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Picking the Distress Signal from the Treasury Bills' Market

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The Interbank Market in Kenya: Picking the Distress Signal from the Treasury Bills' Market

By Jared Osoro* and David Muriithi*

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Abstract

This paper seeks to explore the Kenyan interbank market characteristics at a time of liquidity stress and how it relates to the intervention by the Central Bank of Kenya (CBK) through the open market operation. We seek to ascertain whether the CBK's action during the interbank market distress – arising from either a market player being placed under receivership, or the collapse of a bank – is reactive or proactive. The ARCH family of models, specifically the EGARCH and TGARCH, are applied to explore the interbank market–Treasury bill market nexus. Three episodes of banking industry stress arising from the placement of Dubai Bank, Imperial Bank and Chase Bank placement under receivership within a nine-month period anchor the analytical stress triggers. The key findings are that 91-Day the Treasury Bill rate positively and significantly affects the interbank market rate, with the effect doubling in the wake of a distress in the banking system. The Treasury Bills market reveals two important attributes of a distressed interbank market. One is that the interbank market volatility is long-lived rather than transitory. This implies the CBK intervention through either lender of last resort window or open market operations, and the market response as could be inferred from the Treasury bill market does not solve the structural challenges within the interbank market. Two, there is an asymmetric reaction to news depending on whether they are good news or bad news. The reaction of the interbank market to bad news as would be picked by the Treasury Bills market significantly impacts on interbank market unlike when there are no bad news hence evidence for leverage effect. We further note that even with the intervention by the CBK or the market reaction through liquidity portfolio shifts, the leverage effect in the interbank market still remains.

Key Words: *Interbank, Volatility Clustering, GARCH models and leverage effect*

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1.0 Introduction

This paper seeks to put a spotlight on Kenya's interbank market, particularly how it operates during periods characterised by stress. Unlike other components of the financial markets that are typically analysed in the context of their interface with the wider economy, the interbank market is often seen in the narrow context as an exclusive banking industry market.

In that regard, the critical role of the inter-bank market in ensuring stability is understated. The thrust of the paper therefore is to demonstrate how the interbank market is at the core of the linkages that go beyond those amongst market players.

The role of the interbank market in any economy is critical in allocation of liquidity from banks with surplus to the banks facing liquidity deficit. Shocks in the interbank market caused by liquidity stress are impediments for an efficient interbank market. These shocks lead to volatility in the interbank market as could be seen in the interbank traded volumes and interbank rates. In the worst scenario, these shocks bring distortions that could lead to increased costs of participating in the interbank market.

When the shocks to the interbank market are system-wide, the central bank assumes an intermediary function between liquidity surplus banks and liquidity deficit banks. We posit that by doing so, the central bank takes a reactive intervention as opposed to a proactive role in restoring effectiveness in the interbank market. Such interventions could arise in the wake of a bank run, collapse of a bank, placement of a bank under statutory management among others.

Analyses of Kenya's interbank market have tended to focus on its linkages to monetary policy conduct (Oduor, *et. al.*, 2014; Alper, 2016, *et. al.*). The linkages are explored on the back of the inter-bank being considered to be not only inefficiency but also segmented. While the inefficiency characteristic of the interbank market in the context of Kenya would be attributable to the relativity of market depth compared to those markets considered to be close to efficient, segmentation is a function of market structure and is therefore not unique.

Stylised characterisation of interbank markets that underpin theoretical and empirical studies (e.g. Kim, 2014) draw on the "small-bank"–"big-bank" dichotomy. Three outcomes point toward the odds typically being against small banks:

- The first is that big banks lend to each other at a rate close to the central bank target rate.
- The second is that a small bank borrowing from a big bank tends to pay a higher rate than central bank target rate while if the small bank was lending to a big bank, it will get a lower rate than the central bank target rate.
- The third is that a small bank trading with a big bank will only get more favourable terms for larger loans.

