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The peer monitoring role of the interbank market and implications for bank regulation: Evidence from Kenya

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The peer monitoring role of the interbank market and implications for bank regulation: Evidence from Kenya[1]

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Abstract
This paper investigates whether the interbank market in Kenya is effective as a peer monitoring and market discipline device and can thus complement official bank regulation. We use a unique quarterly dataset on 43 banks which participated in interbank transactions in Kenya over almost a decade. We uncover a new and interesting result - the impact of interbank market activity on bank risk levels mimics a U-curve: At average levels of interbank activity, we find a stable inverse relationship between interbank activity and bank risk levels, after controlling for other bank risk determinants and macroeconomic factors; however, if a bank increases its interbank position beyond a threshold level, the impact on bank risk is reversed from risk-reducing to risk-increasing due to possible contagion effects. We also find that, after grouping banks by different characteristics, the risk reduction effect due to peer monitoring is smaller for less risky banks including larger, listed, foreign and older banks. Overall, we conclude that Kenya's interbank market discipline role may complement official bank regulation. This finding may have exemplary implications for other countries at a relatively early stage of financial development.

JEL classification: G21; G28; E58

Key words: Interbank market; Bank risk; Market discipline; Bank regulation

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Highlights

- The first ever investigation of the peer monitoring role of the interbank market in Kenya
- The impact of interbank market activity on bank risk levels mimics a U-curve
- Beyond a threshold level, the impact is reversed from risk-reducing to risk-increasing
- The risk reduction effect is marginal for less risky, larger, listed, foreign and older banks
- Kenya’s interbank market discipline role may complement official bank regulation

1. Introduction

There is an emerging consensus that a robust interbank market is important for the proper functioning of a modern financial system (Wells, 2004; Iori, et al., 2006; Nier, et al., 2007; Amini et al., 2017; Aldasoro and Alves, 2018). The interbank market enables individual banks to trade with one another to meet their demands and supplies of short term funds. However, except for very few industrial developing economies, the interbank market has been neglected as a research area. This paper begins to remedy the aforementioned neglect; it studies the bank peer monitoring implications of the behaviour of participating banks in the interbank market in Kenya.

Specifically, four recent developments have motivated our work. First is the 2007/08 global financial crisis which brought into stark relief the problem of systemic risk. One of the important lessons learnt from the crisis so far is that government-mandated discipline, in terms of formal bank regulation and supervision, is necessary but not sufficient for mitigating systemic risk, especially as the banking industry grows more complex. The limits to what can be achieved by formal regulation have refocused attention on the possible role of market-based discipline in banking systems; and pillar 3 of the latest Basel Capital Accord lays out disclosure recommendations aimed at enhancing market discipline.[3] Banks that utilise the interbank market may be expected to have specialist knowledge of the market and its participants. To safeguard its lending, each bank has a strong incentive to monitor the activities of other participants. Hence the whole market underpins a peer monitoring process among participating banks that is distinct from the usual regulatory oversight of the central bank and from external private monitors such as rating agencies. The discipline from the interbank market could have an increasingly complementary role to government-mandated

[3] Market discipline in banking may be defined as a situation in which private sector agents face costs that are positively related to the risks undertaken by banks and react on the basis of these costs (Berger, 1991).

regulatory discipline. Indeed, as noted by Berger and Turk-Ariss (2015), the recent financial crisis highlights the importance of regulatory and market discipline.

The second development motivating our paper is that the potential market discipline role of the interbank market is likely to be particularly important in Africa, as African countries seek to accomplish the transition from Basel I through to Basel III. In this transition, concerns about ‘one size fits all’ official bank regulation for emerging economies have been side-stepped, leaving open the option of exploiting market discipline as a complementary regulatory tool (Murinde, 2010).

Third, one important lesson from the global financial crisis is that liquidity or solvency problems in an individual bank could all too easily be propagated rapidly through the interbank market, leading to a seizing-up of the market as a whole (Green, 2011). The interbank market can therefore also be a channel of contagion in the banking system instead of an instrument for market discipline.

