spillovers effects among SSA countries has attracted little attention in the literature. Some of the few available studies on this topic have focused on the spillovers of economic growth and financial market shocks from developed and emerging markets to African economies (see Gurara and Ncube, 2013; Labuschagne et al., 2016). Others have investigated the level of economic and financial integration among African countries through the contagion of shocks to domestic economic growth and stocks markets (World Bank, 2016; Collins and Biekpe, 2003). The possibility of contagion among internationally-traded securities from Africa has not yet been investigated despite the plausibility of the hypothesis that investors could dwell on the similarities of SSA debt securities to assign them some sort of similar consideration and treatment in their portfolio construction strategies. If proved true, this hypothesis hints to the possibility of shocks to the performance of one SSA debt securities to spill over by pushing investors to adjust their expectation about the performance of others SSA debt securities and, in the worst case, shy away from this asset class altogether.

This study revisits the evolution of SSA eurobond yields on secondary markets to investigate, as stated above, the degree of interconnection and the possibility of spillover effects among these assets. Drawing insights from Antonakakis and Vergos (2013) and Gande and Parsley (2005), it assesses the extent to which major shocks (news) to individual securities affect the performance of their peers using the Diebold and Yilmaz (2012)'s spillover index. Our results show that, on average, 66.37% of the forecast error variance is explained by cross-SSA eurobonds yields spillovers, and that Angola is the dominant transmitter of SSA eurobond yield spillovers followed by Ghana and Zambia, while Namibia, folowed by Tanzania and Rwanda are dominant receivers of SSA eurobond yield spillovers. They also indicate higher levels of spillovers effects in moments of economic distress such as shocks in global commodity prices, the alarming fiscal deficits in Ghana and Zambia, and default in Mozambique.

2 Literature review

Several studies have been devoted to spillovers effects between emerging and developed economies, and across African economies taking different perspectives and approaches. Gurara and Ncube (2013) analyze the global growth spillover effects on Africa and find that, besides a significant growth spillover effect to African economies from both the Euro zone economies and BRICs, the quantitative easing measures in the US, Euro, UK, and Japan could have a mild inflationary effect in addition to putting pressure on exchange rates to appreciate. World Bank (2016) reviews SSA region progress in regional integration, intra-regional trade and cross-border financing flows and concludes that shocks to growth in the two largest economies – Nigeria and South Africa – appear to have no measurable effects on other countries in the region.

Some studies have investigated the contagion and interdependence of African equity markets. For instance, in their studies covering the pre-2008 economic crisis, Collins and Biekpe (2003) find an evidence of contagion from global emerging market crises to Egypt and South Africa, the only largest and most traded markets in Africa by then. They also conclude to the lack of causal relationships between African markets, which suggests a relatively high degree of isolation among them. This heterogeneity of the African equity markets has also been confirmed by the results of Labuschagne et al. (2016) in the context of the 2007-2009 financial crisis. Moreover, this study fails to reject the hypothesis of no contagion and no integration effects among the U.S., the U.K., and selected African stock markets (South Africa, Namibia, Egypt, Nigeria, Morocco and Kenya) during the global financial crisis of 2007-2009.

The interdependence and contagion effects among African sovereign eurobonds has not yet been investigated, be it in calm or nervous market times. However, the experience of more developed economies sheds light on the possibility of sovereign bond yield spillovers among markets sharing some similarities such as belonging to the same economic union or geographical location, especially during moments of market distress. The case in point is the study by Antonakakis and Vergos (2013) who find highly intertwined bond yield spread spillovers between Euro zone countries during the turbulent period encompassing the global financial crisis and the Euro zone debt crisis. They also find that shocks to sovereign bond yield spreads are related to news announcements and policy changes, which corroborates to some extent the results by Gande and Parsley (2005) which suggest a significant spillover effect of a credit rating downgrade in one country on the sovereign credit spreads of other countries. This study draws insights from these two pieces of research to analyze the possibility of spillovers effects among SSA eurobond yields.

3 Methodology

This study follows the methodology of Diebold and Yilmaz (2012) which departs from a generalized N-variable VAR(p), $X_t = \sum_{t=1}^{p} \Phi_i X_{t-i} + \varepsilon_t$ with $\varepsilon \sim (0, \Sigma)$ a vector of independently and identically distributed disturbances, and analyzes the dynamics of this VAR system using variance decompositions. These latter allow the decomposition of the forecast error variances of each variable into parts that are attributable to the various shocks to the system, hence allowing the assessment of the fraction of the H-step-ahead error variance in forecasting x_i that is due to shocks to x_j with $j \neq i$ for each i.

This methodology relies on the the generalized VAR framework of Koop et al. (1996) and Pesaran and Shin (1998), henceforth KPPS, which produces variance decompositions that are invariant to the ordering of variables in the VAR specification. It then becomes possible to distinguish between *own variance shares*, the fraction of the H-step-ahead error variances in forecasting x_i that are attributable to shocks to x_i for $i = 1, 2, \ldots, N$, and *cross variance shares* or *spillovers*, the fraction of the H-step-ahead error variances in forecasting that are due to shocks to x_j, for $i, j = 1, 2, \ldots, N$, such that $i \neq j$.

Denoting by Σ the variance matrix of the error vector ε and $\theta_{ij}^{g}(H)$ [1] the H-step-ahead forecast error variance decompositions for $H = 1, 2, \ldots$, we have

$$\theta_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} \left(e_i' A_h \Sigma e_j \right)^2}{\sum_{h=0}^{H-1} \left(e_i' A_h \Sigma A_h' e_i \right)} \tag{1}$$

with σ_{jj} the standard deviation of the error term for the jth equation, and e_i the selection vector with one as the ith element and zero otherwise. The obtained $\theta_{ij}^{g}(H)$ are normalized as follows to ensure that $\sum_{j=1}^{N} \theta_{ij}^{g}(H) = 1$ and $\sum_{i,j=1}^{N} \theta_{ij}^{g}(H) = N$:

$$\tilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N} \theta_{ij}^{g}(H)} \tag{2}$$

[1] g denotes the KPPS generalized VAR framework that circumvents the issue of order-dependent spillovers driven by the Cholesky factor orthogonalization in a simple VAR framework.

The total spillover index is obtained by

$$S^g(H) = \frac{\sum_{\substack{i,j=1\\ i\neq j}}^{N} \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^g(H)} \times 100 = \frac{\sum_{\substack{i,j=1\\ i\neq j}}^{N} \tilde{\theta}_{ij}^g(H)}{N} \times 100 \tag{3}$$

Since in the KPPS generalized VAR framework the impulse-responses and variance decompositions are invariant to the ordering of the variables, it becomes possible to measure the *directional spillovers* in terms of 1) spillovers received by market i from all other markets, $S_{i.}^g(H)$, and 2) spillovers transmitted by market i to all other markets, $S_{.i}^g(H)$, and the *net spillovers*, i.e. the difference between the gross volatility shocks transmitted to and those received from all other markets, as follows:

$$S_{i\leftarrow j}^g(H) = \frac{\sum_{\substack{j=1\\ j\neq i}}^{N} \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^g(H)} \times 100 = \frac{\sum_{\substack{j=1\\ j\neq i}}^{N} \tilde{\theta}_{ij}^g(H)}{N} \times 100 \tag{4}$$

$$S_{i\rightarrow j}^g(H) = \frac{\sum_{\substack{j=1\\ j\neq i}}^{N} \tilde{\theta}_{ji}^g(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ji}^g(H)} \times 100 = \frac{\sum_{\substack{i,j=1\\ j\neq i}}^{N} \tilde{\theta}_{ji}^g(H)}{N} \times 100 \tag{5}$$

$$S_i^g(H) = S_{i\rightarrow j}^g(H) - S_{i\leftarrow j}^g(H) \tag{6}$$

We construct a VARX[2] model of the selected SSA eurobond yields with the Bloomberg commodity price, the US 10 year Treasury Bond Index and VIX indices as exogenous variables. The consideration of these exogenous variables is based on the results by Gevorkyan and Kvangraven (2016) and Presbitero et al. (2016) which indicate that SSA eurobond yields are influenced by these variables among others factors affecting global economic conditions. Their inclusion in the model allows the mitigation of the impact of global factors in our VAR dynamics and forecast error variance decomposition to be considered in the computation of the spillovers. The order or our VAR is determined using the Schwarz information criterion and the results of the estimation are restricted to 5% significance level of the coefficients.

