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Segmentation of the interbank money market in Zambia

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SEGMENTATION OF THE INTERBANK MONEY MARKET IN ZAMBIA

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Abstract

This study examined segmentation in the interbank money market. Commercial banks were classified according to asset size and ownership. Network framework analysis was used to establish lending and borrowing preferences as well as the utilization of credit lines in the market. Segmentation by pricing behavior was also undertaken by assessing the deviation of the interbank rate from the policy rate for trades within and across bank categories. Further, long-range dependence in interbank pricing was conducted by estimating the Hurst exponent. Daily data spanning from January 2012 to March 2019 were used. Preliminary results have revealed the existence of segmentation in the interbank market: the market structure is incomplete (not all banks have credit lines), but not disjointed as both within and cross bank categories trades occur to some extent. Specifically, large banks fully trade with each other by utilizing all the available credit lines. Nonetheless, they charge a relatively higher premium than small and medium banks. The interaction among small banks and peers is relatively high and attracts a relatively lower premium than is the case with lending to medium and large banks. There is limited interaction among the medium-medium pair and tend to charge each other a relatively higher premium. Ownership tends to matter in interbank trading. Bank categories with similar or related ownership tend to have more interactions as opposed to bank categories with diverse ownership. All the trading pairs of banks considered transacted above the policy rate and the deviation was even higher when monetary policy was tightened. Finally, there is evidence of uniform pricing behavior in the interbank money market and predictability in interbank lending rates, suggesting absence of price segmentation. However, the pricing behavior is susceptible to monetary policy stance change which makes lending rates unpredictable for some trading relationship pairs.

1 Introduction

The interbank market was in its nascent stage prior to 1990 and dominated by banks[1] established after Zambia gained independence in 1964. The financial sector was dominated by foreign commercial banks mainly serving the needs of expatriate and foreign businesses (Brownbridge, 1996). The market was characterized by excess liquidity and there is very little evidence of interbank money market trading in the early post-colonial years (Bank of Zambia Annual Report, 1968 and 1977). However, as the market started to develop from the 1970s, economic reforms

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[1] Only four commercial banks established in the 1960s exited.

adopted in the early 1990s, and with the increase in the number of commercial banks, the importance of interbank money market became more pronounced in terms of the traded volumes.

By 1994, there were signs of the financial system transitioning towards market-based structures as exchange controls were abolished, interest rates decontrolled, control on goods prices lifted, and the Banking and Financial Services Act enacted in 1994. In addition, secondary market trading in government securities, not only between commercial banks but also between non-bank financial institutions, emerged. During this period, a number of commercial banks started to rediscount government securities while repurchase agreements involving Treasury bills between commercial banks and their clients also increased (Bank of Zambia Annual Report, 1994). With these developments, interbank money market transactions rose and overnight loans reached K40 billion within weeks from virtually no trades at all (Bank of Zambia Annual Report, 1994).

The interbank money market in Zambia is dominated by commercial banks, although there are other institutions such as pension funds, building societies, insurance companies, a development bank, a national savings and credit bank that borrow or lend funds in the overall financial sector. Treasury bills are widely used as collateral in interbank transactions. However, to date, there are no clearly defined and specific laws or regulations to guide the interbank money market, let alone a code of conduct for money market players. The code of conduct guides market participant's responsibilities, integrity, trust, honesty and faith in dealing with interbank transactions.

The interbank market is indirectly regulated by some provisions of the Bank of Zambia Act and the Banking and Financial Services Act by virtue of this market being dominated by commercial banks. In addition, the interbank money market benefits, to a large extent, from spillover regulations governing the foreign exchange and government securities markets. Unlike the foreign exchange market where participants provide both bid and offer prices using a trading platform, participants in the interbank money market trade with each other over-the-counter (OTC) where banks negotiate among themselves.

Typically, commercial banks tend to exhibit different behavior in the interbank market based on their size. There are several approaches to classifying a bank as large, medium or small. This could be based on different quantiles from bank asset size distribution (Kim, 2017). In Zambia, the majority of small banks dominate on the borrowing side while big banks tend to be mostly on the lending side (Muhanga, Mutoti and Zgambo, 2009). In addition, large banks have a huge deposit base which they exploit to provide funds to small banks. However, not all the large banks are active in the interbank market mostly due to their internal policies. Further, overnight transactions dominate the trades in the interbank money market on both secured and unsecured basis depending on the relationship with the parties involved (Muhanga, Mutoti and Zgambo, 2009). However, while the overnight interbank market is the most active, structural constraints or rigidities exist that contribute to the segmentation of the market.

Segmentation prevents the interbank money market from effectively performing its typical function of optimally distributing liquidity, facilitating the transmission of monetary policy, as well as stabilising and contributing to the efficiency of the financial system (Oduor *et al.*, 2014; Mayordomo *et al.*, 2015; and Osoro and Muriithi, 2017). Segmentation can be measured in terms of prices and volumes. Typically, market segmentation should lead to high dispersion in market

prices or interest rates quoted by participants which makes it hard for them to infer a fair price (Mayordomo *et al.*, 2015).

While the volume of interbank trading has increased over the years (Figure 1 in the appendix), structural rigidities are cited as contributing to the persistent deviation of the overnight interbank rate (operating target since April 2012)[2] from the monetary policy rate in Zambia (Figure 2 in the appendix). As a consequence, banks continue to rely on central bank standing liquidity facilities for adjustment funds (Figure 3 in the appendix) despite the interbank market being characterized by excess liquidity (Figure 4 in the appendix). In addition, it is observed in figure 4 that there are periods when the overnight interbank rate counterintuitively responds to changes in liquidity conditions as opposed to the traditional inverse relationship (Lungu, Bwalya and Chanda, 2018). Gereben (1999) characterizes this as an anomaly of the interbank money market. Persistent volatility in the interbank rate, irrespective of the underlying factors, tends to affect other interest rates with longer maturities which in turn creates uncertainty, constrain consumer and business investment spending and ultimately economic growth. Further, in the presence of distortions, the market is not able to precisely distinguish the intended effects of the monetary policy stance through changes in the target policy rate and changes induced by liquidity shocks. Commercial banks respond to liquidity shocks by borrowing in the interbank market or liquidating assets. However, borrowing tends to be limited by credit lines and when it is possible, stringent borrowing constraints exist. Large banks are reluctant to create sufficient credit lines with small banks partly due to mistrust (Arukaevu, 1998). Commercial banks with higher levels of credit risk tend to suffer the most during periods of severe market stress when banks are not willing to lend to each other.

Interest rates vary across different lender-borrower categories or pairs undertaken under mutual agreement. Underlying this difference is the liquidity cost[3], default or credit risk, and strength of relationship among lender-borrower pair. The marginal cost of acquiring funds during periods of liquidity shortage increases with the size of the shortage and the marginal cost of offloading excess funds in an attempt to earn a return increases with the accumulated amount of excess liquidity (Kim, 2017). The liquidity cost for large banks is zero as parties are not willing to accept a lower return on excess liquidity as they are not willing to accept a higher borrowing cost (Kim, 2017). This results in little variation in interest rates such that trading between large banks tends to be very close to the central bank target (policy) rate. Kim (2017) found that small banks tend to lend funds to large banks below the central bank target rate; small banks tend to borrow at interest rates above the central bank target rate from large banks; and favourable rates are applied when a small bank trades with a large bank for larger loans: receive a higher rate for big loans provided to large banks and get charged a lower rate when borrowing from a large bank for a large loan.

Thus, various aspects of the interbank market are analysed, including the drivers of the cost of funds, and the effect of the state of financial system on the outcome of the interbank market (Kim, 2017). This study analyses the extent, and not the underlying factors, of segmentation of the interbank money market in Zambia. It extends Muhanga, Mutoti and Zgambo (2009) and examines interbank market segmentation by covering a longer sample period (2012m1-2019m3), and

[2] The Bank of Zambia shifted from a monetary targeting to an interesting rate targeting framework in April 2012. The operating target changed to the overnight interbank rate from base money. With this framework, the Bank of Zambia seeks to steer the interbank rate as close as possible to the target rate (policy rate) within the defined band.
[3] How banks handle the cost of excess or deficit liquidity.

broaden the classification of banks by focusing on bank total assets, ownership, volumes, and prices using network framework analysis, lending and borrowing (trading) preference indices, as well as price differential analysis. Muhanga, Mutoti and Zgambo (2009) focused on a relatively smaller sample (2006-2009), solely on ownership structure of banks (domestic or foreign) of small and big banks, and price dynamics analysis. Understanding the role of medium sized banks in the interbank market is equally important than just the small and large (big) banks as they may help to establish the category of banks that may pose (in) efficiencies in the market. Inefficiencies in the interbank market tend to impede the smooth operation of monetary policy.

Preliminary results have revealed the existence of segmentation in the interbank market: the market structure is incomplete (not all banks have credit lines), but not disjointed as both within and cross bank categories trades occur to some extent. Specifically, large banks fully trade with each other by utilizing all the available credit lines. Nonetheless, they charge a relatively higher premium than small and medium banks. The interaction among small banks and peers is relatively high and attracts a relatively lower premium than is the case with lending to medium and large banks. There is limited interaction among the medium-medium pair and tend to charge each other a relatively higher premium. Ownership tends to matter in interbank trading. Bank categories with similar or related ownership tend to have more interactions as opposed to bank categories with diverse ownership. All the trading pairs of banks considered transacted above the policy rate and the deviation was even higher when monetary policy was tightened. Finally, there is evidence of uniform pricing behavior in the interbank money market and predictability in interbank lending rates, suggesting absence of price segmentation. However, the pricing behavior is susceptible to monetary policy stance change which makes lending rates unpredictable for some trading relationship pairs.

The rest of the paper is organized as follows: Section 2 presents the literature on interbank money market segmentation while section 3 outlines the methodology. Section 4 discusses data sources. Section 5 presents preliminary findings and section 6 concludes.

2 Literature Review

The interbank market plays a critical role of allocating liquidity from banks with surplus funds to banks facing liquidity deficits. The ability of banks to trade in the interbank market is principally affected by liquidity shocks, their operating costs and reputation as well as the operations of the central bank (Green *et al.*, 2016). The interbank money market is mainly utilized as a source of funds for short-term liquidity obligations and not to expand liquidity. Anticipation of changes in policy and/or operating costs influence individual bank's trading decisions as well as decisions to supply or withhold liquidity in the interbank market.