These three characteristics are nuanced in the Kenyan case, cognisant that the policy signalling ability of the interbank rate is constrained by inefficiency and segmentation attributes. We therefore contextualise the Kenyan market along three characteristics:

- One, banks in the "big" category – to the extent that size is perceived to be a basis for quality – lend to each other at less limiting terms that they do to "small" banks. This view is aligned to Kim (2014)
- Two, the interbank network structure is asymmetrical such that "big" banks often have opportunity for access relationships across the industry while "small" banks do not. The ease of access is enhanced if a bank belongs to a regional or international network, a perspective highlighted by Deb (2016) in a comparison between belonging to different networks and creating a related party network. In other words the benefits of multimarket banking as envisaged in Berrospide, et. al., (2016) go beyond spreading credit and funding risks to include boosting interbank market access at the local level.
- Three, in the event of flight to quality – and if the perspective is that size and quality have a positive correlation – banks in the "small" category are subject to the access, not even cost, squeeze.

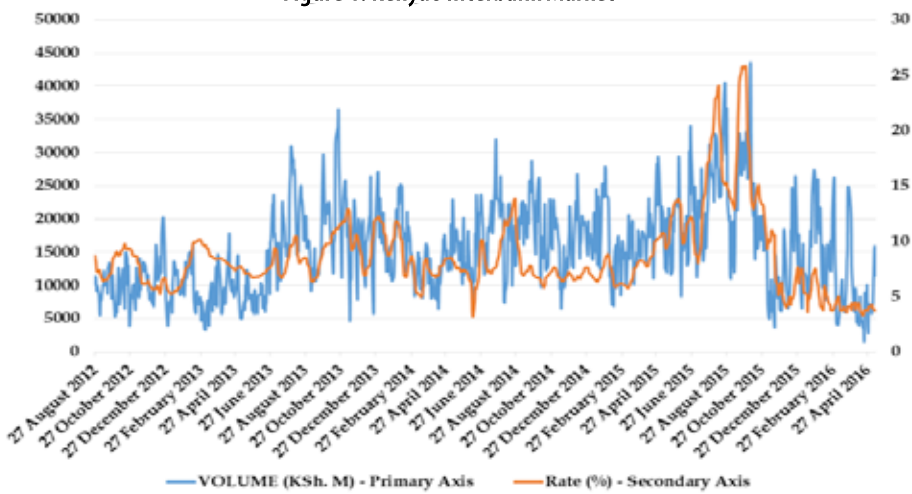
By seeking to understand the interbank market beyond its relationship with monetary policy conduct, this paper enhances the appreciation of the market when it is distressed. Such appreciation is often masked when the market is superficially assessed based on the volume-price tracking. As **Figure 1** shows, the recent evolution of the Kenyan interbank market shows 'normal' market behaviour. In reality, the market has been far from normal.

In the recent episodes three banks, considered "small" under the "small bank - big bank" dichotomy, were placed under receivership by the Central Bank of Kenya (CBK) anchor this paper's analytical stress triggers. As Kim (2014) observes, the disadvantage that small banks experience in the interbank market during a crisis can largely be explained by a shift in the liquidity cost, rather than by changes in loan supply and demand. In the Kenyan case, such distress could be seen to be beyond costs; in stances there has been obvious supply cuts that cannot be observed from the aggregated datasets.

Why the interbank market

In order to unmask the interbank market, We step back and looks at the basics of why the interbank market exists in the first place. We then trace the linkages between the inter-bank market and other markets with a view to assessing whether the signal of distress could be picked from another price besides the interbank rate. The conceptual thinking of looking for the distress signal of one money market price in another money market price is motivated by Dornbusch (1976) seminal analysis and especially its core observation that financial markets are dynamic to the extent of the that prices of relatively more liquid financial assets adjusting much faster than goods' prices or even other financial assets such as loans.

Figure 1: Kenya's Interbank Market



Source: Central Bank of Kenya

The interbank market could aptly be described as a liquidity co-insurance market (Castiglionesi, *et. al.*, 2014). Banks are typically exposed to liquidity risks by virtue of the fact that they transform short-term liquid liabilities to long-term illiquid assets. To manage the risk, they hold reserves as a self-insurance mechanism. Reserves however present a cost to banks as they forgo income by not investing in risky assets that are illiquid or at the very least near-liquid assets such as short-tenor government securities. Banks therefore participate in the interbank market where they exchange resources with each other thus co-insuring themselves against liquidity risks.