Based on the results of the VAR estimation, we proceed as in Antonakakis and Vergos (2013) to compute

[2]VARX refers to a VAR system supplemented by exogenous variables.

the normalized $H = 10$ days step-ahead forecast error variance decomposition in equations (1) and (2), which are then used to compute the total spillover index, the directional and net spillovers as indicted in equations (3), (4), (5) and (6) respectively. These results are also used for the evaluation of impulse-response functions on a 30 days forecasting horizon.

The same procedure is carried out using 120 day rolling windows to allow a dynamic analysis of the SSA eurobond yield spillovers. In addition to the dynamic total spillover index, we compute for each of the bonds the dynamic spillovers from and to its peers, and the net spillovers by applying the formulas above on each of the 120 day sub-samples in the rolling windows.

4 Data

This study uses daily secondary market yields of SSA eurobonds for the period of January 2015 – June 2017 collected from Datastream. The data span the course of the recent commodity prices crash that created market nervousness and brought a halt to the SSA eurobond issuance spree. In order to circumvent the influence of bond-specific characteristics in case of multiple issues, we select in our analysis the latest eurobond issue as of January 1, 2015. Therefore, the following sovereign and sovereign-guaranteed eurobonds from 12 countries have been considered: the Angolan-Northern Lights III issue of 2012, the sovereign eurobonds of Ethiopia 2014, Gabon 2013, Ghana 2013, Kenya 2014, Namibia 2011, Nigeria 2013, Rwanda 2013, Senegal 2011, Tanzania 2013 and Zambia 2014, and the sovereign guaranteed Ematum eurobond of Mozambique 2013. Specific attention has been given to this latter to take into account the restructuring of the Ematum eurobond in March 2016; the yield series of the original issue of 2013 has been complemented by the yields of the 2016 issue starting 7 April 2016. Besides, daily data have been collected for the Bloomberg commodity, US 10 year Treasury bonds and VIX indices to account for global trends and developments on international markets during our study period.

The summary statistics presented in Table 1 drop several hints on the performance and resilience of the individual SSA eurobonds under consideration. With its mean and median of respectively 4.36% and 4.24%, Namibia appears to be the top performer of the group followed respectively by Tanzania, Senegal and Rwanda. Namibia dominates also the group in terms of resilience with the lowest standard deviation of 0.52% followed respectively by Rwanda and Ethiopia. On the other end, Mozambique appears to be by all standards the least performer of the group with its 15.79% and 5.38% mean and standard deviation

Variables	Mean	Min	Max	St.Dev	Median	Skew	Kurtosis
ANGOLA	7.3352	3.9856	13.5250	1.8287	7.4043	0.4402	0.5217
ETHIOPIA	7.6645	6.5155	10.0774	0.7715	7.5671	0.7235	-0.0130
GABON	8.3088	6.2410	12.9670	1.3828	8.0572	0.9013	0.5133
GHANA	10.1771	7.2302	16.8398	1.9025	9.5809	1.0553	0.6386
KENYA	7.5183	6.1371	10.0246	0.9046	7.4751	0.4478	-0.4394
MOZAMBIQUE	15.7929	7.1852	28.0906	5.3855	16.4927	0.0349	-1.0697
NAMIBIA	4.3633	3.5404	6.0483	0.5192	4.2355	1.0105	0.6196
NIGERIA	7.1503	5.4896	9.6003	0.9174	7.1239	0.2340	-0.7620
RWANDA	6.9145	5.9953	8.3213	0.5266	6.7445	0.6870	-0.2695
SENEGAL	6.3765	4.4256	8.6826	0.9381	6.4046	-0.0340	-0.6180
TANZANIA	5.8870	3.3904	10.9842	1.6614	5.5868	0.9204	0.2713
ZAMBIA	9.9799	7.1892	16.8179	2.3616	9.1427	0.8106	-0.2253
BCOM	312.6747	252.5313	347.2783	22.9378	319.3677	-0.7851	-0.4071
US10	2.0592	1.3640	2.6080	0.2926	2.1225	-0.2958	-0.9425
VIX	16.7757	11.6300	26.4200	3.0036	16.2700	0.8490	0.5327

Notes: Eurobond and US 10 year Treasury Bonds (US10) yields as well as VIX index expressed in percentage, and Bloomberg commodity index (BCOM) expressed in spot prices.

Table 1: Summary statistics

respectively. Less pronounced but still worrying is the case of Angola, Ghana and Zambia whose standard deviations exceed 1.80%.

Table 2 shows high positive correlations among secondary market yields of the selected SSA eurobonds, exception made for Mozambique. They also indicate that these bonds are negatively correlated with commodity prices (here measured by the Bloomberg Commodity Index), and positively correlated with markets volatility (mesured by the VIX index) in line with the literature (see Gevorkyan and Kvangraven, 2016; Presbitero et al., 2016; Senga et al., 2018). As concerns the US 10 year Treasury Bonds Index, these figures suggest a weak and negative correlation with the SSA eurobonds. Mozambique features a rather exceptional correlation pattern with both its peers and the global factors, which is no surprise given its idiosyncratic shocks experienced during this period.

Figure 1 shows the evolution of the selected SSA eurobonds' yields over the period under study. It can be seen that, a part from the case of Mozambique after mid-2015, these seem to move together and react in almost the same way to common shocks. However, there seems to be salient differences in the magnitude of reaction to common shocks, with for instance Namibia, Rwanda and Senegal featuring a strong resilience while Ghana and Zambia showing signs of pronounced vulnerability. Once more, the oddness of Mozambique features prominently, stressing the derailing behavior of this country's yields since the suspicion of cases of hidden debt by the International Monetary Fund (IMF) in May 2015.

Variables	ANG	ETH	GAB	GHA	KEN	MOZ	NAM	NIG	RWA	SEN	TAN	ZAM	BCOM	US10	VIX
ANGOLA	1														
ETHIOPIA	0.59	1													
GABON	0.79	0.87	1												
GHANA	0.81	0.75	0.92	1											
KENYA	0.63	0.86	0.91	0.79	1										
MOZAMBIQUE	-0.21	0.47	0.21	-0.03	0.35	1									
NAMIBIA	0.75	0.84	0.88	0.82	0.83	0.07	1								
NIGERIA	0.86	0.80	0.90	0.84	0.79	0.03	0.87	1							
RWANDA	0.73	0.86	0.92	0.89	0.88	0.15	0.87	0.85	1						
SENEGAL	0.84	0.61	0.77	0.83	0.68	-0.33	0.80	0.81	0.81	1					
TANZANIA	0.85	0.61	0.81	0.83	0.74	-0.25	0.84	0.82	0.80	0.90	1				
ZAMBIA	0.75	0.82	0.96	0.93	0.91	0.18	0.83	0.84	0.92	0.77	0.81	1			
BCOM	-0.78	-0.63	-0.86	-0.85	-0.78	0.04	-0.79	-0.80	-0.75	-0.74	-0.87	-0.86	1		
US10	-0.34	-0.01	-0.30	-0.39	-0.12	0.11	0.04	-0.23	-0.19	-0.18	-0.16	-0.31	0.28	1	
VIX	0.82	0.51	0.70	0.73	0.53	-0.25	0.67	0.77	0.66	0.78	0.76	0.67	-0.66	-0.35	1