Shocks caused by liquidity stress may generate distortions and inefficiencies in the functioning of the interbank market including the cost of funds which may be transacted in a characteristically segmented market. The interbank money market may be segmented in terms of products offered, pricing, concentration of liquidity, and the operational structure in which banks trade with each other (Osoro and Muriithi, 2017).

Sichei, Kiplang and Shimba (2012) demonstrate how segmentation can limit the interbank market's ability to facilitate banks' liquidity management strategy in the Kenyan interbank market. The study employed the network framework analysis and case studies of countries with developed interbank markets, namely the UK, EU and the US. Daily data for the Kenyan interbank market covering the period June 2003-September 2012 were used. The interbank market was found to be incomplete and highly segmented by size: small, medium and large banks. Large banks tended to discriminate against small banks in terms of credit extension and the interest rate charged which was usually higher than that charged on their peers. The study concluded that segmentation was the reason the interbank market in Kenya had limited ability to facilitate banks' liquidity management strategy. Further, the analysis of the case studies revealed that the efficiency of the interbank market in Kenya could be enhanced through a number of developments such as adding lending products with maturities of more than one day to extend the term structure, increasing the number of currencies traded, developing a benchmark interbank interest rate, and increasing linkages with other money market segments and monetary policy.

Muhanga, Mutoti and Zgambo (2009) investigated segmentation in the interbank money market in Zambia during the period 2006-2009. The study focused on the distribution of funds in the market based on pricing mechanisms using period averages and comparative borrowing costs. The findings revealed segmentation of the interbank market both in terms of the distribution of funds and pricing. On average, 42.7% of the settlement balances maintained at the central bank was held by major foreign-owned banks while an average proportion of 42.4% was held by two major locally-owned banks. With regard to pricing, the results showed that locally-owned smaller banks tended to borrow funds at interest rates usually higher than the average market rate while foreign-owned large banks tended to borrow below market averages. The study concluded that the concentration of funds among a few banks would be the basis for market segmentation as the dominant banks in the interbank market may use their position to influence the pricing of interbank funds.

Relationships and network dynamics also appear to increasingly influence interactions in the interbank money market (Green, et al, 2016). The position and direction of the credit relationship between banks seems to have an effect on the price a bank pays for liquidity in the interbank market (Craig, Fecht and Tümer-Alkan, 2015; and Temizsoy, Iori and Montes-Rojas, 2015) . Studies by Chiu, Eisenschmidt and Monnet (2019) Colliard *et al.*, (2016) and Bräuning and Fecht (2017) all concluded that banks rely on repeated interactions with the same counterparties to access liquidity. Banks choose to build relationships in order to insure against liquidity shocks and to economize on the cost to trade in the interbank market. They further claimed that relationships explain some anomalies in the level of interest rates and how monetary policy affects the network structure of the interbank market and its functioning.

Large banks prefer to lend to each other at rates close to the central bank target rate and limit their transactions with small banks as they view them as very risky due to the size of their assets (Allen and Gale, 1990; and Allen and Saunders, 1992). Thus, small banks are left with the option of borrowing funds from their peers which may not be adequate (Ho and Saunders, 1985). Small banks borrowing from large banks tend to pay higher rates than the central bank target rate. However, they get lower rates than the central bank target rate when they lend to large banks. It follows therefore that large banks usually tend to be net borrowers while smaller banks tend to be

net lenders, the principle at the core of the 'small-bank' – 'big-bank' dichotomy concept initially advanced by Ho and Saunders (1985).

Kim (2017) draws on the 'small-bank' – 'big-bank' dichotomy concept and contends that empirically, odds point to outcomes being against small banks partly attributed to information asymmetry between a small borrowing financial institution and a prospective counterparty. In addition, some banks tend to shy off from banks with less profitable and lower market reputation.

The foregoing depicts a high degree of continuous interaction and interdependence with connections among banks stemming from both the asset and the liability sides of their balance sheets which has evolved in a web of structured relationships increasingly classified as networks – the core of the network theory. Formerly, Chen, Zhang and Li (2016) defined a network as a collection of nodes and edges that can be a useful method to depict the interrelationships among organizations and explain the idiographic effect that one organization has on another. Each bank is taken as a node and the credit lending relationship between banks as the edges connecting these nodes in the network. Thus, the nodes and edges compose the interbank market network. In these networks, nodes in each category for example "small and big" or "local and foreign" classes generally prefer to link to the nodes.

Colliard, Foucault and Hoffmann (2016) studied the core-periphery model of trading in the overnight interbank market during crisis period in the euro area. The study focused on the market power of periphery banks connected to the core, dispersion of rates in the interbank market and the inefficient recourse to the central bank standing facilities. They concluded that segmentation between core and periphery banks poses significant challenges to central banks. They found that there is dispersion in interest rates between core and periphery banks that no longer reflect borrowing conditions of the interbank market.

Craig, Fecht and Tümer-Alkan (2015) assessed the interconnectedness of banks and the price they pay for liquidity in Germany. The concentration of credit relationships and the position of a bank in the network topology of the financial system influence the bank's ability to meet liquidity demand in Germany. Controlling for bank characteristics and daily fulfilment of reserves requirements, the study findings revealed that banks with a more diversified borrowing structure in the interbank market bid significantly less aggressively and pay a lower price for liquidity in the ECB's main refinancing options. Further, Gabrieli (2012) investigated the overnight lending market network in European countries. The study established that the network is very scattering, with characteristics of a small-world network, and the distribution of its nodes subject to power-law distribution. This implies that the majority of banks only build relationships with fewer banks and there are only a few banks (usually large banks) that have a larger network connection. Similar to the European bank overnight market network, the federal funds market network also has the characteristics of small-world network, but the distribution of network node degree is a heavy-tailed rather than a power-law distribution (Bech and Atalay, 2010).

3 Empirical Methodology

To investigate the extent of interbank money market segmentation in Zambia, the study employs network framework analysis, lending and borrowing (trading) preference indices, as well as price differential analysis.

As alluded to in section 1, the assessment of interbank segmentation takes into account the size of the bank. In this study, banks are classified according to asset size as follows:

a) Determine the ratio of an individual bank total asset to industry total asset using balance sheet data:

$$\beta_{it} = \left(\frac{\theta_{it}}{\Omega_t}\right) 100\%, i = 1, \dots\dots\dots\dots\dots\dots\dots\dots, 18 - - - - - - (1)$$
$$t = 0,1,2 \dots\dots\dots\dots\dots\dots, T$$

where

$\beta = Bank\ size$
$\Theta = Individual\ bank\ total\ assets$
$\Omega = Industry\ total\ assets$

b) Compute the average bank size for each individual bank for the period January 2017-February 2019 when closures and mergers of banks took place:

$$\bar{\beta}_i = (T-t)^{-1} \sum_{t=0}^{T} \beta_{it} - - - - - - - - - - - - - - - (2)$$

where

$\bar{\beta}_i = Mean\ bank\ size\ for\ individual\ banks$
$(T-t) = Number\ of\ observations$

c) Decision rule for a bank being either large, medium or small is as follows:

$$\bar{\beta}_i = \begin{cases} \geq 0.10, \text{large bank} \\ 0.03\ but < 0.10\ , medium \\ < 0.03, \text{small bank} \end{cases} - - - - - - - - - - - - - (3)$$

If the average market share is at least 10 percent (0.10), such a bank is considered large. Otherwise it is small if the market share is less than 4 percent (0.03), and medium if the market share is between at least 4 and less than 10 percent. The rule is arbitrarily determined, but ensures that large banks have a combined market share of at least 50 percent share of the industry; small banks have a combined market share; and for medium size banks, their market share should be in the middle of the pack.

Applying the procedure to the data involving 14 commercial banks, five banks are classified as small with the average market share ranging from 1.15 to 1.63 percent (Table 1). The combined market share is only 6.98 percent. There are five medium sized banks with the market share ranging from 3.16 to 9.68 percent, and combined market share of 37.56 percent. Four large banks are

identified with the market share ranging from 12.17 to 16.58 percent, and the total market share of 55.46 percent.

Banks are also classified based on ownership within each category. Ownership is one of the factors considered when setting credit lines among banks. It is therefore imperative to understand how ownership affects interbank trades within and across different bank categories. When setting credit lines, at the group or board level, most banks check for bank ownership as a default risk measure (Lungu, Chanda, & Bwalya, 2018).

Table1 Bank Classification by Asset Size

Bank	Markets Share (%)	Classification		Ownership
Bank S1	1.4	Small		Local
Bank S2	1.6	Small		Local
Bank S3	1.2	Small		Local
Bank S4	1.5	Small		Local
Bank S5	1.3	Small		Foreign
Bank M1	7.6	Medium		Foreign
Bank M2	9.7	Medium		Foreign
Bank M3	3.6	Medium		Foreign
Bank M4	3.2	Medium		Foreign
Bank M5	8.4	Medium		Local
Bank B1	13.8	Large		Foreign
Bank B2	12.2	Large		Foreign
Bank B3	16.6	Large		Foreign
Bank B4	12.9	Large		Local

Source: Author's computation using Bank of Zambia database

Network Framework Analysis

The network framework proposed by Allen and Gale (2000) is based on interbank credit lines in which exposure matrices are used. According to this framework, three types of interbank structures exist: complete, incomplete as well as incomplete and discounted.

A complete structure is where each bank is symmetrically connected to other banks in the market irrespective of their size (Table 2). This means that each bank transacts (borrows and lends) with all the banks in the market (Sichei, Kiplang and Shimba, 2012). When an interbank market has a complete structure, the effect caused by unexpected shock in one bank can be absorbed by a large number of banks thereby reducing the intensity of the shock (Allen and Gale, 2000).