The existence of the interbank market by no means imply that the ensuing co-insurance offers a full solution to liquidity challenges. The interbank solution to liquidity challenges becomes at best partial, considering that liquidity challenges could be systemic, in which case it is impossible to co-insure. Furthermore, the interbank market being typically an over-the-counter affair means that it hinges on pre-established connections that could be limited; this makes it hard to co-insure liquidity risks if there are no pre-established connections or they have been severed. As an alternative, banks could resort to capital holders to whom they will adjust the pay-out; in essence banks could transfer part of the liquidity uncertainty to capital holders, this itself being costly because capital to banks also comes at a cost.

The foregoing rationale for the existence of the interbank market as well as the alternatives in the form of reserves and capital with the attendant costs, are instructive on how to approach the understanding of the recent distress in interbank market in Kenya following three episodes namely placing of receivership of Dubai Bank Limited on 13th August 2015, Imperial Bank Limited on 15th October 2015 and Chase Bank Limited on 7th March 2016. These episodes point towards three linked observations that are key to this paper's objective.

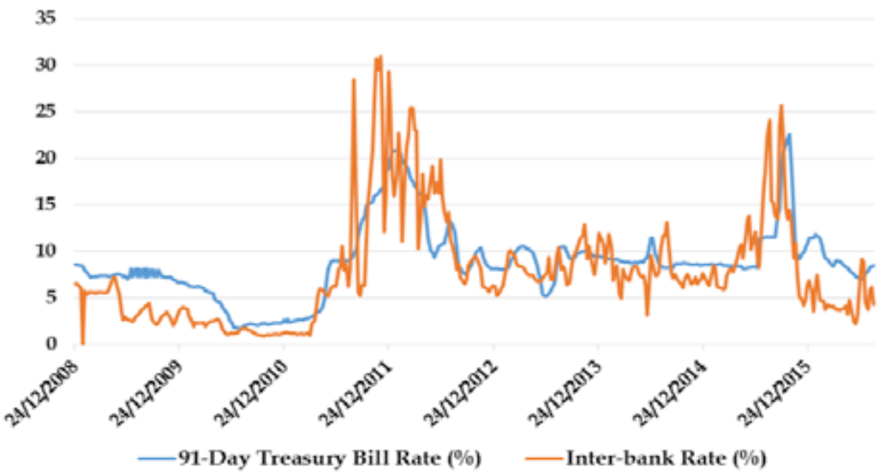
First, pre-existing connections at a bilateral level were severely tested to the disadvantage of "small banks", which are manly borrowers in the interbank market. It didn't help that the "small banks" experienced capital flight as could be confirmed by the CBK on April 2016 when it availed a liquidity support framework for commercial and microfinance banks following market linked to the placement of Chase Bank Limited under receivership. Under the circumstances, the lender banks in the interbank market considered the Treasury Bills market as an alternative.

Second, the challenges associated with the three banks – whose common characteristics are that they were all local banks without foreign principals and were not in the "big-bank" category – were not considered to be systemic in the sense of affecting the general stability of the Kenyan banking industry. In any case pinning systemic risks to a given institution is not easy (see Danielsson *et. al*., 2016). Nonetheless, the effect on the interbank market has been system-wide.

Third, there is no evidence to suggest that the liquidity challenges observed and the ensuing system-wide effect on the interbank market have led to a capital response from shareholders; in any case such response requires more time.

These observations motivate the search for a signal alternative to the interbank rate to guide gauge the persistence or lack thereof of distress following market disturbance. Given the first observation, this paper hypothesises that the alternative signal can be picked from the shortest tenor of the Treasury Bills market. The hypothesis stems from two factors. One, there is a very close association between the interbank rates and the 91-Day Treasury Bill rates (**Figure 2**).

Figure 2: Interbank – Treasury Bill Rates Evolution



Source: Central Bank of Kenya

Two, the Treasury Bills have both policy and market inclinations. To the extent it is associated with Government resource requirements as triggered by the fiscal policy stance, the Treasury Bills market could have a big influence on the overall market liquidity as the government is arguably a major market player. A rise in the Treasury Bill rate could be interpreted as signal of tight liquidity conditions owing to the Government presence the market. The policy angle arises from the fact that CBK Monetary policy actions could somewhat be influence by the Governments fiscal action, a phenomenon called fiscal dominance.