Table 2: Correlations

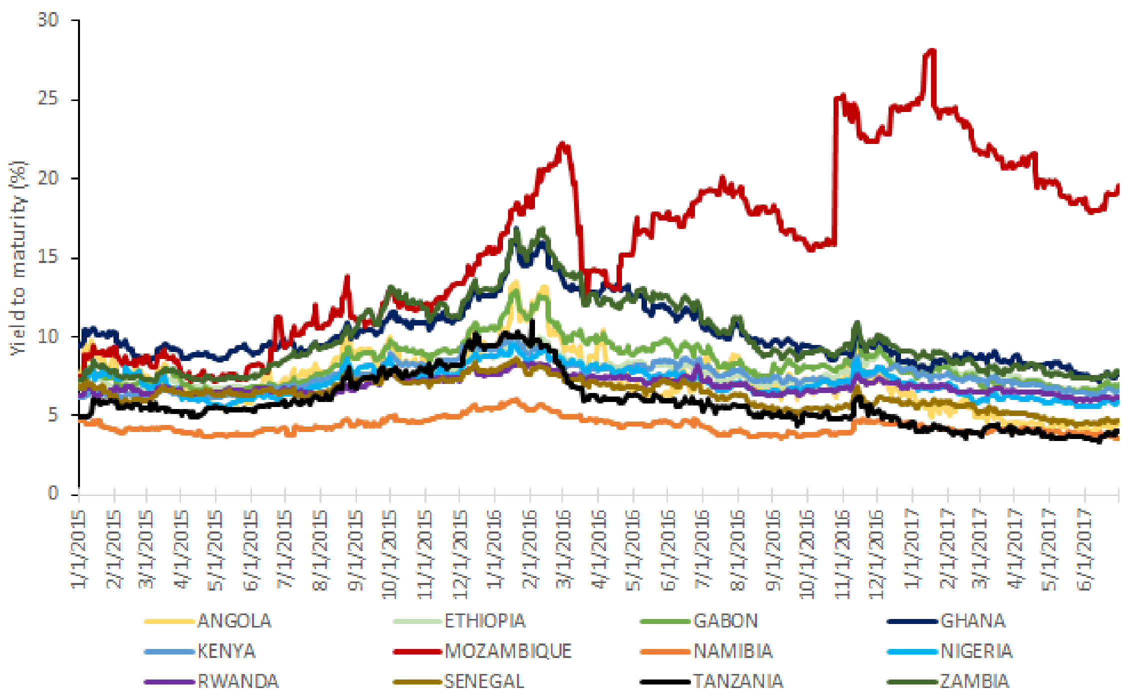

Figure 1: Yields evolution

5 Empirical results

The empirical analysis of SSA eurobonds spillovers has been carried out in two major steps. We first perform a static analysis by considering the whole sample of 652 observations covering our study period January and compute the overall total spillover index, directional and net spillovers using equations (3), (4), (5) and (6). In the second step, the same procedure is carried out using 120-days rolling windows to analyze the dynamics of the spillovers across the study period. We thus compute the evolution of the total spillover index, the directional and net spillovers and use these outputs to relate the picks of spillovers to their potential triggers, i.e. the major news and events that might have affected the evolution of individual or group of SSA eurobonds during this period. These steps have been complemented with an analysis of the impulse-response functions to assess the reaction of each of these bonds to idiosyncratic shocks affecting the system. The results of our analyses are discussed in the following paragraphs.

5.1 Static analysis of spillovers

The results of the static analysis of secondary market SSA eurobond yields are presented in Table 3. Read linewise, this table contains the fraction of the spillovers received by the country in the line (i) from the country in the column (j), i.e. the $S^g_{i \leftarrow j}(10)$ computed as in equation (4), and that sum to 1 by normalization to cover the 100% spillovers affecting country (i). Columnwise, the table contains the spillovers transmitted by the country in column (j) to the country in line (i), i.e. the $S^g_{i \to j}(10)$ computed as in equation (5). The diagonal elements correspond to the countries' own spillovers. The total spillover index corresponds to the percentage of the H-step-ahead forecast error variances attributable to other countries in the system's overall H-step-ahead forecast error variance decomposition (from and to others plus own spillovers), i.e. the $S^g(10)$ computed as in equation (3). The net spillovers in the last line correspond to the the difference between the percentage of transmitted and received spillovers, i.e. the $S^g_i(10)$ computed as in equation (6).

	ANG	ETH	GAB	GHA	KEN	MOZ	NAM	NIG	RWA	SEN	TAN	ZAM	From others
ANGOLA	0.5995	0.0243	0.0705	0.0754	0.0412	0.0181	0.0116	0.0478	0.0112	0.0344	0.0076	0.0582	0.4005
ETHIOPIA	0.1161	0.1670	0.1234	0.1176	0.0715	0.0970	0.0239	0.0681	0.0481	0.0604	0.0137	0.0929	0.8330
GABON	0.1377	0.0462	0.2429	0.1432	0.0951	0.0420	0.0252	0.0626	0.0224	0.0576	0.0073	0.1180	0.7571
GHANA	0.1240	0.0454	0.1161	0.3098	0.0693	0.0342	0.0207	0.0486	0.0315	0.0709	0.0062	0.1234	0.6902
KENYA	0.0921	0.0502	0.1181	0.1374	0.2156	0.0341	0.0127	0.0810	0.0306	0.0731	0.0258	0.1293	0.7844
MOZAMBIQUE	0.0093	0.0351	0.0086	0.0079	0.0118	0.8873	0.0030	0.0092	0.0055	0.0010	0.0029	0.0185	0.1127
NAMIBIA	0.1111	0.0514	0.1172	0.1226	0.0857	0.0326	0.1987	0.0663	0.0579	0.0498	0.0120	0.0946	0.8013
NIGERIA	0.1512	0.0506	0.0922	0.1105	0.0787	0.0406	0.0199	0.2602	0.0355	0.0639	0.0088	0.0879	0.7398
RWANDA	0.0997	0.0487	0.1027	0.1374	0.0777	0.0348	0.0229	0.0767	0.2139	0.0705	0.0085	0.1067	0.7861
SENEGAL	0.1330	0.0554	0.1003	0.1212	0.0818	0.0076	0.0158	0.0747	0.0366	0.2458	0.0178	0.1100	0.7542
TANZANIA	0.1444	0.0264	0.0692	0.0834	0.0801	0.0144	0.0094	0.0488	0.0123	0.0458	0.3827	0.0831	0.6173
ZAMBIA	0.0729	0.0529	0.1079	0.1423	0.0897	0.0330	0.0215	0.0540	0.0278	0.0580	0.0273	0.3125	0.6875
To others	1.1915	0.4867	1.0262	1.1988	0.7828	0.3884	0.1867	0.6378	0.3194	0.5853	0.1379	1.0226	**Total spill-**
Plus own effect	1.7910	0.6537	1.2691	1.5086	0.9984	1.2757	0.3854	0.8980	0.5333	0.8311	0.5206	1.3352	**over index =**
Net spillover	0.7910	-0.3463	0.2691	0.5086	-0.0016	0.2757	-0.6146	-0.1020	-0.4667	-0.1689	-0.4794	0.3352	**66.37%**

Notes: Positive (negative) net spillover indicates country's position as net transmitter (receiver) of spillovers.

Table 3: Spillovers

Three main messages can be drawn from these results. First, the total spillover index indicates that, overall, 66.37% of the 10-day step ahead forecast error variance across the examined eurobonds come from spillovers. Second, Angola appears to be the dominant spillover transmitter followed by Ghana and

Zambia, while Namibia followed by Tanzania and Rwanda are deemed the dominant receivers of SSA eurobond yield spillovers. Third, with almost 90% and 60% of own spillovers respectively, Mozambique and Angola share the particularity of having more of their 10-day step ahead forecast error variance attributed to their own idiosyncratic shocks.