Table 2 Complete Structure

			Borrowing								
			Small Banks			Medium Banks			Large Banks		
			Bank S1	Bank S2	Bank S3	Bank M1	Bank M2	Bank M3	Bank L1	Bank L2	Bank L3
Lending	Small Banks	Bank S1		√	√	√	√	√	√	√	√
		Bank S2	√		√	√	√	√	√	√	√
		Bank S3	√	√		√	√	√	√	√	√
	Medium Banks	Bank M1	√	√	√		√	√	√	√	√
		Bank M2	√	√	√	√		√	√	√	√
		Bank M3	√	√	√	√	√		√	√	√
	Large Banks	Bank L1	√	√	√	√	√	√		√	√
		Bank L2	√	√	√	√	√	√	√		√
		Bank L3	√	√	√	√	√	√	√	√	

Source: Author's computations

√ *means existence of an active interbank credit line while 0 implies no trade between the corresponding banks*

Note: S- small banks, M-medium sized banks and L-large banks

In incomplete interbank markets, banks are only connected to their neighbours i.e. those in the same or neighbouring segment. For instance, small banks trade amongst themselves and medium banks, but do not trade with large banks (Table 3). When the interbank market is incomplete, the initial shock in one bank is transmitted to its neighbours, but in a large magnitude with ripple effects.

Table 3 Incomplete Structure

			Borrowing								
			Small Banks			Medium Banks			Large Banks		
			Bank S1	Bank S2	Bank S3	Bank M1	Bank M2	Bank M3	Bank L1	Bank L2	Bank L3
Lending	Small Banks	Bank S1		√	√	√	√	√	0	0	0
		Bank S2	√		√	√	√	√	0	0	0
		Bank S3	√	√		√	√	√	0	0	0
	Medium Banks	Bank M1	√	√	√		√	√	√	√	√
		Bank M2	√	√	√	√		√	√	√	√
		Bank M3	√	√	√	√	√		√	√	√
	Large Banks	Bank L1	0	0	0	√	√	√		√	√
		Bank L2	0	0	0	√	√	√	√		√
		Bank L3	0	0	0	√	√	√	√	√	

Source: Author's computations

√ *means existence of an active interbank credit line while 0 implies no trade between the corresponding banks*

Note: S- small banks, M-medium sized banks and L-large banks

In an incomplete and disconnected interbank market structure, trades only occur within bank categories i.e. there are no cross category trades. (Table 4).

Table 4 Incomplete and Discounted Structure

			Borrowing								
			Small Banks			Medium Banks			Large Banks		
			Bank S1	Bank S2	Bank S3	Bank M1	Bank M2	Bank M3	Bank L1	Bank L2	Bank L3
Lending	Small Banks	Bank S1		√	√	0	0	0	0	0	0
		Bank S2	√		√	0	0	0	0	0	0
		Bank S3	√	√		0	0	0	0	0	0
	Medium Banks	Bank M1	0	0	0		√	√	0	0	0
		Bank M2	0	0	0	√		√	0	0	0
		Bank M3	0	0	0	√	√		0	0	0
	Large Banks	Bank L1	0	0	0	0	0	0		√	√
		Bank L2	0	0	0	0	0	0	√		√
		Bank L3	0	0	0	0	0	0	√	√	

Source: Author computations

√ *means existence of an active interbank credit line while 0 implies no trade between the corresponding banks*

Note: S- small banks, M-medium sized banks and L-large banks

Further centrality measures, namely betweenness centrality, closeness centrality, and the cluster coefficient are employed as part of network analysis. Centrality measures in network analysis give a deeper understanding of how interrelationships among banks work.

Under the centrality concept, a network is defined as a collection of points or "nodes" connected together by lines or "edges." The interpretation of nodes and edges depends on the context. In this study, nodes are commercial banks and edges are interbank loans extended to counterparties. A network is a representation of how elements are related in a system, which can be in matrix (exposure matrices highlighted above) or graphical form (Table 5).

Table 5 Representation of a Network

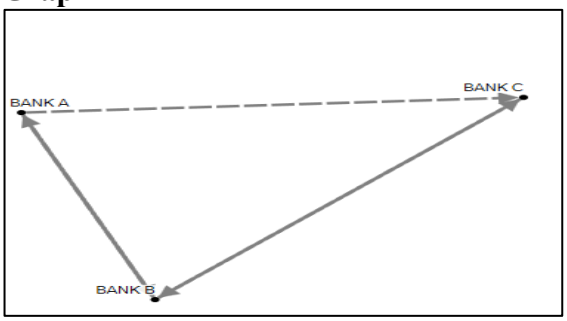
Edge list

Lender	Borrower	amount
BANK A	BANK B	20
BANK A	BANK C	5
BANK B	BANK A	15
BANK B	BANK C	22
BANK C	BANK B	60

Matrix

	BORROWER			
LENDER		BANK A	BANK B	BANK C
	BANK A	0	20	5
	BANK B	15	0	22
	BANK C	0	60	0

Graph



Source:" Comesa Monetary Institute, 2019

Edges are lines that show relationships between vertices; financial networks assume different edges, depending on what they depict; and Vertices/Nodes are number of items, pieces, banks, countries in a relationship graph.

As earlier highlighted, the interbank money market may be characterized by banks that may not actively transact with the rest. In the context of network analysis, the clustering coefficient can be used to measure segmentation in the interbank market by establishing how connected vertices are to one another. More specifically, it is the number of edges connecting a vertex's neighbours divided by the total number of possible edges between the vertex's neighbours (COMESA Monetary Institute, 2019). If all neighbours of a node are not connected to each other, the coefficient will take the value of 0. Conversely, if all the neighbours are connected, the cluster coefficient will be 1. Thus, the clustering coefficient ranges from 0 to 1 ($0 \leq x \leq 1$).

Closeness centrality shows the importance of a bank in the network by how close it is it to the counterparties and betweenness measures the importance of the bank by determining its role as a mid-agent between banks without credit lines in the network[4]. Closeness centrality in this study indicates how close a commercial bank is to all the banks in the network in terms of interbank trades. For betweenness centrality, the measure captures a commercial bank's role in acting as a mid-agent in liquidity flow between two banks with no credit lines in the network. Commercial banks may act as a mid-agent to facilitate the flow of liquidity between two of its counterparties who do not directly have credit lines despite both having credit lines with it.

[4] https://www.sciencedirect.com/topics/computer-science/betweenness-centrality

Lending and Borrowing (Trade) Preference Indices

To assess the intensity of both lending and borrowing between bank categories, the lender preference index (LPI) and borrower preference index (BPI) are computed in line with Cocco, Gomes and Martins (2009). In this study, banks are categorized into three groups: large, medium, and small based on their market share in relation to total assets. In this case, for every lender category and borrower category, the LPI is computed as follows:

$$\text{LPI}_{\text{category X banks to category Y banks}} = \frac{\text{Total lending of funds by category X banks to category Y banks}}{\text{Total lending of funds by category X banks in the market}}$$

This ratio is more likely to be high if category X banks rely on fellow category X banks more than they do on category Y banks to lend funds in the market.

The Borrower Preference Index (BPI) is computed in a similar way as follows:

$$\text{BPI}_{\text{category X banks to category Y banks}} = \frac{\text{Total borrowed funds by category X banks from category Y banks}}{\text{Total borrowed funds by category X banks in the market}}$$

Price Differential Analysis

Two measures of pricing behaviour (within and across bank segments) are employed: deviation of interbank lending rate from the central bank target rate and long-range dependence.

It is generally established that interest rates vary across different lender-borrower categories or pairs undertaken under mutual agreement (Kim, 2017). Underlying this difference is mainly the liquidity cost (how banks handle the cost of excess or deficit liquidity), default or credit risk, and the strength of the relationship among lender-borrower pair. Trading between large banks tends to be very close to the central bank target (policy) rate; small banks tend to lend funds to large banks at interest rates below the central bank target rate; small banks tend to borrow at rates above the central bank target rate from large banks; and favourable rates are applied when a small bank trades with a large bank for larger loans[5](Kim, 2017). In this way, small banks will tend to transact at rates different from the central bank target. Thus, the mean is used to assess the pricing behavior in the money market over time within and across different categories of banks measured as the deviation of the actual lending rate from the central bank target (policy rate).

Long-range dependence techniques are used to establish whether pricing behaviour differs and/or is predictable within and across the segments of the interbank market. If the pricing behaviour is the same, this points to herd behavior, suggesting lack of pricing segmentation. In this study, the Hurst parameter (H) is used to measure long-range dependence[6] (persistence) in lending rates within and across different categories of banks. The parameter values of H are defined as $H \in [0,1]$, where $0 < H < 0.5$ means the data process is anti-persistent, akin to being mean reverting within some bound - implying a short memory. For $0.5 < H < 1$, the process is persistent with a

[5] Receive a higher rate for big loans provided to large banks and get charged a lower rate when borrowing from a large bank for a large loan.

[6] In this context, long-range dependence is taken as a characterisation of the underlying process of a given time series.

long memory. For $H = 0.5$, the process is independent, akin to being a random walk. If the value for the estimated H parameter is within the same range for all the categories of banks, then the pricing behavior should be the same signifying absence of price segmentation in the interbank market.

In this study, the discrete wavelets transform (DWT) is adopted to estimate H as the data on interbank pricing is measured on a discrete basis and is irregular[7]. With the DWT, a given signal is decomposed into filtered series at different time scales.

Long-range dependence in interest rates has been explored by Tabak and Cajueiro (2005), Cajueiro and Tabak (2007), and Cajueiro and Tabak (2009). Although the focus was on establishing long-range dependence in the context of predictability, persistence in behavior, and implications on tests for expectation hypothesis, the idea can also be extended to establishing pricing segmentation. The Hurst parameter is applied in assessing pricing behaviour across market segments and thereby draw insights on different pricing behaviour intra and across bank categories.

Further, data for each trading pair was subjected to structural break tests using an empirical fluctuation process implemented in **R** under the package **strucchange** credited to Zeileis et al. (2002). The rationale behind structural breaks reflect specific events relating to monetary policy decisions as outlined in Table 6 (a-c). As outlined earlier, banks tend to use the central bank policy rate as reference in the pricing of funds as they trade with each other. Thus, structural break tests are intended to determine whether changes in the monetary policy stance influences the pricing behavior of banks in the interbank market. According to Table 6, five monetary policy events were identified and subjected to an empirical test to determine whether they had influence on interbank rate setting. The events mostly relate to changes in the monetary policy rate and the to the overnight lending facility (OLF)[8] rate.