It is recognised that the CBK can influence liquidity in the market by way of repurchase orders (Repos). When banks have liquidity shortage, they can borrow from the CBK at the Repo rate – the rate at which the central bank lends short-term money to the banks against securities. A reduction in the Repo rate helps banks get money at a cheaper rate. The reverse repo rate - the rate at which the banks maintain surplus funds with CBK signals the level of liquidity surplus in the market. The reverse Repo rates have almost perpetually been zero. This is by no means suggestive of no instances of liquidity abundance in the market;

instead it is suggestive of the limitations of using the Repo and reverse Repo rates as a signal of liquidity distress or abundance.

The next section of this paper specifies the model for the empirical assessment of the extent to which the Treasury Bills market reveals the nature of distress in the interbank market. The assessment is undertaken around three recent episodes of bank failures that distressed the interbank market at varying degrees. The empirical results are reported in the following section, upon which conclusions and policy inferences are made in the final section.

2.0 Empirical Model Specification

This paper models the influence of the Treasury Bills market – which market reflects both policy and market adjustments when there is distressed influence – on the interbank market. The central bank's open market operations during the time could lead to either transitory or long lived influence the interbank market.

If such influence is transitory, then the effectiveness of such central bank's intervention in curing the interbank market by realigning the structural deficiencies of interbank market is questionable. This would therefore confirm that central bank's intervention is a reactive policy whose effect dissipate shortly after the interbank market comes back to near – normal operation. Such reactive policy therefore does not address the weak structure of the interbank market which could results to recurring systemic problems in the interbank.

Given the integration in the short term interest rates market, we acknowledge that shocks in the interbank market could trigger open market operations response. It could also lead to the Treasury bill market being the resort of the lender banks seeking the next nearest liquid asset. By taking into account such dynamics, this paper avoids a one sided analysis and instead takes a dual analysis approach.

The paper therefore adopts the Autoregressive Conditional Heteroscedastic (ARCH) models in analysing the nexus between interbank market volatility and the open market operations as reflected in the Treasury Bills market. More specifically, the paper adopts the Exponential Generalized Autoregressive Conditional Heteroscedastic (EGARCH) by Nelson (1991) and Threshold Generalized Autoregressive Conditional Heteroscedastic (TGARCH) model by Zakoian (1994) which is ideal for capturing information asymmetry in financial data.

We specify the EGARCH and TGARCH models for interbank rates as follows:

$$IR_t = \alpha + IR_{t-1} + TBR + \varepsilon_t \quad (1)$$

$$Ln(h_t) = Ln\sigma_t^2 = \omega + \sum_{j=1}^{p} \beta_j Ln(\sigma_{t-j}^2) + \sum_{i=1}^{q} \alpha_i \left\{ \left| \frac{\varepsilon_{t-i}}{\sigma_{t-i}} \right| - \sqrt{\frac{2}{\pi}} \right\} - \gamma_i \frac{\varepsilon_{t-i}}{\sigma_{t-i}} \quad (2)$$

Where:

IR_t	Is the current week interbank rate
IR_{t-1}	Is the last week interbank rate
TBR	is the 91-DayTreasury Bill Rates
ε_t	is the error term for the model

$h_t = \sigma_t^2$ is the variance for the model

Model 1 is the mean equation while model 2 is the variance equation for the EGRACH model.

$$IR_t = \alpha + IR_{t-1} + TBR + \varepsilon_t \quad (3)$$

$$h_t \quad \sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \gamma d_{t-1} \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad (4)$$

Similarly, we specify our TGARCH model as follows:

Where d_{t-1} is a dummy where

$$d_{t-1} = \begin{cases} 0 \text{ if } \varepsilon_{t-1} < 0, \text{bad news} \\ 1 \text{ if } \varepsilon_{t-1} \geq 0, \text{good news} \end{cases}$$