With this results, we find an indication of substantial contagion effects among SSA eurobonds, suggesting that the evolution of secondary market yields is not only influenced by global and country-specific factors but also to a large extent by spillovers of shocks affecting their peers. For instance, our figures indicate that 83.30% of the 10-day step ahead forecast error variance of Ethiopian yields come from spillovers against only 16.70% attributed to its own shocks. On the other hand, the dominance of Angola and Ghana in spillovers transmission is no surprise. In fact, the economy of this country has been crippled by the recent oil prices crash that has seriously affected the public finances and spilled over to all the other sectors. The protracted worsening situation resulted in a series of credit rating downgrades in 2016 sending this country into the highly speculative territory, with serious consequences on the amount of foreign investment inflows and indeed the performance of its eurobonds on financial markets. The request for IMF bailout and the successive devaluations of the Kwanza amid the drastic shrink in foreign reserves were in fact far from reassuring investors. As concerns Ghana, it is worth reminding that this country issued its debut sovereign eurobond in 2007, making it the first African beneficiary of debt relief to tap the international bond markets. However, it is documented that the country increased its debt amid the discovery of oil and a rapid economic growth, but that the proceeds were used to increase public sector salaries instead of being invested in growth-generating infrastructure or reforms susceptible of generating extra revenues to service the debt. As a result, this country faced unsustainable pressure on its public finance that affected the value of the cedi, leaving no option but to return to the IMF for a three-year rescue package of US $1 billion in 2014. Ghanaian finances were further affected by plummeting commodity prices that considerably restricted the ability of the government to address the soaring prices for electricity, water and fuel, thus stoking public's anger amid a perception of that politicians are mishandling the economic crisis and mismanaging public finances. It is no surprise that, along the way, the deterioration of investors' confidence in the credit quality of Ghana did affect the performance of its bonds on international markets.

Furthermore, the result show negative net spillovers for Namibia, Tanzania, Rwanda, Ethiopia, Senegal, Nigeria and Kenya. Rather than a simple coincidence, these countries have in common a commendable degree of macroeconomic stability and resilience to global economic shocks thanks to improvements in economic diversification and the quality of macroeconomic management. For example, Namibia's eurobond was the only one holding an investment grade credit rating throughout our study period, indicating the level of markets' confidence in the creditworthiness of this country. Also, Tanzania, Rwanda, Ethiopia and Senegal have for a long time been praised for their infrastructure development and service sector-based sustained economic growth in spite of the global shocks, particularly so for Ethiopia and Tanzania that have been projected among the 10 world fastest growing economies of 2017 by World Bank (2017). As a rule, these countries' lower level of spillovers transmission is undoubtedly explained by their established resilience to both idiosyncratic and global shocks.

5.2 Dynamic analysis of spillovers

The results of the static analysis provide a general picture of spillovers among SSA eurobonds. However, it is unlikely that the total and directional spillovers have remained unchanged over time given the occurrence and severity of idiosyncratic and global shocks that may have had heterogeneous impacts on SSA eurobond yields, and therefore affect both the size and direction of spillovers among these assets. In the following paragraphs, we present the results of the same exercise as above using 120-days rolling windows. In addition to the evolution of the total spillover index, we extend the analysis to the directional and net spillovers in an attempt to identify the potential sources of increases in the total spillover index over time.

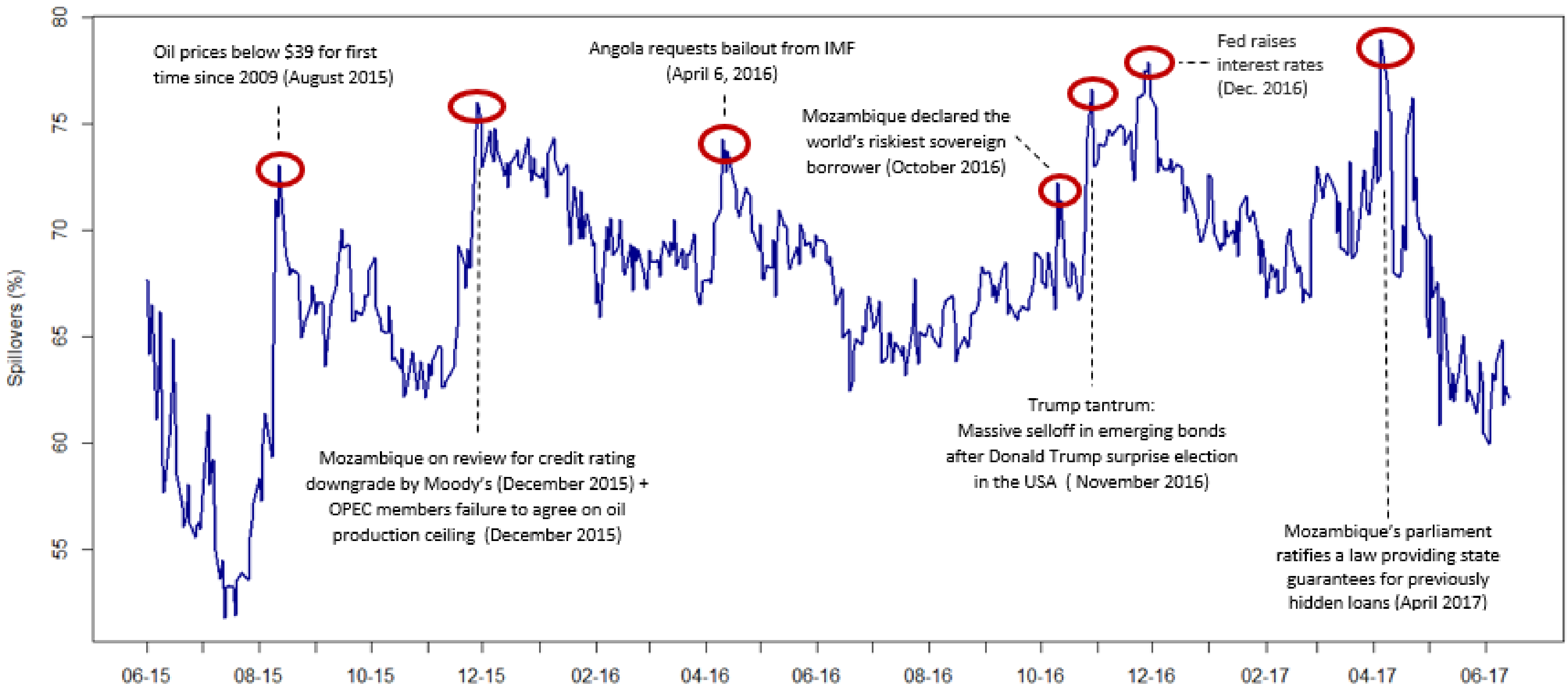

Figure 2: Total spillover index

Figure 2 shows the evolution of the total spillover index over our study period. As expected, rather than being constant, this index has had a sawtoothed evolution with salient picks that seem to be related to major news and events that affected these bonds either collectively or individually. Starting at around 65% in mid-June 2015, it is observed that after a declining trend reaching a trough in end-July of the same year, this index hiked to reach a pick of 73% in August amid the crude oil selling at less than 39 US$ per barrel for the first time since 2009. The index appear to have further increased to 76% in reaction to the news about the OPEC failure to agree on oil production ceiling to curb the falling prices. Besides the effects of plummeting oil prices, this index has been sensitive to idiosyncratic shocks affecting some of the bond issuers as well as the political and economic changes in the USA. It seems justified to relate the pick of 74.29% in April 2016 to the Angola's decision to request a bailout from the IMF, and the 72.21% pick to the Mozambique's surprise announcement of the intention to restructure once again its eurobond, announcement that triggered a dramatic hike in the yields making this country the world's riskiest sovereign borrower in October 2016. The index has not been immune to the Trump tantrum that is documented to have caused a massive sell-off of emerging markets securities amid uncertainty about the outcomes of Mr. Trump's economic and trade policies, nor to the decision by the FED to raise interest rates in December 2016 for the second time since the 2008's financial crisis. Likewise, the index has been affected by the default of Mozambique on its interests due in January 2017 and, even more, the ratification by the parliament of the controversial previously-hidden debts in April 2017 that corresponds to the index maximum level of 78.99%.