[7] Rea et al. (2013) have evaluated the efficacy of various methods used in estimating the Hurst coefficient. They include Fourier spectral techniques, Wavelet, aggregated variance methods, detrended fluctuation analysis (DFA), generalised Hurst exponents (GHE), detrended moving average (DMA), Local Whittle estimator, and the rescaled range analysis (R\S). The Wavelet transform methods have become popular in the estimation of the Hurst parameter (Chamoli, et al., 2007; Kantelhardt, 2009; Kirichenko et al. 2011). The Wavelet was unbiased for all the parameter values for longer lengths, but was minimally (very small) biased for shorter lengths. In this regard, the Wavelet emerged as the relatively more effective method. Kirichenko et al. (2011) also assessed the most commonly used methods in estimating the Hurst coefficient. The detrended fluctuation analysis (DFA) and the Wavelets methods were found to have minimal bias for stationary series, but the DFA was accurate for the non-stationary series while the Wavelets was good also but for the data with a slight trend.

[8] The overnight lending facility is a discount window from which commercial banks borrow from the central bank for liquidity management. The interest rate (OLF rate) is set off the monetary policy rate on which a margin is added s determined by the central bank.

Table 6a: Structural Breaks relating to Monetary Policy Events

	Event	Period Covered			Observations	Structural Break Dates	Possible Factors
Small to Small sized Inter-Bank Market	1	April 3, 2012	to	March 18, 2014	244	NA	
	2	March 21, 2014	to	November 4, 2015	338	March 21, 2014	OLF tightened by 600 bps and acess to OLF window restricted to once a week
	3	November 5, 2015	to	December 8, 2016	181	November 5, 2015	Policy rate raised to 15.5% from 12.5% and interest rate caps removed
	4	December 12, 2016	to	October 31, 2017	179	December 12, 2016	Inflation declined to single digit and expected to remain relatively low, signifying decline in risk premium
	5	November 3, 2017	to	March 15, 2019	250	November 3, 2017	Expectations of further monetary policy loosening following a policy rate reduction in February 2017
Total Obsservations					**1,192**		
Small to Medium sized Inter-Bank Market	1	April 10, 2012	to	March 18, 2014	234	NA	
	2	March 19, 2014	to	November 1, 2015	256	March 19, 2014	OLF tightened by 600 bps and acess to OLF window restricted to once a week
	3	November 3, 2015	to	August 27, 2016	47	November 3, 2014	Policy rate raised to 15.5% from 12.5% and interest rate caps removed
	4	August 31, 2016	to	March 21, 2017	90	August 31, 2016	
	5	March 30, 2017	to	February 11, 2019	128	March 30, 2017	
Total Obsservations					**755**		
Small to Large sized Inter-Bank Market	1	June 1, 2012	to	March 19, 2014	72	NA	
	2	March 25, 2014	to	August 11, 2014	60	March 25, 2014	OLF tightened by 600 bps and acess to OLF window restricted to once a week
	3	August 18, 2014	to	October 13, 2015	54	August 18, 2014	
	4	October 20, 2015	to	March 17, 2017	58	October 20, 2015	Tightened foreign exchange trading rules
	5	April 20, 2017	to	February 27, 2019	133	April 20, 2017	
Total Obsservations					**377**		

Table 6b: Structural Breaks and Monetary Policy Events: Medium sized banks pricing

	Event	Period Covered			Observations	Structural Break Dates	Possible Factors
Medium to Small sized Inter-Bank Market	1	April 2, 2012	to	March 19, 2014	289	NA	
	2	March 20, 2014	to	November 6, 2015	351	March 20, 2014	OLF tightened by 600 bps and acess to OLF window restricted to once a week
	3	November 9, 2015	to	October 3, 2016	204	November 9, 2015	Policy rate raised to 15.5% from 12.5% and interest rate caps removed
	4	October 4, 2016	to	August 28, 2017	206	October 4, 2016	
	5	August 29, 2017	to	March 22, 2019	334	August 29, 2017	Policy rate reduced to 11% from 12.5%
Total Obsservations					**1,384**		
Medium to Medium sized Inter-Bank Market	1	April 2, 2012	to	March 19, 2014	169	NA	
	2	March 20, 2014	to	November 10, 2015	362	March 20, 2014	OLF tightened by 600 bps and acess to OLF window restricted to once a week
	3	November 16, 2015	to	May 12, 2016	102	November 16, 2015	Policy rate raised to 15.5% from 12.5% and interest rate caps removed
	4	May 17, 2016	to	August 10, 2017	206	May 17, 2016	Some FX trading rules relaxed
	5	August 11, 2017	to	March 15, 2019	181	August 11, 2017	Policy rate reduced to 11% from 12.5%
Total Obsservations					**1,020**		
Medium to Large sized Inter-Bank Market	1	April 10, 2012	to	March 19, 2014	149	NA	
	2	March 20, 2014	to	August 11, 2014	240	March 20, 2014	OLF tightened by 600 bps and acess to OLF window restricted to once a week
	3	November 13, 2015	to	May 10, 2016	112	November 13, 2015	Policy rate raised to 15.5% from 12.5% and interest rate caps removed
	4	May 11, 2016	to	March 17, 2017	92	May 11, 2016	Some FX trading rules relaxed
	5	September 7, 2017	to	February 27, 2019	380	September 7, 2017	Policy rate reduced to 11% from 12.5%
Total Obsservations					**973**		

Table 6c: Structural Breaks and Monetary Policy Events: Large sized banks pricing

	Event	Period Covered			Observations	Structural Break Dates	Possible Factors
Large to Small sized Inter-Bank Market	1	April 2, 2012	to	March 19, 2014	251	NA	
	2	March 25, 2014	to	November 3, 2015	286	March 25, 2014	OLF tightened by 600 bps and acess to OLF window restricted to once a week
	3	November 4, 2015	to	May 11, 2016	73	November 4, 2015	Policy rate raised to 15.5% from 12.5% and interest rate caps removed
	4	May 20, 2016	to	February 23, 2017	103	May 20, 2016	Some FX trading rules relaxed
	5	June 20, 2017	to	March 22, 2019	101	June 20, 2017	Policy rate reduced to 11% from 12.5%
Total Obsservations					**814**		
Large to Medium sized Inter-Bank Market	1	April 2, 2012	to	March 12, 2014	261	NA	
	2	March 20, 2014	to	November 3, 2015	272	March 20, 2014	OLF tightened by 600 bps and acess to OLF window restricted to once a week
	3	November 4, 2015	to	May 10, 2016	93	November 4, 2015	Policy rate raised to 15.5% from 12.5% and interest rate caps removed
	4	May 17, 2016	to	May 18, 2017	161	May 17, 2016	Some FX trading rules relaxed
	5	June 14, 2017	to	March 22, 2019	219	June 14, 2017	Policy rate reduced to 11% from 12.5%
Total Obsservations					**1,006**		
Large to Large sized Inter-Bank Market	1	April 10, 2012	to	March 18, 2014	156	NA	
	2	March 20, 2014	to	November 11, 2015	248	March 20, 2014	OLF tightened by 600 bps and acess to OLF window restricted to once a week
	3	November 12, 2015	to	May 12, 2016	74	November 12, 2015	Policy rate raised to 15.5% from 12.5% and interest rate caps removed
	4	May 13, 2016	to	May 15, 2017	107	May 13, 2016	Some FX trading rules relaxed
	5	May 31, 2017	to	March 20, 2019	264	May 31, 2017	Policy rate reduced to 11% from 12.5%
Total Obsservations					**849**		

4 Data Sources

The study employed daily data for the period January 2012-March 2019 for which a reliable data set was available. All the data were sourced from the Bank of Zambia covering 14 commercial banks.

Lending data was utilised and include transacting bank, counterparty, loan amount, tenor, interest rate, collateral type, collateral face value, and currency in which the loan was denominated, which were all in the local currency, Kwacha.

Lending transactions are split into intra and cross category trades. The transactions analysed include small to small, small to medium, small to large, medium to small, medium to medium, medium to large, large to small, large to medium and large to large interbank lending. For pricing behavior, lending rates data are used and cover nine trading pairs involving small, medium, and large banks as follows: small-small, small-medium, small-large, medium-small, medium-medium, medium-large, large-large, large-medium, and large-small.

5 Preliminary Findings

According to the exposure matrix results (Table 7), the interbank market in Zambia is incomplete, but not disjointed. An assessment of annual exposure matrices of interbank trades over the sample period (2012-2019) also confirmed the incomplete structure of the interbank money market (Tables a – h in the Appendix).

Table 7: Interbank Market Exposure Matrix (2009m1-2019m3)

			Lending														
			Small banks					Medium banks						Large banks			
		Bank	Bank SL1	Bank SL2	Bank SL3	Bank SL4	Bank SF5	Bank MF1	Bank MF2	Bank MF3	Bank MF4	Bank MF5	Bank ML6	Bank BF1	Bank BF2	Bank BF3	Bank BL4
Borrowing	Small banks	Bank SL1		√	√	√	√	√	0	0	√	√	√	0	√	0	√
		Bank SL2	√		√	√	√	√	0	0	√	√	√	0	√	√	√
		Bank SL3	√	√		√	√	√	0	0	√	0	√	√	√	0	√
		Bank SL4	0	√	√		√	√	0	0	√	√	√	√	√	√	√
		Bank SF5	√	√	√	√		√	0	0	√	0	√	0	√	0	√
	Medium banks	Bank MF1	√	√	√	√	√		0	0	√	√	√	√	√	√	√
		Bank MF2	0	0	0	0	0	0		0	0	0	0	0	0	0	0
		Bank MF3	0	√	√	√	0	√	0		0	√	√	√	√	√	√
		Bank MF4	√	√	√	√	√	√	0	0		√	√	0	√	0	√
		Bank MF5	√	√	√	√	0	√	0	0	√		√	0	√	√	√
		Bank ML6	√	√	√	0	0	0	0	0	√	√		√	√	√	√
	Large banks	Bank BF1	√	√	√	√	0	√	√	√	0	√	√		√	√	√
		Bank BF2	0	√	√	√	√	0	√	√	√	√	√	√		√	√
		Bank BF3	0	√	√	√	√	√	0	√	√	√	√	√	√		√
		Bank BL4	0	√	√	0	√	√	0	√	√	√	√	√	√	√	

Source: Author's computation using Bank of Zambia database

√ means existence of an active interbank credit line while 0 implies no trade between the corresponding banks

Note: sl- small local banks, ml-medium local sized banks and bl-Big local banks

Further, despite the interbank market being well connected, banks are not completely connected to each other, evidenced by the clustering coefficient of close to 1 (Table 8). Cluster coefficients close to 1 imply that most counterparties of a bank also have credit lines among themselves. This

means that, on average, most counterparties of a bank have trading relationships among themselves (but not all of them). For instance, a bank may have credit lines with numerous counterparties, but this does not necessarily mean that all of these counterparties also have credit lines among themselves. In addition, banks maintained trades with the usual frequent counterparties over the sample period based on the closeness centrality measure reported in Table 7. On average, each bank has acted as a mid-agent for about 1 to 3 banks based on the betweenness centrality measure. This helps with the flow of liquidity in a segmented market.