Bad news here refers to placement of a bank under statutory management while good news would refer to the revival of the lender who has been under statutory management. Model 3 is the mean equation while model 4 is the variance equation for the TGARCH model. As stated earlier, this paper adopt a dual analysis approach unlike a one sided analysis approach. With this regard, therefore we acknowledge that what happens in the interbank market influences the open market operations in management of liquidity challenges in the market. By the same symmetry we specify our EGARCH and TGARCH models for Treasury bill market as follows:

$$TBR_t = \alpha + TBR_{t-1} + IR + \varepsilon_t \quad (5)$$

$$Ln(h_t) = Ln\sigma_t^2 = \omega + \sum_{j=1}^{p} \beta_j Ln(\sigma_{t-j}^2) + \sum_{i=1}^{q} \alpha_i \left\{ \left| \frac{\varepsilon_{t-i}}{\sigma_{t-i}} \right| - \sqrt{\frac{2}{\pi}} \right\} - \gamma_i \frac{\varepsilon_{t-i}}{\sigma_{t-i}} \quad (6)$$

Model 5 is the means equation while model 6 is the variance equation for the **EGARCH** model.

$$TBR_t = \alpha + TBR_{t-1} + IR + \varepsilon_t \quad (7)$$

$$h_t = \sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \gamma d_{t-1} \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad (8)$$

Model 7 is the means equation while model 8 is the variance equation for the **TGARCH** model.

3.0 Results and discussion

The financial sector stress periods is captured by the period in which three banks were placed under receivership.

In this case we had period 1 which is the period from January 2009 but before the placement of any bank under receivership, period 2 captures the period when Dubai bank was place under receivership, period 3 captures the time when Imperial bank was placed under receivership while period 4 captures the period when chase bank was placed under receivership. Period 5 captures all the three stress period in the banking industry, with the analyis period being January 2009 to August 2016.

Table 1: Exponential GARCH results for interbank market volatility analysis

EGARCH (1, 1) Results - INTERBANK					
Mean equation					
	Period 1 (prior)	Period 2 (Dubai)	Period 3 (Imperial)	Period 4 (Chase)	Period 5 (Overall)
Constant	0.0793***	0.0657**	0.0557	0.0637**	0.0494
	(0.0058)	(0.0547)	(0.1147)	(0.0463)	(0.1673)
Interbank (-1)	0.9225***	0.9085***	0.9100***	0.9225***	0.9084***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Treasury bill market	0.0294**	0.0462***	0.0456***	0.0306**	0.0474***
	(0.0182)	(0.0012)	(0.0017)	(0.0159)	(0.0020)
Dummy Dubai		-0.1177			1.3829
		(0.6222)			(0.3376)
Dummy Imperial			-0.1453***		-1.5642
			(0.0012)		(0.2832)
Dummy Chase				0.0328	0.1023
				(0.8740)	(0.6778)

EGARCH (1, 1) Results - INTERBANK					
Mean equation					
	Period 1 (prior)	Period 2 (Dubai)	Period 3 (Imperial)	Period 4 (Chase)	Period 5 (Overall)
Conditional Volatility Equation					
Constant	-0.4426***	-0.4079***	-0.4135***	-0.4617***	-0.4440***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ARCH (1) (α1)	0.6508***	0.5777***	0.6131***	0.6650***	0.6385***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Asymmetry (γ)	0.0729	0.1396**	0.1039***	0.1574*	0.1141**
	(0.1827)	(0.0185)	(0.0048)	(0.0718)	(0.0710)
GARCH (1) (β)	0.7522***	0.9404***	0.9483***	0.9539***	0.9383***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Dummy Dubai		0.0893***			0.3155
		(0.0110)			(0.1213)
Dummy Imperial			-0.0292		-0.5952**
			(0.4857)		(0.0116)
Dummy Chase				0.2382***	0.5586***
				(0.0053)	(0.0001)
R2	0.8359	0.8387	0.838618	0.836908	0.837799
Adjusted R2	0.8351	0.8375	0.8374	0.8356	0.8357
Log likelihood	-620.3749	-620.5510	-621.8022	-619.4122	-609.2092
Durbin - Watson	1.7350	1.7330	1.7357	1.7381	1.7359

Note: Significance probabilities in parenthesis, *** (significant at 1%) ** (significant at 5%) and * (significant at 10%).