The evolution of spillovers among SSA eurobonds is further illustrated by the dynamic directional and net spillovers presented in Figure 3, Figure 4 and Figure 5 which present respectively the evolution of the percentage amount of the 10-step-ahead forecast error variances spilled over to and received from others, and the net spillovers computed as in the static analysis. Cases of excessive spillovers have been identified using an arbitrary cutoff of 1.5 corresponding to 150% transmitted or net spillovers as observed for each bond over the study period. In line with the evolution of the total spillover index, these graphs show that this threshold was at he onset crossed by Angola and Nigeria as a result of plummeting oil prices. Many among the rest of the countries appear to have followed suit amid the intensification of the commodity prices crisis and most probably the consequences of the Chinese rebalancing. This is particularly the case for Gabon, Ghana and Zambia that got their public finances jeopardized with severe consequences on their macroeconomic and, sometimes, political stability. These stability threats were reverberating into the series of credit rating downgrades and therefore soaring yields at secondary markets.

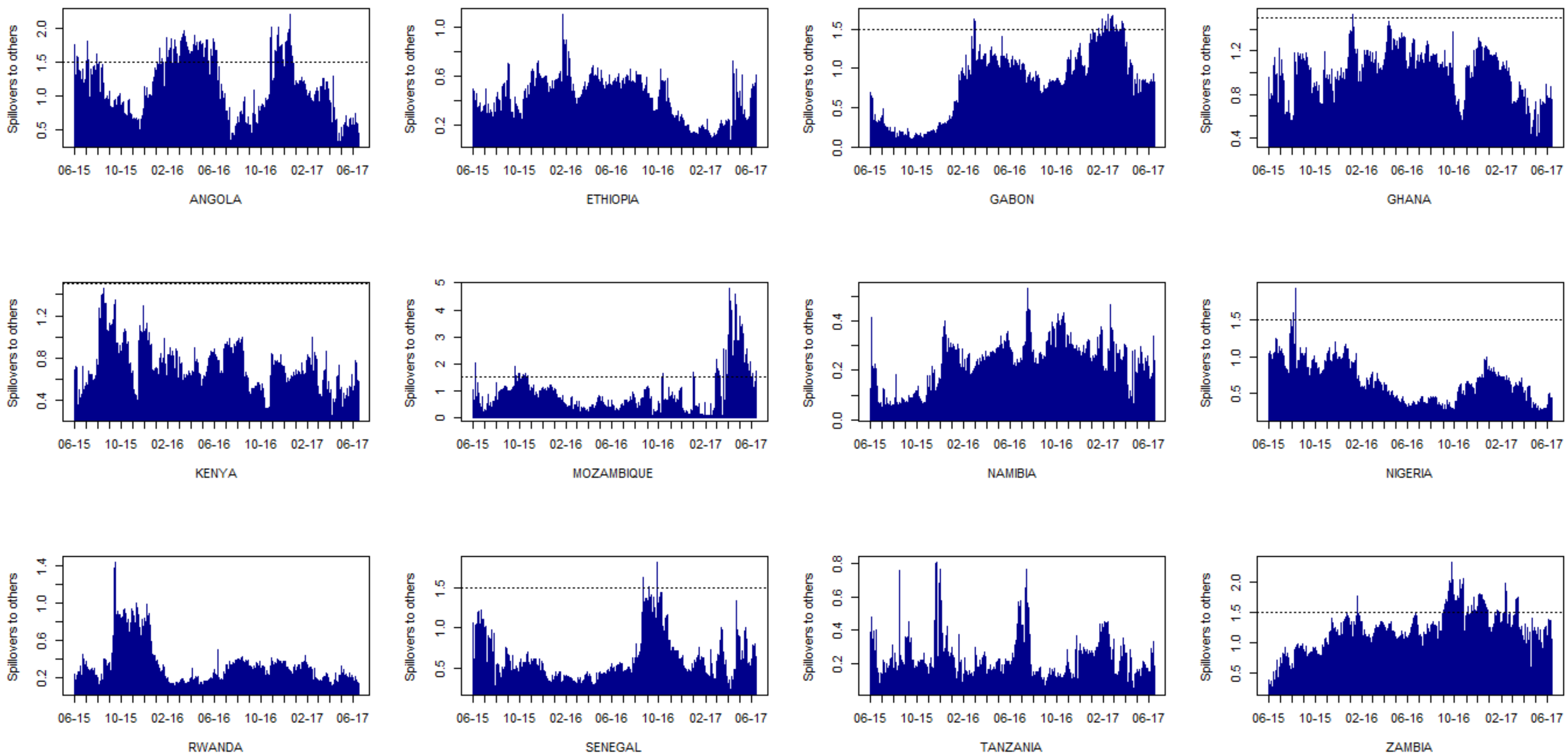

Figure 3: Spillovers to others

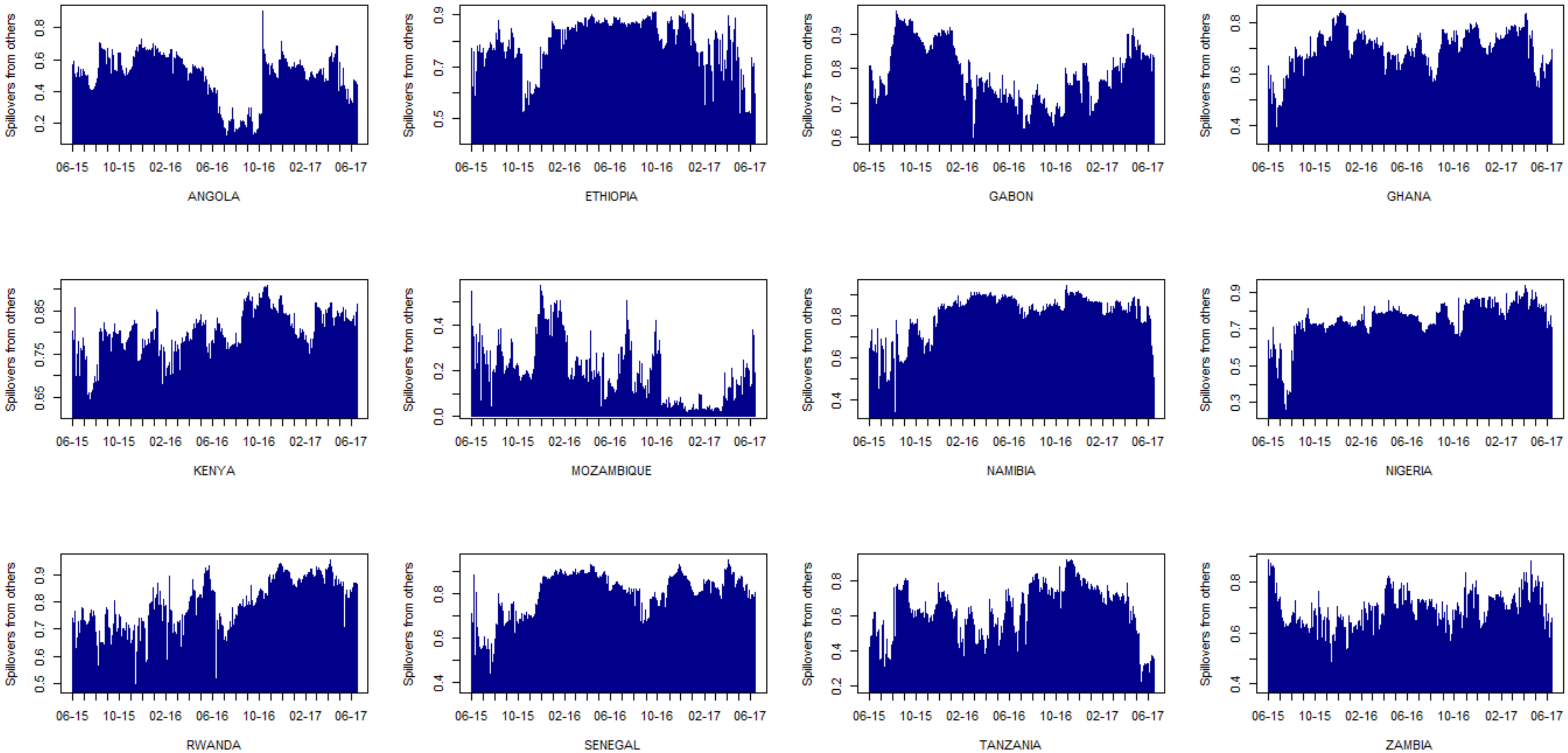

Figure 4: Spillovers from others

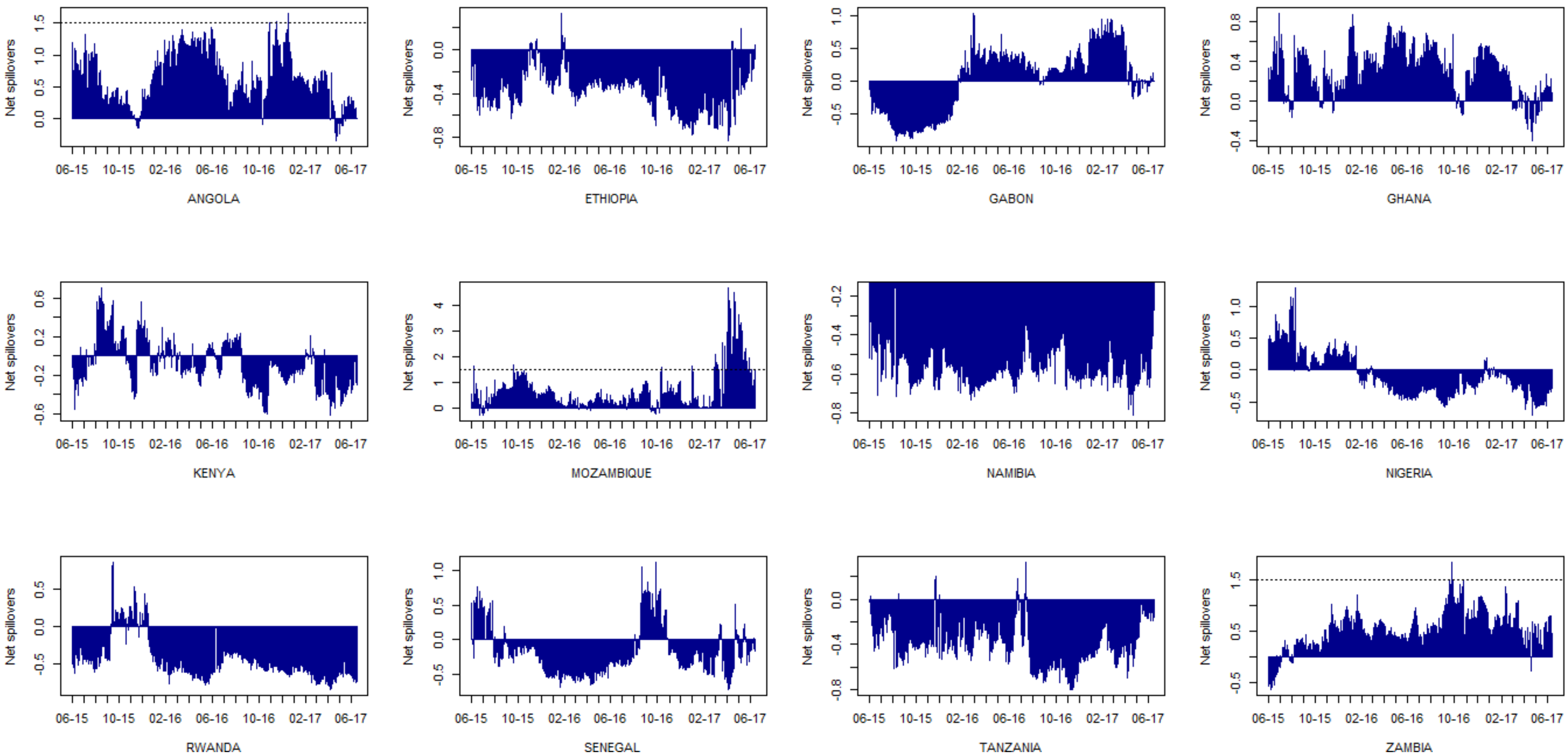

Figure 5: Net spillovers

The case of Mozambique deserves a particular attention. The evolution on Figure 3 and Figure 5 show that this country has in most of the time had the highest level of spillovers transmission and has in almost every time a net transmitter of spillovers to the other bonds. Besides the influence of global factors, it is worth reminding that this country's economic nightmare is reported to derive from cases of serious breach of trust and lack of transparency such as allegations of misallocation of the bond proceeds and, even worse, the disclosure of hidden debt of over 1.4 billion US$ by the Mozambican government in April 2016. Since then, Mozambique yields have been soaring to unprecedented levels and thus deviating from the general evolution of other SSA eurobond yields. In October 2016, the country was deemed the world's riskiest sovereign borrower amid a series of attempts to restructure the eurobond in disagreement with the bondholders. To top it all, the country defaulted on its interest payments of January 2017 thus creating panic among investors regarding the probability of other SSA eurobond issuers to default in the near future[3].

However, though the results of the dynamic analysis of the directional and net spillovers indicate substantial levels of spillovers transmitted by the Mozambique's eurobond to its peers, the overall picture drawn from the static analysis depicts a rather limited degree of interdependence between this bond and the rest of the SSA eurobonds under consideration. First, it is indicated that 88.73% of the 10-step-ahead forecast error variances of Mozambique's bond come from idiosyncratic shocks and that only 11.27% can be attributable to