Table 8 Measures of Network Centrality (Annual Average)

	Betweenness Centrality	Closeness Centrality	Clustering Coefficient
Overall Sample	1.20000	0.06224	0.92787
2019	3.53333	0.04873	0.70106
2018	2.26667	0.05515	0.84795
2017	2.86667	0.05212	0.73967
2016	2.53333	0.05407	0.77809
2015	1.07143	0.06713	0.89340
2014	1.21429	0.06588	0.87848

Source: Author computations

A further analysis of the interaction of banks reveals that large banks are able to trade (interact) among themselves fully by utilizing all the available credit lines (Table 9). However, their interaction with small and medium banks is limited as they are able to utilize 75% and 83% of the available credit lines on the borrowing side and 70% and 71% on the lending side, respectively. While the interaction among the small-small banks is relatively high, it is, however, limited among the medium-medium pair (Table 9). This implies that large and small banks interact amongst themselves more than the medium sized banks do with the peers.

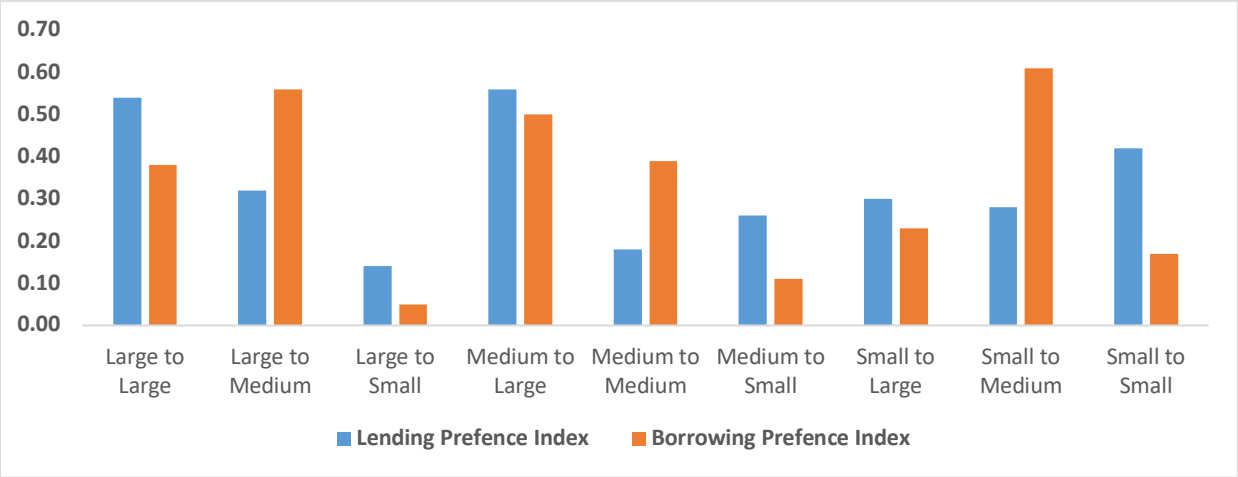
Table 9 Utilisation of Credit Lines (%)

		Lenders		
Borrowers		Small	Medium	Large
	Small	95	60	70
	Medium	67	50	71
	Large	75	83	100

Source: Author's computation using Bank of Zambia database

In terms of trading preference, large banks tend to borrow from and lend to medium sized banks and among themselves than they do with the small sized banks (Chart 1). This could be attributed to the strict credit risk compliance rules that large and medium sized banks follow when dealing with small banks. On the other hand, large and medium sized banks have more credit lines among themselves and few credit line with small banks. Medium sized banks prefer to trade with large banks than they do with peers and small banks. The preference by small banks is to borrow from medium sized banks than large banks and the peers. Conversely, their lending preference is to the peers (Chart 1).

Chart 1 Lending and Borrowing Preference Indices



Source: Author's computation using Bank of Zambia database
Note: Data used is based on traded volumes in billions of Kwacha

Ownership partially explains intense intra-trading within the small and large bank categories. The small bank category is dominated by local banks while the medium and large bank categories are dominated by foreign ownership. The only locally owned banks in the medium and large categories are those in which the Government of Zambia holds shares. Most locally owned banks tend to have more trading linkages among peers. Correspondingly, foreign banks also prefer trading with fellow foreign counterparties. This is consistent with the utilisation of credit lines results (Table 7). Large banks utilize all available credit lines as banks in this category are predominantly foreign owned. Equally, small banks utilize 95% of the credit lines as most of them are locally owned. However, intra category trading among medium banks is the lowest. This is mainly due to the diversity of foreign banks in this category. Most of the foreign banks are Pan-African while others are global multinationals. Generally, global multinational banks have limited and in some cases no credit lines with most local banks unless Government has a stake, and most Pan-African owned banks as these banks are consider as risky counterparties (default risk is higher than most big banks) Therefore, global multinationals prefer to trade mostly with banks in the large category.

In terms of pricing behavior, all the trading pairs among various categories of banks transacted above the policy rate (Table 10). The deviation was even higher in periods when monetary policy was tightened. This was partly to ensure that the pricing of the interbank facility was positive in real terms as the policy rate tended to be lower than the inflation rate at the time. This was coupled with tight liquidity conditions obtaining especially in late 2015 and in 2016 when monetary policy was tightened to contain inflationary pressures. The deviation is more pronounced for the small-large and medium-medium bank pairs where the lending rate exceeded the policy rate by 200 basis points. This could be attributed to limited credit lines between small and large banks as lending by small banks to large banks is usually at a higher premium. This result is in contrast with the evidence by Kim (2017) where large-large banks trade around the target rate and only small-large is below the policy rate while the large-small was above the target rate. On the other hand, the least deviations from the policy rate were among the large-small followed by large-medium pairs. This result is consistent with Muhanga, Mutoti and Zgambo (2009) who established a tendency

for large bank lenders to demand a premium from fellow large bank borrowers compared to small bank borrowers

It is noted that for small-large and medium-medium pairs, the volumes traded tend to be lower than the rest of the pairs. The relatively higher premium over the policy rate for the small to large lending pair than the large to small could be explained in the context of the liquidity cost. This is despite small banks having more credit lines and trading preference with large and medium banks. Large banks tend to generally charge the lowest premium compared to the other categories of banks. This could be explained by their large presence in the retail market where they are able to mobilise deposits at relatively lower cost in addition to having a large network of relationship banking with the corporates. The latter may give them an advantage in the wholesale market outside the interbank that ultimately lowers their liquidity cost.

The Hurst parameter estimates suggest a long-range dependence in interbank lending rates and thus persistence in loan pricing overall: increases in interbank lending rates take a relatively long period followed by an equally relatively long period of decline. This means that the interbank rate is predictable across relationship pairs as the estimated Hurst parameters ranged from 0.640 to 0.818 i.e. there is uniformity in pricing behavior in the interbank money market. This result suggests the absence of price segmentation in the interbank money market contrary to the findings by Muhanga, Mutoti and Zgambo (2009). However, monetary policy actions identified above tend to alter pricing behavior in the interbank market as pricing was characterised by anti-persistence ($0 < H < 0.5$) and randomness (unpredictable, $H = 0.5$). For example, when monetary policy was tightened and interest caps[9] removed in November 2015, the pricing behavior changed and lending rates became unpredictable for the small-medium, small-large, and medium-large pairs given the estimated H parameter value of close to 0.5. While there exists intra-group price segmentation for the large-large pair and mostly for the medium-medium pair across different regimes, it is not the case with the small-small pair. This is due to the Hurst parameter values falling within the same range, suggesting a persistence in pricing, and may interpreted as a case of "colleagueship."

[9] In 2012 the Bank of Zambia introduced interest caps on lending rates charged by banks and non-bank financial institutions but was, however, discontinued in November 2015.

Table 10a: Pricing Differential

Inter-Bank Sagement	Pricing Differential (Overall Sample)		Structural Break Dates	Regime	Pricing Differential (Sub-Samples)	
	mean	Standard Deviation			mean	Standard Deviation
Small to Small sized Inter-Bank Market	1.62	3.42		1	-0.30	0.94
			March 21, 2014	2	2.62	3.47
			November 5, 2015	3	5.83	4.77
			December 12, 2016	4	0.35	0.76
			November 3, 2017	5	-0.01	0.31
Small to Medium sized Inter-Bank Market	1.68	3.60		1	-0.45	0.92
			March 19, 2014	2	5.06	4.30
			November 5, 2014	3	3.72	3.47
			May 30, 2016	4	1.02	0.94
			September 8, 2017	5	-0.08	0.36
Small to Large sized Inter-Bank Market	2.21	4.25		1	-0.30	0.75
			March 25, 2014	2	7.15	2.32
			August 18, 2014	3	0.25	2.32
			October 20, 2015	4	7.39	4.48
			April 20, 2017	5	-0.09	0.46
Medium to Small sized Inter-Bank Market	1.69	3.51		1	-0.36	1.00
			March 20, 2014	2	2.62	3.46
			November 9, 2015	3	6.95	4.46
			October 4, 2016	4	0.59	0.67
			August 29, 2017	5	0.16	0.31
Medium to Medium sized Inter-Bank Market	2.09	3.81		1	-0.23	0.97
			March 20, 2014	2	2.70	3.59
			November 16, 2015	3	10.94	1.09
			May 17, 2016	4	1.30	1.00
			August 11, 2017	5	-0.06	0.48
Medium to Large sized Inter-Bank Market	1.97	3.87		1	-0.47	0.97
			March 20, 2014	2	3.04	3.90
			November 4, 2015	3	9.93	2.58
			May 11, 2016	4	1.17	1.36
			September 7, 2017	5	-0.10	0.38
Large to Small sized Inter-Bank Market	1.37	3.42		1	-0.63	1.01
			March 25, 2014	2	2.75	3.76
			November 4, 2015	3	3.46	4.29
			May 20, 2016	4	0.90	1.88
			June 20, 2017	5	-0.02	0.47
Large to Medium sized Inter-Bank Market	1.41	3.41		1	-0.65	0.94
			March 20, 2014	2	1.78	2.48
			November 4, 2015	3	10.35	2.11
			May 17, 2016	4	1.08	1.07
			June 14, 2017	5	-0.14	0.56
Large to Large sized Inter-Bank Market	1.59	3.43		1	-0.55	0.86
			March 20, 2014	2	2.20	2.89
			November 12, 2015	3	10.49	1.50
			May 13, 2016	4	1.46	0.92
			May 31, 2017	5	-0.14	0.53