From **Table 1,** it is clear that from the mean equation, the previous week's interbank rate significantly affects the current week's interbank rate. This is evidenced by the coefficient of Interbank (-1) for period 1 which is 0.9225 significant at 1 percent. Similar results are replicated for the other periods. The mean equation results indicate that the 91 Treasury bill rate positively and significantly affects the interbank market rate in all the periods. However, the results indicate that the effect rises significantly up in the stress times as compared to the stress free period. Prior to placement of any lender under receivership, the effect of 91 Treasury bill rate on interbank rate stands at 0.0294. This doubles to 0.0462 upon collapse of Dubai bank, 0.0456 upon collapse of Imperial bank and 0.0306 with placement of Chase bank under receivership. For the overall stresses combined, the effect of 91 Treasury bill rate on interbank rate is 0.0474. Both the Dubai bank dummy and the imperial bank dummy negative affect the interbank rates with only the imperial bank dummy being significant.

From the conditional variance equation results, the arch 1 (α1) reveal that volatility clustering was high following the placement of Chase bank under receivership as compared to Dubai and imperial bank case. However, as for the persistence in the shock as measured by GARCH term (β), it's clear that upon the occurrence of a financial stress, the persistence of volatility in the interbank market rises. For the period 1, β = 0.7522. However, upon financial stress the value of β (s) for period 2 up to period 5 are close to unity. Therefore, volatility shocks at the interbank are long lived rather than transitory. This implies that the Central bank intervention to restore the efficiency of the interbank market in allocating liquidity does not solve the structural challenges within the interbank hence long lived shocks in the interbank market upon the occurrence of such banking industry shocks.

The Exponential GARCH captures the asymmetry at the interbank market which is measured by coefficient γ. γ=0.0729 in absence of financial stress. However, in presence of financial stress, the measure of asymmetry rises significantly. Its significance reveal presence of asymmetry and thus bad and good news drive the interbank market.

Table 2: Exponential GARCH results for Treasury bill market volatility analysis

EGARCH (1, 1) Results					
Mean equation					
	Period 1 (prior)	**Period 2 (Dubai)**	**Period 3 (Imperial)**	**Period 4 (Chase)**	**Overall**
Constant	0.1132***	0.1299***	0.1222***	0.1135***	0.1304***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Treasury bill (-1)	0.9472***	0.9434***	0.9434***	0.9472***	0.9432***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Interbank market	0.0480***	0.0494***	0.0508***	0.0480***	0.0492***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Dummy Dubai		0.0809**			0.3565
		(0.0260)			(0.4955)

EGARCH (1, 1) Results					
Mean equation					
	Period 1 (prior)	**Period 2 (Dubai)**	**Period 3 (Imperial)**	**Period 4 (Chase)**	**Overall**
Dummy Imperial			0.0741**		-0.2078
			(0.0249)		(0.7039)
Dummy Chase				-0.0337*	-0.1728**
				(0.0913)	(0.0356)
Conditional Volatility Equation					
Constant	-1.0607***	-1.2043***	-1.0829***	-1.0659***	-1.2117***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ARCH (1) (α1)	1.2263***	1.3117***	1.2390***	1.2449***	1.2982***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
(RESID<0) ARCH (1) (α2)	-0.2723***	-0.2418***	-0.2449***	-0.2768***	-0.2558***
	(0.0001)	(0.0007)	(0.0003)	(0.0001)	(0.0003)
GARCH (1) (β)	0.8757***	0.8532***	0.8755***	0.8725***	0.8458***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Dummy Dubai		0.1568			0.7531
		(0.1439)			(0.1111)
Dummy Imperial			-0.0409		-0.6687
			(0.7142)		(0.2395)
Dummy Chase				-0.3230*	-0.3564
				(0.0637)	(0.1786)
R2	0.9623	0.9624	0.9622	0.9623	0.1786
Adjusted R2	0.9621	0.9621	0.9619	0.9623	0.9627
Log likelihood	0.7729	-176.9241	-180.8254	-180.9994	0.9622
Durbin - Watson	1.0132	1.0137	1.0086	1.0126	0.7716

Note: Significance probabilities in parenthesis, *** (significant at 1%) ** (significant at 5%) and * (significant at 10%).