Fourth, existing studies have provided very limited understanding of interbank markets especially in emerging economies. As one of the most important and developed financial markets in Africa, a study of Kenya’s interbank market can provide important insights to help fill this research gap. Kenya's banking sector is characterised by its size and diversity. The participation of banks with different ownerships, listed status and sizes in the interbank market provide a rich data source to give further insights into how and how far different institutions implement market discipline within Kenya’s interbank market.

Hence, our research makes the following contributions to existing knowledge. First, from the regulators’ point of view, the interbank market has two important features, “good” and “bad”: A market discipline function alongside a potential channel of contagion. As far as we are aware, previous studies never considered the good and the bad together. Hence their results are incomplete at best. In this paper, we study these two effects within the framework of a single model. Second, we analyse a unique dataset provided by the Central Bank of Kenya (CBK) that includes the actual interbank exposures of individual banks with one another and bank-specific characteristics. The data are anonymized for use in this paper. This means that we can study interbank market discipline in much more depth than previous researchers. Most studies are not able to use data on bilateral exposures, and commonly assume that banks spread their lending as evenly as possible among other banks by maximizing the entropy of interbank connections. We object to the entropy approach because it is not necessarily optimal behaviour (Glasserman and Young, 2015); in particular, the maximum entropy method is liable to underestimate the extent of contagion (Mistrulli, 2011); moreover, our data show in fact that interbank asset and liability exposures in Kenya are both substantially asymmetrically distributed. With our unique dataset, our study can avoid these problems.

The remainder of this paper is structured into five parts. Section 2 presents a review of the relevant literature explaining further why we focus on Kenya and highlighting the link between interbank market peer monitoring and regulation. Section 3 presents the methodology and data. Section 4 reports and discusses the empirical results, and Section 5 offers some concluding remarks and policy implications. Some supplementary results are provided in an appendix.

2. Literature review

2.1. Why Kenya?

African financial systems are generally lacking in breadth and depth. In comparison with other East African economies, Kenya's banking sector has become more developed especially in size and diversification; for example, the ratio of private credit to GDP was 23.7% in 2008 compared with a median of 12.3% for Sub-Saharan Africa (Beck, Demirguc-Kunt and Levine, 2009). The financial sector is still largely bank-based as the capital market is relatively narrow and shallow, so financial intermediation depends mainly on commercial banks (Kamau, 2009). In theory, therefore, the system may be particularly vulnerable to contagion: any bank failure could lead to bank runs or crises, and could have a disproportionately large impact on economic growth. The CBK is in charge of banking sector regulation and supervision in Kenya. Over the past decades, there have been numerous revisions to the Banking Act, Central Bank of Kenya Act and prudential guidelines in order to strengthen CBK's supervisory role. Economic theory provides conflicting predictions about the impact of regulatory and supervisory policies on bank performance (e.g., Barth et al., 2004, 2007, 2010). Among the potential problems of regulation is that it may interfere with the efficient operation of banks. Regulators are also subject to their own personal incentives and political pressures when exercising their duties. Regulatory capture could arise from the close working relation between the regulators and the regulated, and the remoteness of those in whose interest the regulation is being carried out.

Market discipline can help regulators limit political pressure and tolerance in microprudential regulation. Barth et. al. (2006) show that economies that emphasize banking sector market monitoring perform better based on a range of criteria. Following the banking crisis of 1985/86, Kenya established a Deposit Protection Fund Board (DPFB) with a wide mandate (Beck, et al., 2010). Deposit insurance is often seen as an integral part of a financial safety net, but it can also weaken market discipline as depositors are less motivated to properly monitor and discipline banks, which results in additional pressure on official regulators (Demirguc-Kunt and Detragiache, 2002). See Demirguc-Kunt and Kane (2002) for a detailed survey of this literature. Like Kenya, countries with poorly developed capital markets, accounting standards, and legal systems may not be able to rely effectively on external private monitoring, particularly as transparency is often lacking in such environments. Even in developed economies, banking activities have become more complicated and opaque, making effective monitoring much more difficult. Therefore, excessive reliance on external private monitoring may lead to the exploitation of depositors and poor bank performance. Equity holders and bondholders may be unable to monitor managers effectively without the use of "last-resort" measures including bankruptcy or takeovers, which may not always be the first-best solution. In this context, interbank market discipline is another possible candidate to complement regulatory discipline and external private monitoring.