Table 10b: Long Range Dependence Results

Inter-Bank Sagement	Hurst Parameter (Overall Sample)		Structural Break Dates	Regime	Hurst Parameter (Sub-Samples)
Small to Small sized Inter-Bank Market	0.707	Persistent Process		1	0.565
			March 21, 2014	2	0.802
			November 5, 2015	3	0.751
			December 12, 2016	4	0.780
			November 3, 2017	5	0.774
Small to Medium sized Inter-Bank Market	0.818	Persistent Process		1	0.412
			March 19, 2014	2	0.699
			November 5, 2014	3	0.468
			May 30, 2016	4	0.853
			September 8, 2017	5	0.773
Small to Large sized Inter-Bank Market	0.679	Persistent Process		1	0.463
			March 25, 2014	2	0.934
			August 18, 2014	3	0.408
			October 20, 2015	4	0.945
			April 20, 2017	5	0.673
Medium to Small sized Inter-Bank Market	0.768	Persistent Process		1	0.487
			March 20, 2014	2	0.736
			November 9, 2015	3	0.911
			October 4, 2016	4	0.781
			August 29, 2017	5	0.565
Medium to Medium sized Inter-Bank Market	0.77	Persistent Process		1	0.442
			March 20, 2014	2	0.812
			November 16, 2015	3	0.776
			May 17, 2016	4	0.561
			August 11, 2017	5	0.384
Medium to Large sized Inter-Bank Market	0.64	Persistent Process		1	0.537
			March 20, 2014	2	0.838
			November 4, 2015	3	0.522
			May 11, 2016	4	0.216
			September 7, 2017	5	0.632
Large to Small sized Inter-Bank Market	0.646	Persistent Process		1	0.562
			March 25, 2014	2	0.810
			November 4, 2015	3	0.769
			May 20, 2016	4	0.076
			June 20, 2017	5	0.989
Large to Medium sized Inter-Bank Market	0.646	Persistent Process		1	0.568
			March 20, 2014	2	0.806
			November 4, 2015	3	0.702
			May 17, 2016	4	0.488
			June 14, 2017	5	0.679
Large to Large sized Inter-Bank Market	0.691	Persistent Process		1	0.004
			March 20, 2014	2	0.521
			November 12, 2015	3	0.556
			May 13, 2016	4	0.734
			May 31, 2017	5	0.589

6 Conclusion

The segmentation of the interbank money market in Zambia was analysed using network framework analysis, lending and borrowing (trading) preference indices, as well as price differential analysis. The daily data spanned from January 2012 to March 2019.

The study has revealed the existence of segmentation in the interbank market in Zambia. The market structure is incomplete (not all banks have credit lines) but not disjointed as both within and cross bank categories trades occur. Specifically, large banks fully trade with each other by utilizing all the available credit lines. Nonetheless, they charge a relatively higher premium compared to small and medium sized bank borrowers. This result is consistent with Muhanga, Mutoti and Zgambo (2009) where large bank lenders were found to demand a premium from fellow large bank borrowers compared to small bank borrowers. This notwithstanding, large banks interaction with small and medium banks has been limited. The interaction among the small banks with each other is relatively high but commands a relatively lower premium than the case is with lending to medium sized and large banks, indicative of pricing segmentation. However, there is limited interaction among the medium-medium pair and tend to charge each other a relatively higher premium compared to small and large banks. The study also shows that large and small banks interact amongst themselves more than the medium sized banks do with peers. This perhaps could be the reason for high premium charged when medium-medium banks trade among themselves. Further, the paper reveals that trades are also based on ownership. Bank categories with similar or related ownership tend to have more interactions as opposed to bank categories with diverse ownership

Although the results on long-range dependence in pricing show lack of segmentation and predictability in interbank lending rates, the pricing behavior is susceptible to monetary policy stance change which makes lending rates unpredictable for some trading relationship pairs.

It will be interesting to extend this study by considering the role of volume of funds traded and how they may influence pricing behavior of banks in light of the price segmentation established. This is because liquidity in the Zambian interbank market is skewed among the large banks and two medium sized banks.

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Appendix

Figure 1 Overnight Interbank Traded Volumes (K billion): 2012-2019

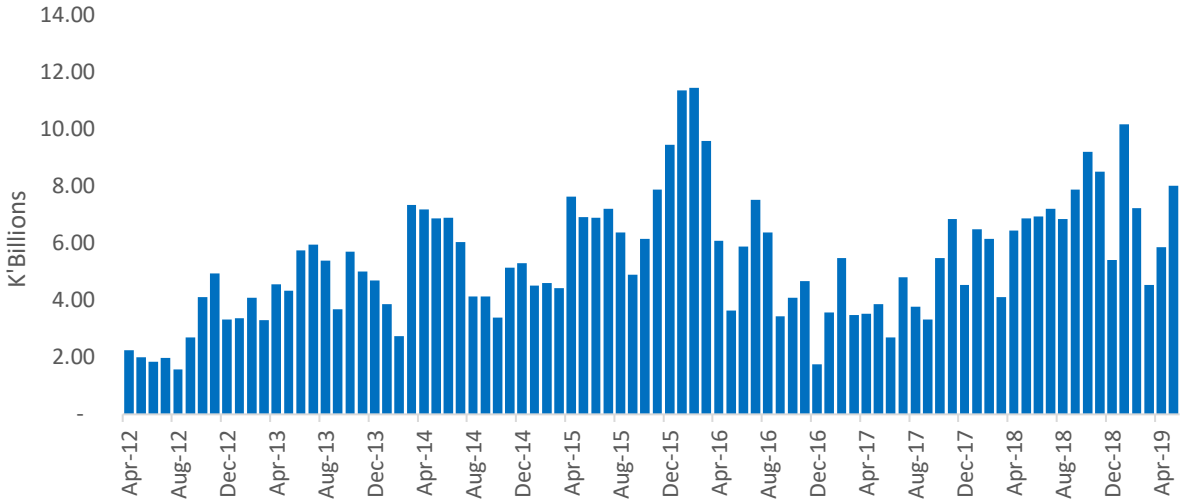

Figure 2 Overnight Interbank Rate and Bank of Zambia Policy Rate: 2012-2019

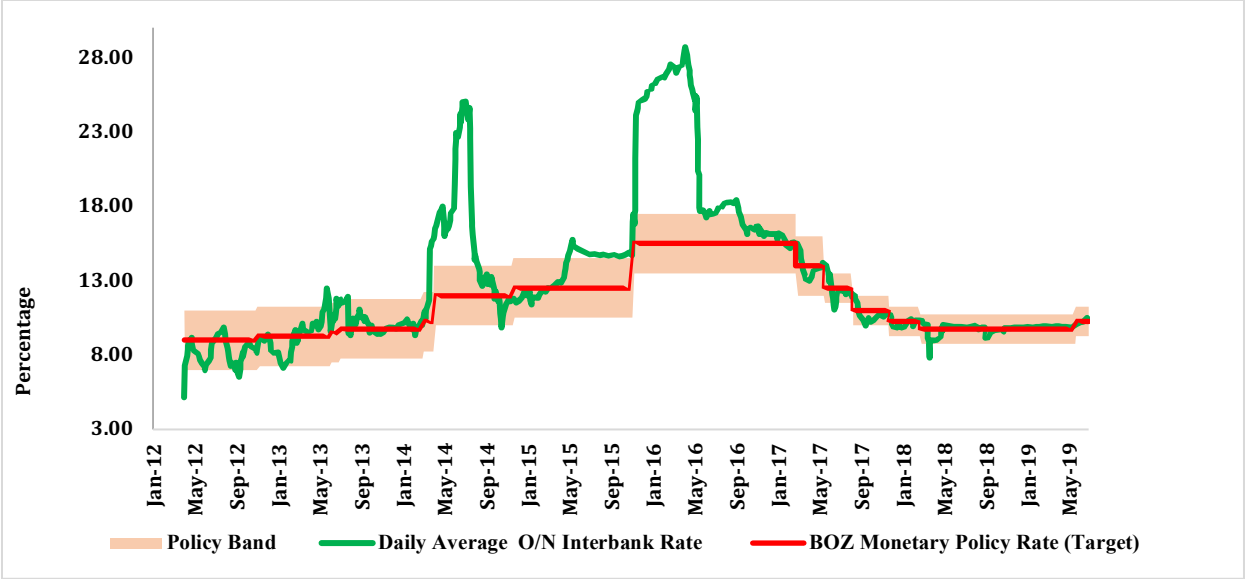

Figure 3 Access to Bank of Zambia Liquidity (OLF Volumes: 2012-2019)