For the Treasury bill market, it is evidently clear that the last week's rate significantly positive influences the current week's rate as given by Treasury bill (-1) coefficients in all the periods. However, looking at the effect of interbank market on the TB market, we find a unique outcome in that the interbank market positively and significantly affects the TB market. However, the change in of interbank market on TB market, is very minimal as we move from financial free situation to a situation of financial stress. This is opposite of the effect of TB market on interbank where we find that the effect of TB market on interbank rates doubles as we move from financial stress free situation to financial stress situation.

On volatility, high volatility clustering is evidenced in all period as measured by (α1). The persistence of volatility as measured by GARCH (1) (β) changes minimal across all periods. This is opposite of the results of the EGARCH results for interbank market.

Further we apply the Threshold GARCH (TGARCH) model analysis to ascertain the presence or absence of leverage effect in the allocation of liquidity through the interbank market. From **Table 3** results we deduce that placement of Imperial and chase bank under receivership negatively impacts on interbank rates though insignificant. The effect of Treasury bill rate on interbank market still remains to be high with the banking sector stress compared to banking sector stress – free period with the effect being high for Dubai bank dummy.

Table 3: Threshold GARCH results for interbank market volatility analysis

TGARCH (1, 1) Results - INTERBANK					
Mean equation					
	Period 1 (prior)	Period 2 (Dubai)	Period 3 (Imperial)	Period 4 (Chase)	Overall
Constant	0.0481	0.6750***	-0.0405	-0.0189	-0.0531
	(0.3686)	(0.0000)	(0.6761)	(0.8356)	(0.5517)
Interbank (-1)	0.9440***	-0.0394	0.7900***	0.8044***	0.8327***
	(0.0000)	(0.6851)	(0.0000)	(0.0000)	(0.0000)
Treasury bill market	0.0192	0.7891***	0.0683***	0.0606***	0.0689***
	(0.1495)	(0.0000)	(0.0045)	(0.0071)	(0.0022)
Dummy Dubai		0.0681***			0.8502
		(0.0045)			(0.5623)

TGARCH (1, 1) Results - INTERBANK					
Mean equation					
	Period 1 (prior)	**Period 2 (Dubai)**	**Period 3 (Imperial)**	**Period 4 (Chase)**	**Overall**
Dummy Imperial			-0.4794		-1.0750
			(0.2065)		(0.4697)
Dummy Chase				-0.2712	-0.0431
				(0.6560)	(0.9456)
Conditional Volatility Equation					
Constant	0.0160***	0.0130***	0.0127***	0.0124***	0.0172***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ARCH (1) (α1)	0.7067***	0.6189***	0.6091***	0.5867***	0.6737***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
(RESID<0) ARCH (1) (α2)	-0.3331**	-0.5590***	-0.5474***	-0.5267***	-0.5760***
	(0.0277)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
GARCH (1) (β)	0.6336***	0.7308***	0.7352***	0.7373***	0.6969***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Dummy Dubai		0.1672**			0.9938
		(0.0234)			(0.5259)
Dummy Imperial			0.1383**		-1.1304
			(0.0492)		(0.4702)
Dummy Chase				0.3242**	0.4990***
				(0.0146)	(0.0009)
R2	0.8359	0.8299	0.8302	0.8320	0.8350
Adjusted R2	0.8351	0.8282	0.8284	0.8302	0.8324
Log likelihood	-627.3749	-617.3807	-617.4061	-615.5887	-609.3318
Durbin - Watson	1.7650	1.6226	1.6227	1.6417	1.6821

Note: Significance probabilities in parenthesis, *** (significant at 1%) ** (significant at 5%) and * (significant at 10%).

Within the TGARCH model leverage effect is captured by α1 and α2 which measure the bad news and good news on interbank market respectively. The sum of α1 and α2 measures the effect of bad news. For conditional variance equation, the coefficient β captures the degree of persistence of shocks while the sum of α +β give the persistence of shocks. The results posit that bad news in the event of banking industry stress impacts the interbank market more even with the Treasury bill rate market's intervention compared to good news of the same magnitude signifying presence of leverage effect in the interbank market.