shocks to all the bonds taken together. Second, the bond seems to transmit in total not more than 38.84% to its peers, just a bit more than the individual contributions of Rwanda, Namibia or Tanzania. While the case of these latter seems logical given their proven strong resilience and hence the status of net-spillover receivers, the relatively low amount of spillovers transmitted by Mozambique contrasts significantly with the performance of this bond as observed in Figure1. Commonsense would hypothesize that, given their nature and frequency, the shocks that have been afflicting Mozambique could spill over to the performance of other bonds by triggering a loss of confidence by investors in the whole universe of SSA eurobonds. By rejecting this hypothesis, our results suggest that markets have been able to isolate Mozambique from the rest of the bonds, thus confining to the best the consequences of its derailing behaviors to its own performance.

[3]The Bloomberg post of February 3rd, 2017 titled "African issuers scrutinized after Mozambique's bond default" indicated that, using its sovereign credit risk model, Senegal, Tunisia, Ghana and Zambia were likely the next to default in the following 12 months with the probabilities of 5.6%, 3.5%, 3.4% and 1.04% respectively. More details on https://www.bloomberg.com/news/articles/2017-02-03/default-in-mozambique-prompts-some-analysts-to-ask-who-s-next

5.3 Impulse responses

The impulse-response functions of our VAR system are presented in Figure 6. These graphs show the impact of onestandard deviation shock to our individual SSA eurobond on its own yields and those of its peers on a 30 day forecasting horizon. However, as stressed by Antonakakis and Vergos (2013), these results should be interpreted with care given that they have been produced in the generalized VAR framework that impairs the orthogonality of shocks affecting these individual bonds. Moreover, the global characteristic of the main shocks that have affected financial markets during our study period increases the chances of synchronization and correlation of shocks across countries. We therefore agree with Antonakakis and Vergos (2013) that our generalized impulse-responses are simply indicative of the impact of future shocks.

Our impulse-response results suggest significant but short-lived reactions of these individual bond yields to their own shocks and those affecting their peers. In almost all cases, the impact appears to die off within the following 20 days, exception made for Mozambique whose reactions seem inconsistent and non-convergent. Equally important is the Angola and Mozambique's high reaction of respectively over 30% and almost 80% to their own shocks. Consistent with the results of the directional spillovers, this observation further confirms the fact that the biggest share of impact of the shocks affecting these countries was absorbed internally, with the effects to their peers being rather limited. On the other hand, Namibia and Rwanda appear to be the least affected by their peers' shocks thus confirming their highest resilient status across the universe of our selected bonds.