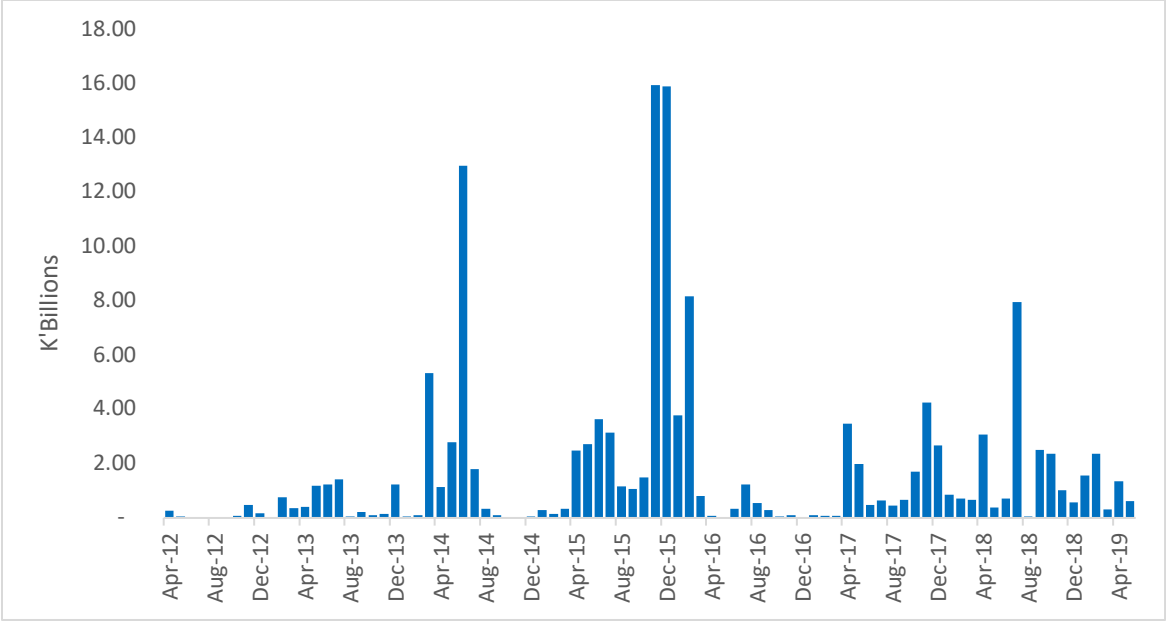

Figure 4 Settlement Balances (Excess Reserves) held at the Bank of Zambia and the Overnight Interbank Rate: 2012-2019

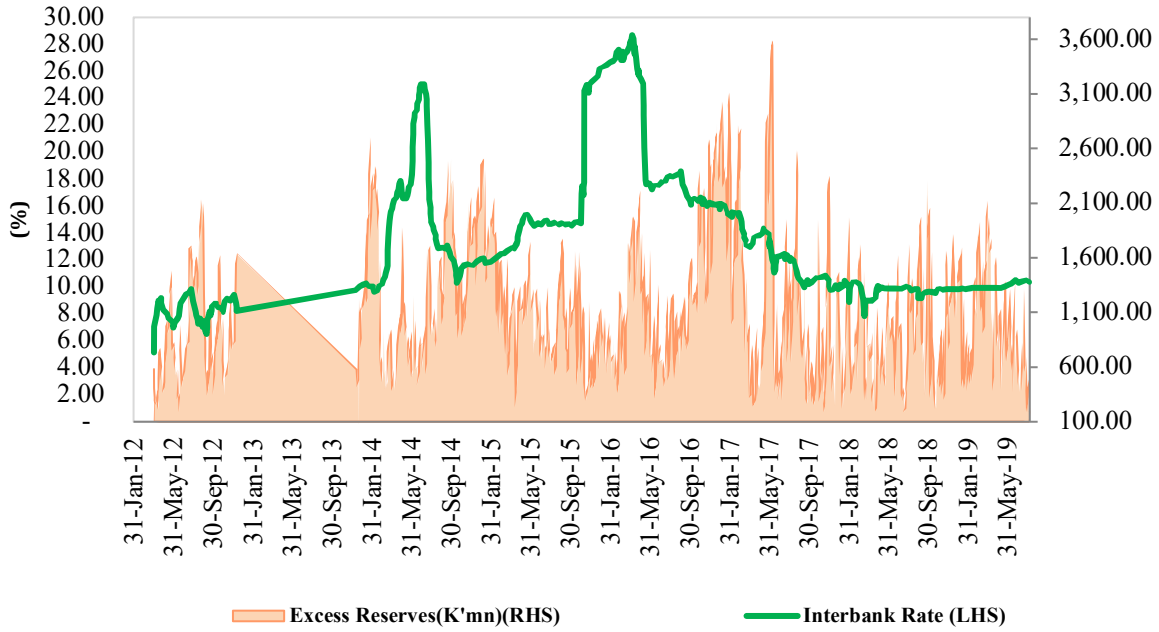

Table a: Exposure matrix- Zambian Interbank Market (2012)

			Lending														
	2012		Small banks					Medium banks						Large banks			
		Bank	Bank SL1	Bank SL2	Bank SL3	Bank SL4	Bank SF5	Bank MF1	Bank MF2	Bank MF3	Bank MF4	Bank MF5	Bank ML6	Bank BF1	Bank BF2	Bank BF3	Bank BL4
Borrowing	Small banks	Bank SL1		√	√	√	√	√	0	0	√	√	√	0	√	0	√
		Bank SL2	√		√	√	0	√	0	0	√	√	√	0	0	√	√
		Bank SL3	√	√		√	0	√	0	0	0	0	√	√	√	0	√
		Bank SL4	√	√	√		√	√	0	0	√	√	√	0	√	√	√
		Bank SF5	0	√	√	√		0	0	0	0	0	0	0	√	0	√
	Medium banks	Bank MF1	0	√	√	√	√		0	0	√	√	√	√	√	0	√
		Bank MF2	0	0	0	0	0	0		0	0	0	0	0	0	0	0
		Bank MF3	0	√	√	√	0	0	0		0	0	√	√	√	√	√
		Bank MF4	√	√	√	√	0	√	0	0		√	√	0	√	0	√
		Bank MF5	0	√	√	√	0	0	0	0	√		√	√	√	√	√
		Bank ML6	0	0	√	√	0	√	0	√	√	√		√	√	√	√
	Large banks	Bank BF1	0	√	√	√	0	√	√	√	0	√	√		√	√	√
		Bank BF2	0	0	0	√	0	0	0	√	√	√	√	0		√	√
		Bank BF3	0	0	0	0	0	0	0	√	0	0	0	√	√		√
		Bank BL4	√	√	0	√	√	√	0	√	√	√	√	√	√	√	

Source: Author's computation using Bank of Zambia database

√ *means existence of an active interbank credit line while 0 implies no trade between the corresponding banks*

Note: sl- small local banks, ml-medium local sized banks and bl-large Big local banks Table b: Exposure matrix- Zambian Interbank Market (2013)

			Lending														
	2013		Small banks					Medium banks						Large banks			
		Bank	Bank SL1	Bank SL2	Bank SL3	Bank SL4	Bank SF5	Bank MF1	Bank MF2	Bank MF3	Bank MF4	Bank MF5	Bank ML6	Bank BF1	Bank BF2	Bank BF3	Bank BL4
Borrowing	Small banks	Bank SL1		√	√	0	√	√	0	0	√	√	√	0	0	0	√
		Bank SL2	0		√	0	0	√	0	0	√	0	√	0	√	√	0
		Bank SL3	0	0		0	√	√	0	0	0	0	0	0	√	0	√
		Bank SL4	0	√	√		√	√	0	0	√	√	√	0	√	√	√
		Bank SF5	0	0	√	0		0	0	0	0	0	√	0	√	0	√
	Medium banks	Bank MF1	0	√	√	√	√		0	0	√	√	√	√	√	0	0
		Bank MF2	0	0	0	0	0	0		0	0	0	0	0	0	0	0
		Bank MF3	0	0	0	0	0	√	0		0	0	√	√	√	√	√
		Bank MF4	0	√	√	0	√	√	0	0		√	√	0	√	0	√
		Bank MF5	0	√	0	0	0	√	0	0	√		0	√	√	√	√
		Bank ML6	0	0	0	0	√	0	0	0	0	0		0	√	0	√
	Large banks	Bank BF1	0	0	√	0	0	√	0	√	0	√	√		√	√	√
		Bank BF2	0	0	0	0	√	√	0	√	0	0	√	√		√	√
		Bank BF3	0	√	0	0	0	0	0	√	0	√	0	√	√		√
		Bank BL4	0	√	0	0	√	0	0	√	√	√	√	√	√	√	

Source: Author's computation using Bank of Zambia database

√ *means existence of an active interbank credit line while 0 implies no trade between the corresponding banks*

Note: s- small banks, m-medium sized banks and l-large banks

Table c: Exposure matrix- Zambian Interbank Market (2014)

	2014	Lending															
		Small banks						Medium banks						Large banks			
	Bank	Bank SL1	Bank SL2	Bank SL3	Bank SL4	Bank SF5	Bank MF1	Bank MF2	Bank MF3	Bank MF4	Bank MF5	Bank ML6	Bank BF1	Bank BF2	Bank BF3	Bank BL4
Borrowing	Small banks	Bank SL1		√	√	√	√	0	0	√	0	√	0	0	0	√
		Bank SL2	√		0	√	√	√	0	0	√	0	√	0	√	√	√
		Bank SL3	√	√		√	√	√	0	0	√	0	√	√	√	0	√
		Bank SL4	0	√	√		√	√	0	0	√	√	√	0	√	√	√
		Bank SF5	√	√	√	0		√	0	0	√	0	0	0	√	0	√
	Medium banks	Bank MF1	√	√	√	√	√		0	0	√	√	√	√	√	√	√
		Bank MF2	0	0	0	0	0	0		0	0	0	0	0	0	0	0
		Bank MF3	0	√	0	√	0	√	0		0	0	√	√	√	√	√
		Bank MF4	0	√	√	√	√	√	0	0		0	√	0	√	0	√
		Bank MF5	0	√	0	√	0	√	0	0	√		√	√	√	√	√
		Bank ML6	0	√	0	0	0	√	0	0	0	0		√	0	0	√
	Large banks	Bank BF1	0	√	0	√	0	√	0	√	0	√	√		√	√	√
		Bank BF2	0	√	0	√	√	√	0	√	√	√	√	√		√	√
		Bank BF3	0	√	0	√	0	√	0	√	0	√	√	√	√		√
		Bank BL4	0	√	0	√	√	√	0	√	√	√	√	√	√	√	