Table 4: Threshold GARCH results for Treasury bill market volatility analysis

TGARCH (1, 1) Results					
Mean equation					
	Period 1 (prior)	Period 2 (Dubai)	Period 3 (Imperial)	Period 4 (Chase)	Overall
Constant	0.0978***	0.1434***	0.0857***	0.1026***	0.3412***
	(0.0000)	(0.0000)	(0.0007)	(0.0000)	(0.0004)
Treasury bill (-1)	0.9542***	0.9439***	0.9359***	0.9539***	0.9289***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Interbank market	0.9542***	0.0471***	0.0656***	0.0426***	0.0421***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Dummy Dubai		0.1460***			1.0096***
		(0.0000)			(0.0000)
Dummy Imperial			0.0970**		-1.1063***
			(0.0242)		(0.0000)
Dummy Chase				-0.0494***	0.0972
				(0.0031)	(0.5342)
Conditional Volatility Equation					
Constant	0.0044***	0.0048***	0.0053***	0.0043***	0.2510***
	(0.0005)	(0.0002)	(0.0000)	(0.0010)	(0.0000)
ARCH (1) (α1)	1.3526***	1.4849***	1.1430***	1.3832***	0.4483***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

TGARCH (1, 1) Results					
Mean equation					
	Period 1 (prior)	Period 2 (Dubai)	Period 3 (Imperial)	Period 4 (Chase)	Overall
(RESID<0) ARCH (1) (α2)	1.4426***	0.9557***	0.7753***	1.5047***	0.2202
	(0.0001)	(0.0022)	(0.0011)	(0.0000)	(0.2499)
GARCH (1) (β)	0.2397***	0.2011***	0.2543***	0.2339***	-0.0089
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.8200)
Dummy Dubai		0.0114			0.0895
		(0.7502)			(0.4936)
Dummy Imperial			0.0208		-0.0434
			(0.3500)		(0.8057)
Dummy Chase				-0.0032	-0.2698**
				(0.6055)	(0.0304)
R2	0.9621	0.9624	0.9616	0.9621	0.9643
Adjusted R2	0.9619	0.9621	0.9613	0.9618	0.9639
Log likelihood	-191.5956	-178.9620	-188.6653	-189.9137	-275.4887
Durbin - Watson	1.0130	1.0119	0.9986	1.0123	1.0552

Note: Significance probabilities in parenthesis, *** (significant at 1%) ** (significant at 5%) and * (significant at 10%).

From **table 4** results we deduce that placement of Imperial and chase bank under receivership negatively affected on Treasury bill market though significantly. However, as opposed to the previous results, the effect of interbank market on Treasury bill rate declines significantly with the banking sector stress compared to banking sector stress – free period.

4.0 Conclusion

The paper aims at evaluating the effect of policy and market reaction towards promoting efficiency on the interbank market in the times of stress in the banking industry. The paper uses treasury bill–interbank market link buttressed by the argument that in times of interbank market stress, the Treasury bill market is the resort of the lender banks seeking the next nearest liquid asset.

As liquidity challenges in the "small" bank segment of the industry arising a lender being put under statutory management leads to (near) inter-bank market freeze, lender banks seek to pack their liquidity in sort end of the risk free assets – the 91-day Treasury bills in our case.

The findings of the data analysis indicate that 91-day Treasury bill rate positively and significantly affects the interbank market rate. Results for period prior to banking industry stress and after the industry stress indicate that the effect of 91-day Treasury bill rate on interbank market rate rises significantly upon the occurrence of banking industry stress as compared to the stress free period. In fact, the results indicates that the effect of 91-day Treasury bill rate on interbank rate doubles upon the placement of a lender under receivership. On the volatility front, banking industry stress in awake of collapse of a lender triggers high volatility clustering. As evidenced by results for EGARCH model placement of Chase bank under receivership portrayed high volatility clustering as compared to Dubai and imperial bank case.

From the results we conclude that volatility shocks at the interbank are long lived rather than transitory implying that the intervention by the Central bank to restore efficiency in the interbank market in allocating liquidity upon the occurrence of banking industry stress is deficient of solving structural challenges within the interbank hence long lived shocks in the interbank market upon the occurrence of such banking industry shocks. Such interventions only helps the market to move towards near normal situation but fails to address structural weaknesses of the interbank market. In terms of information asymmetry, our results suggests that bad news significantly impacts on interbank market compared to good news of the same magnitude hence an evidence for leverage effect. Further we note that even with the intervention by the CBK, the leverage effect in the interbank market still remains.

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