All in all, the results of this study confirm the existence of shock-spillover effects among the selected SSA eurobonds over time, and indicate that these spillovers, as measured by the total spillovers index of Diebold and Yilmaz (2012), are responsive to events and news affecting either the global economic environment or the idiosyncratic performance of these bonds. The results of the directional spillovers analysis identify Angola followed by Ghana and Zambia as the dominant spillovers transmitters, while Namibia followed by Tanzania and Rwanda are deemed the dominant receivers of shock spillovers from their peers. These results underscore the that eurobonds issued by countries with strong fundamentals and resilient economies tend to receive more from and transmit less spillovers to its peers under distress. However, it has also been observed that, despite its level of distress, Mozambique has only transmitted less than expected amounts of spillovers to other SSA eurobonds. Instead, it has been absorbing up to almost 90% of own-triggered spillovers and has been the far most respondent to own shocks. In light of this observation, we believe to have found evidence of the isolation of Mozambique by financial markets due to its salient derailing behavior which is, to a considerable extent, a supporting evidence of the *market discipline hypothesis* in the case of SSA eurobonds.

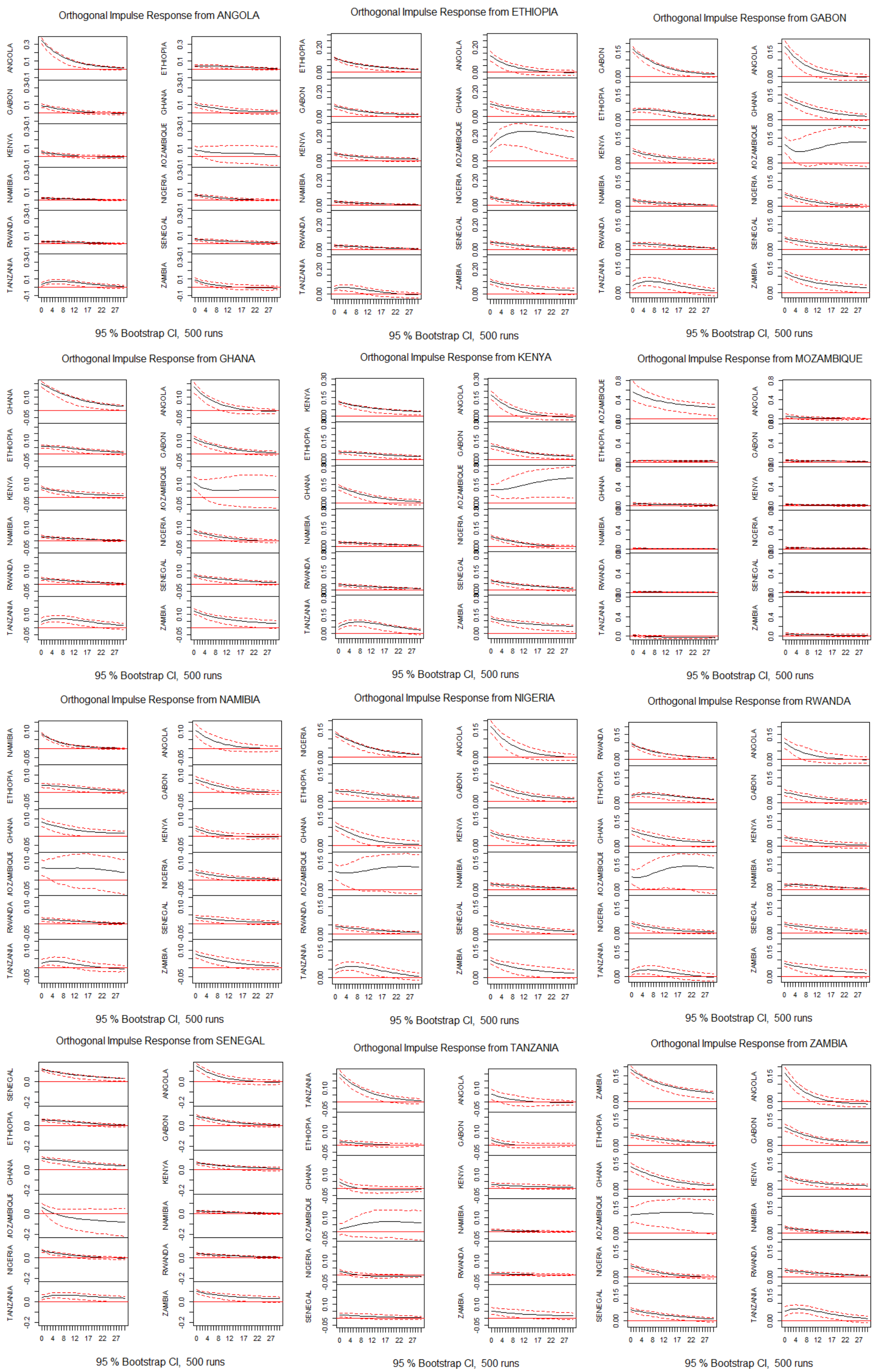

Figure 6: Impulse-response functions

6 Robustness analysis

In this paragraph, we test the robustness of our results by excluding Mozambique in the sample. In fact, the evolution of SSA eurobond yields on Figure 1 shows that Mozambique can rightfully be considered as an outlier with respect to the general trend followed by its counterparts. This exceptional behavior is also observed in the summary statistics in Table 1 with this country bearing the highest yields' mean and standard deviation of 15.79% and 5.39% respectively, and the highest yield level of 28.09%, the maximum ever reached by any SSA eurobond. We perform the same analysis as previously to assess the extent to which the results observed above as well as the subsequent conclusions may have been influenced by the presence of Mozambique, an outlier in our sample.

	ANG	ETH	GAB	GHA	KEN	NAM	NIG	RWA	SEN	TAN	ZAMB	From others
ANGOLA	0.6112	0.0255	0.0719	0.0769	0.0420	0.0118	0.0488	0.0114	0.0346	0.0065	0.0594	0.3888
ETHIOPIA	0.1234	0.1893	0.1387	0.1325	0.0886	0.0257	0.0761	0.0533	0.0666	0.0051	0.1008	0.8107
GABON	0.1446	0.0496	0.2526	0.1492	0.1002	0.0262	0.0654	0.0235	0.0583	0.0072	0.1231	0.7474
GHANA	0.1295	0.0484	0.1193	0.3190	0.0726	0.0214	0.0505	0.0328	0.0722	0.0065	0.1277	0.6810
KENYA	0.0955	0.0515	0.1226	0.1426	0.2237	0.0132	0.0841	0.0318	0.0752	0.0257	0.1342	0.7763
NAMIBIA	0.1149	0.0526	0.1212	0.1267	0.0887	0.2054	0.0685	0.0599	0.0517	0.0126	0.0978	0.7946
NIGERIA	0.1589	0.0543	0.0967	0.1153	0.0829	0.0207	0.2690	0.0371	0.0643	0.0086	0.0920	0.7310
RWANDA	0.1038	0.0498	0.1068	0.1427	0.0808	0.0238	0.0797	0.2220	0.0718	0.0078	0.1109	0.7780
SENEGAL	0.1293	0.0566	0.0860	0.1179	0.0806	0.0152	0.0759	0.0380	0.2718	0.0198	0.1089	0.7282
TANZANIA	0.1178	0.0120	0.0492	0.0674	0.0591	0.0074	0.0417	0.0082	0.0624	0.5001	0.0747	0.4999
ZAMBIA	0.0756	0.0543	0.1119	0.1475	0.0931	0.0223	0.0560	0.0288	0.0597	0.0266	0.3241	0.6759
To others	1.1935	0.4547	1.0242	1.2188	0.7886	0.1879	0.6466	0.3248	0.6169	0.1262	1.0295	**Total spill-**
Plus own effect	1.8047	0.6440	1.2768	1.5378	1.0123	0.3933	0.9156	0.5468	0.8886	0.6263	1.3536	**over index =**
Net spillover	0.8047	-0.3560	0.2768	0.5378	0.0123	-0.6067	-0.0844	-0.4532	-0.1114	-0.3737	0.3536	**69.20%**

Notes: Positive (negative) net spillover indicates country's position as net transmitter (receiver) of spillovers.