Source: Author's computation using Bank of Zambia database

√ *means existence of an active interbank credit line while 0 implies no trade between the corresponding banks*

Note: sl- small local banks, ml-medium local sized banks and bl-large Big local banks

Table d: Exposure matrix- Zambian Interbank Market (2015)

	2015	Lending															
		Small banks						Medium banks						Large banks			
	Bank	Bank SL1	Bank SL2	Bank SL3	Bank SL4	Bank SF5	Bank MF1	Bank MF2	Bank MF3	Bank MF4	Bank MF5	Bank ML6	Bank BF1	Bank BF2	Bank BF3	Bank BL4
Borrowing	Small banks	Bank SL1		√	√	√	√	√	0	0	√	0	√	0	0	0	√
		Bank SL2	√		√	√	√	√	0	0	0	0	√	0	√	√	√
		Bank SL3	√	√		√	√	√	0	0	√	0	√	√	0	0	√
		Bank SL4	0	√	√		√	√	0	0	√	√	√	√	√	√	√
		Bank SF5	√	√	√	√		√	0	0	√	0	√	0	√	0	√
	Medium banks	Bank MF1	√	√	√	√	√		0	0	√	√	√	√	√	√	√
		Bank MF2	0	0	0	0	0	0		0	0	0	0	0	0	0	0
		Bank MF3	0	√	0	√	0	√	√		0	0	√	√	√	√	√
		Bank MF4	0	√	√	√	√	√	0	0		0	√	0	0	0	√
		Bank MF5	0	√	0	0	0	√	0	0	0		√	√	√	√	√
		Bank ML6	√	0	√	0	0	√	0	0	0	0		√	√	√	√
	Large banks	Bank BF1	0	√	0	0	0	√	0	√	0	√	√		0	0	√
		Bank BF2	0	√	√	√	√	√	0	√	√	√	√	√		√	√
		Bank BF3	0	√	√	√	√	√	0	√	0	√	√	√	√		√
		Bank BL4	0	0	0	0	√	√	0	√	√	√	0	√	√	√	

Source: Author's computation using Bank of Zambia database

√ *means existence of an active interbank credit line while 0 implies no trade between the corresponding banks*

Note: sl- small local banks, ml-medium local sized banks and bl-large Big local banks Table e: Exposure matrix- Zambian Interbank Market (2016)

	2016	Lending															
		Small banks						Medium banks						Large banks			
	Bank	Bank SL1	Bank SL2	Bank SL3	Bank SL4	Bank SF5	Bank MF1	Bank MF2	Bank MF3	Bank MF4	Bank MF5	Bank ML6	Bank BF1	Bank BF2	Bank BF3	Bank BL4
Borrowing	Small banks	Bank SL1		0	√	√	√	0	0	0	0	√	0	0	0	0
		Bank SL2	0		0	√	√	√	0	0	0	√	0	√	√	√
		Bank SL3	0	√		√	√	√	0	0	√	0	√	√	0	√	√
		Bank SL4	0	√	√		0	√	0	0	√	0	√	0	0	0	√
		Bank SF5	√	√	0	√		√	0	0	0	0	√	0	0	0	√
	Medium banks	Bank MF1	√	√	√	√	√		0	0	√	√	√	√	√	√	√
		Bank MF2	0	0	0	0	0	0		0	0	0	0	0	0	0	0
		Bank MF3	0	0	√	√	0	√	0		0	√	√	√	√	√	√
		Bank MF4	0	√	√	√	0	√	0	0		0	√	0	0	0	√
		Bank MF5	0	√	0	0	0	√	0	0	0		√	√	√	0	√
		Bank ML6	0	0	0	0	0	√	0	0	0	√		√	√	√	√
	Large banks	Bank BF1	0	0	0	0	0	√	0	√	0	√	√		√	0	√
		Bank BF2	0	√	0	√	0	√	√	√	√	√	√	√		0	√
		Bank BF3	0	√	0	√	√	√	0	√	0	√	√	√	√		√
		Bank BL4	0	√	0	0	√	√	0	√	√	√	√	√	√	√	

Source: Author's computation using Bank of Zambia database

√ *means existence of an active interbank credit line while 0 implies no trade between the corresponding banks*

Note: sl- small local banks, ml-medium local sized banks and bl-large Big local banks

Table f: Exposure matrix- Zambian Interbank Market (2017)

			Lending															
	2017		Small banks					Medium banks						Large banks				
		Bank	Bank SL1	Bank SL2	Bank SL3	Bank SL4	Bank SF5	Bank MF1	Bank MF2	Bank MF3	Bank MF4	Bank MF5	Bank ML6	Bank BF1	Bank BF2	Bank BF3	Bank BL4
Borrowing	Small banks	Bank SL1		√	√	√	√	√	0	0	√	√	√	0	0	0	0
		Bank SL2	√		0	√	√	√	0	0	√	0	√	0	0	0	√
		Bank SL3	√	√		0	√	0	0	0	√	0	√	√	√	0	√
		Bank SL4	0	√	0		0	√	0	0	√	0	√	0	0	0	√
		Bank SF5	√	√	√	√		√	0	0	√	0	√	0	0	0	√
	Medium banks	Bank MF1	0	√	√	√	√		0	0	√	0	√	√	√	√	√
		Bank MF2	0	0	0	0	0	0		0	0	0	0	0	0	0	0
		Bank MF3	0	0	0	0	0	√	0		0	√	√	√	√	√	√
		Bank MF4	0	0	√	√	0	√	0	0		0	√	0	0	0	0
		Bank MF5	0	√	√	0	0	0	0	0	√		0	√	√	√	√
		Bank ML6	√	√	√	√	0	0	0	0	√	0		√	0	√	√
	Large banks	Bank BF1	0	√	√	0	0	√	√	√	0	√	√		√	√	√
		Bank BF2	0	0	0	0	√	0	0	√	√	√	0	√		0	√
		Bank BF3	0	√	√	√	0	√	0	√	√	√	√	√	√		√
		Bank BL4	0	√	√	0	0	√	0	√	√	√	√	√	√	√	

Source: Author's computation using Bank of Zambia database

√ *means existence of an active interbank credit line while 0 implies no trade between the corresponding banks*

Note: sl- small local banks, ml-medium local sized banks and bl-large Big local banks

Table g: Exposure matrix- Zambian Interbank Market (2018)

			Lending															
	2018		Small banks					Medium banks						Large banks				
		Bank	Bank SL1	Bank SL2	Bank SL3	Bank SL4	Bank SF5	Bank MF1	Bank MF2	Bank MF3	Bank MF4	Bank MF5	Bank ML6	Bank BF1	Bank BF2	Bank BF3	Bank BL4
Borrowing	Small banks	Bank SL1		√	√	√	0	√	0	0	√	0	√	0	0	0	0
		Bank SL2	0		√	√	0	0	0	0	√	0	√	0	0	0	0
		Bank SL3	0	0		0	0	√	0	0	0	0	0	0	0	0	0
		Bank SL4	0	√	0		0	√	0	0	√	0	√	0	0	0	0
		Bank SF5	√	√	√	√		√	0	0	√	0	√	0	0	0	√
	Medium banks	Bank MF1	0	√	√	0	0		0	0	√	0	0	√	√	0	√
		Bank MF2	0	0	0	0	0	0		0	0	0	0	0	0	0	0
		Bank MF3	0	0	0	0	0	0	0		0	√	0	√	0	√	√
		Bank MF4	0	√	√	√	0	√	0	0		0	√	0	0	0	√
		Bank MF5	0	0	0	0	0	0	0	0	0		0	√	0	0	0
		Bank ML6	0	√	√	0	0	0	0	0	√	0		√	√	0	√
	Large banks	Bank BF1	√	0	√	√	0	√	√	√	0	√	√		0	0	√
		Bank BF2	0	√	√	0	0	0	√	√	√	√	√	√		√	√
		Bank BF3	0	√	0	0	0	√	0	√	√	√	√	√	0		√
		Bank BL4	0	0	√	0	0	√	0	√	√	√	0	√	0	0	

Source: Author's computation using Bank of Zambia database

√ *means existence of an active interbank credit line while 0 implies no trade between the corresponding banks*

Note: sl- small local banks, ml-medium local sized banks and bl-large Big local banks

Table h: Exposure matrix- Zambian Interbank Market (2019)

			Lending															
	2019		Small banks					Medium banks						Large banks				
		Bank	Bank SL1	Bank SL2	Bank SL3	Bank SL4	Bank SF5	Bank MF1	Bank MF2	Bank MF3	Bank MF4	Bank MF5	Bank ML6	Bank BF1	Bank BF2	Bank BF3	Bank BL4
Borrowing	Small banks	Bank SL1		√	√	0	√	√	0	0	√	0	√	0	0	0	√
		Bank SL2	0		0	0	√	0	0	0	√	0	√	0	0	0	0
		Bank SL3	0	√		0	√	√	0	0	√	0	√	√	√	0	0
		Bank SL4	0	√	0		0	√	0	0	√	0	√	0	0	0	√
		Bank SF5	0	√	√	0		√	0	0	√	0	√	0	0	0	√
	Medium banks	Bank MF1	0	0	√	0	0		0	0	√	0	0	√	√	0	0
		Bank MF2	0	0	0	0	0	0		0	0	0	0	0	0	0	0
		Bank MF3	0	0	0	0	0	0	0		0	0	0	0	0	0	0
		Bank MF4	0	√	√	0	√	√	0	0		0	√	0	0	0	√
		Bank MF5	0	0	0	0	0	0	0	0	0		0	√	√	√	√
		Bank ML6	0	√	0	0	0	0	0	0	0	0		√	0	0	√
	Large banks	Bank BF1	0	0	0	0	0	0	0	√	0	√	0		√	√	√
		Bank BF2	0	√	√	0	0	√	√	√	√	√	√	√		√	√
		Bank BF3	0	0	0	0	0	0	0	√	√	√	0	√	0		0
		Bank BL4	√	√	√	0	0	√	0	√	√	√	√	√	√	√	

Source: Author's computation using Bank of Zambia database

√ *means existence of an active interbank credit line while 0 implies no trade between the corresponding banks*

Note: sl- small local banks, ml-medium local sized banks and bl-large Big local banks