Table 4: Spillovers without Mozambique

The results of our new analysis (without Mozambique) are presented in Table 4. We find a total spillover index of 69.20% indicating the amount of the 10-day step ahead forecast error variance across the examined eurobonds coming from spillovers. We do not find significant changes in the ranking as Angola remains the dominant spillover transmitter followed by Ghana and Zambia, while Namibia followed by Rwanda and Tanzania keep their positions of the dominant receivers of SSA eurobond yield spillovers. The observation that countries with a commendable degree of macroeconomic stability and resilience to global economic shocks have the lowest net spillovers is not challenged either as Namibia, Tanzania, Rwanda, Ethiopia, Senegal and Nigeria still have negative net spillovers, and Kenya has the next lowest level nearing zero.

Besides the robustness to the presence of an outlier, these results indicate a low contribution of Mozambique to the total spillover index as its exclusion raises the index to 69.20% (versus 66.37% previously). In fact, in light of the formula in Equation (3), its obvious that only little amount of cross-country spillovers (numerator) have been lost by the exclusion of Mozambique compared to the shrink in the number of countries under consideration (denominator) to result in a higher index level. This is consistent with the information in Table 3, Figure 3 and Figure 5 showing that shocks to Mozambique were mainly affecting its own performance and exceptionally (end 2015 and mid-2017) spilling-over to its peers.

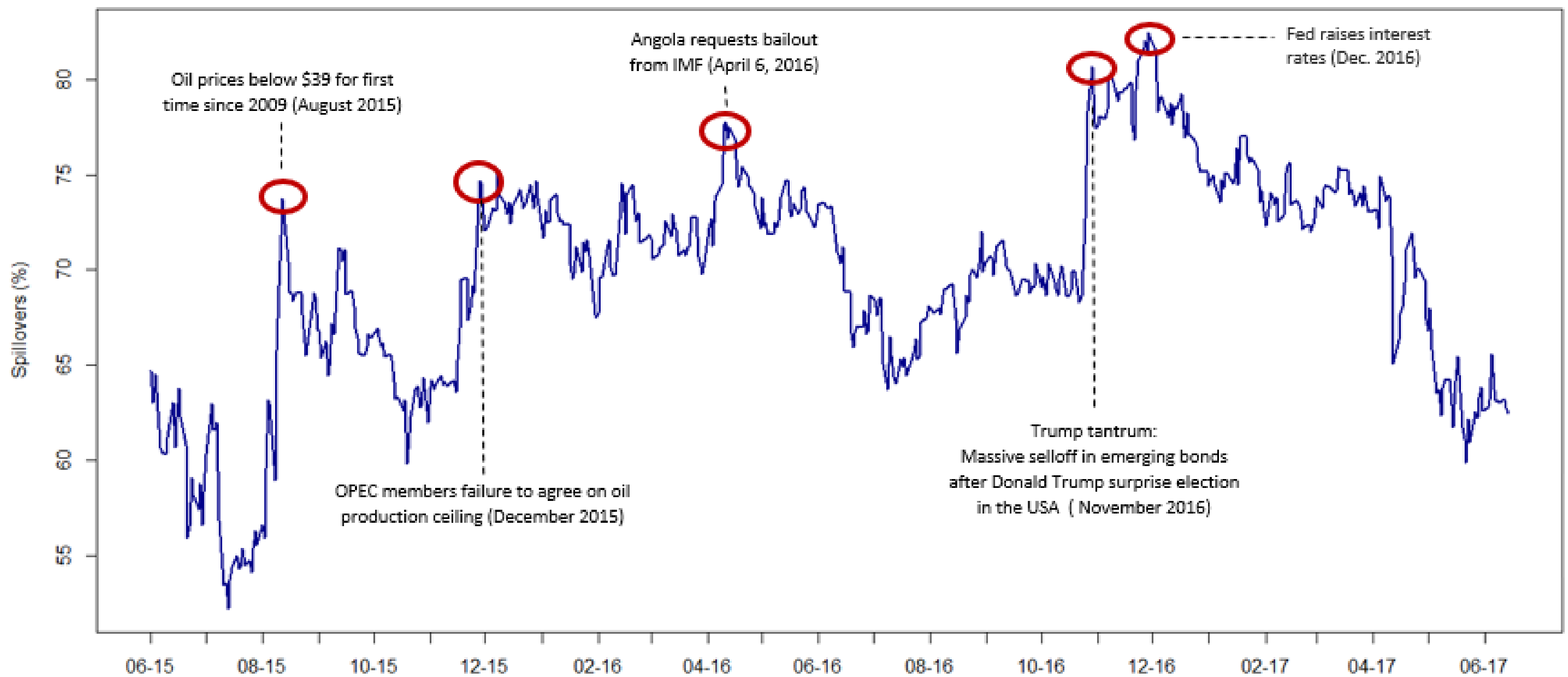

Figure 7: Total spillover index (excl. Mozambique)

As regards the soundness of the methodology, the results of the dynamic analysis presented in Figure 7 show that the effects of Mozambique have been appropriately filtered out to produce an index evolution clean from the pics related to this country's idiosyncratic shocks. Moreover, it has produced slightly higher levels of the total spillover index compared to Figure 2 (except for the Mozambique-related pics), which is consistent with the observation made above of the static analysis. The low spillovers contribution of Mozambique constitutes, in our view, an additional evidence of the isolation of the abnormal case of Mozambique by the market when it comes to forecasting the performance of SSA eurobonds.

7 Conclusion

This study has investigated yield spillovers among selected Sub-Saharan African (SSA) eurobonds for the period January 2015 – June 2017. The results of the VAR-based spillover index indicate that 66.37% of the forecast error variance in all the 12 considered SSA eurobond yields come from spillovers. The directional spillovers analysis points to Angola as the dominant transmitter of SSA eurobond yield spillovers followed by Ghana and Zambia, while Namibia followed by Tanzania and Rwanda appear to be the dominant receivers of SSA eurobond yield spillovers. The same analysis on 120-day rolling windows show that the total spillover index has been responsive to major economic events and news announcements such as the OPEC failure to agree on oil production ceiling to curb the falling prices in December 2015, the Angola's decision to request a bailout from the IMF in April 2016, the Mozambique's surprise announcement of the intention to restructure once again its eurobond in October 2016 or the Trump tantrum documented to have caused a massive sell-off of emerging markets securities in November 2016 amid uncertainty about the outcomes of the newly-elected US president's economic and trade policies. At the individual level, these results underscore the fact that eurobonds from countries with weak fundamentals and less resilient economies transmit more to and receive less from their peers, but that this relationship is not linear: cases of extreme fragility such as that of Mozambique do no translate as expected into higher spillovers to peers. This non-linear linearity between the strength of countries' macroeconomic fundamentals and degree of transmitted spillovers provide to a considerable extent support to the *market discipline hypothesis* in the case of SSA eurobonds as markets prove to have been able to factor-in and discriminate against bonds emanating from economies experiencing salient abnormal derailments.

The generalized VAR framework used in this analysis has had the advantage of producing spillovers that independent of the ordering of our variables in our VAR system. However, this desirable feature has at the same time brought a limitation to the interpretation of the impulse-response results given the difficulty of ensuring orthogonality of shocks affecting these individual bonds in this framework that rather accounts for the correlation of shocks across the system's constituents. While a certain caution would be attached to the interpretation of the impulse-responses with a 'ceteris paribus' mindset, we still believe that our results provide good indications of the impact of future shocks on our variables since, in any case, we do not expect shocks to these bonds to appear in isolation from each other given the degree of increased globalization of economies hence the synchronization and correlation of shocks across countries. However, we do believe that the use of a framework allowing for orthogonal shocks constitutes an interesting avenue for the extension and update to this study.

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