Compared with interbank markets in the rest of the Africa, Kenya's interbank market is already entrenched (Green, et al., 2017). Appendix Table A1 lists key events in Kenya's interbank market from 2007 to 2011. The market is actively managed and used by Kenyan commercial banks and the CBK. Prior to 2011, there was a shortage of dollars in the Kenyan money market causing the Kenya shilling to depreciate. A survey conducted by the CBK indicated that the weakening and associated volatility of the shilling against other major currencies was attributable in part to reverse carry transactions. For example, between April and August 2011 the level of activity in the foreign exchange market increased threefold from around US$5bn. per month to US$15bn. Commercial banks increasingly resorted to CBK discount window borrowing averaging Ksh16bn. per day in the two weeks ending November 4^{th}, 2011 (CBK, 2011). To restore and enhance the capacity of the discount window to attain its monetary policy objectives, the CBK issued new guidelines which stipulated that any bank that was lending in the interbank market would not be allowed access to the discount window. In determining eligibility for access, the CBK would consider an individual bank's foreign exchange trading behaviour in the previous four trading days.

In addition to its interbank market, Kenya has a banking sector that is well-developed and diversified in comparison with most other African markets. The ownership structure of banks in Kenya has changed over the last few years with many regulatory and financial reforms. According to CBK Bank Supervision Annual Reports (e.g. Central Bank of Kenya, 2009, 2015), state involvement in the banking sector has been declining over time, and foreign bank operations have been increasing, including the number of locally incorporated foreign banks. The role of foreign banks in emerging markets remains contentious. Some studies suggest that foreign banks stimulate domestic banks as they bring increased competition and efficiency, performing better with higher profit margins and lower costs compared to their domestic counterparts (Claessens, et. al., 2001; Kodongo et al., 2015). Others find no evidence of better performance by foreign banks (Nikolov, et. al. 2004) or argue that impact and performance depend in part on the economic development of the host country (Lensink & Hermes, 2004). More strongly, Detragiache et. al. (2008) argue that if domestic banks have a comparative advantage in evaluating soft domestic information, then the entry of foreign banks tends to reduce welfare as they cherry-pick less risky customers. This leaves domestic customers who have soft information no longer served because of competitive pressures in the market as a whole. However, existing studies provide no evidence on foreign bank behaviour in the interbank market discipline role.

Despite the development of Kenya's banking sector in the last decades, competitiveness is still restricted by structural rigidities and segmentation (Beck and Fuchs, 2004). Many small banks concentrate on specific niches, without contributing to competition in the sector as a whole. Large banks prefer to transact with one other in the interbank market but not with smaller banks due to perceived risk or non-existence of credit lines. The current structures may thus have an impact on how they respond to policy directives from the regulator and also how they behave in their market discipline role. Van Lelyveld and Liedorp (2006) find that the bankruptcy of one of the large banks in the Netherlands would put a considerable burden on other banks, but would not lead to a complete collapse of the interbank market. The contagion effects of the failure of a smaller bank are limited, but exposures to foreign counterparties are not investigated. Overall Kenya's interbank market offers an interesting and important model for other countries at a relatively early stage of financial development. As yet, we have no systematic studies of Kenya's interbank market especially its market discipline role. This paper starts to fill this gap.

2.2. The bright side of the story - interbank market discipline and monitoring

With rapid developments in technology and innovation in finance, regulators and supervisors face the challenge of adapting to the increasing sophistication of banking systems world-wide. Policy makers and academic researchers have begun to look at the marketplace as a potential additional monitor of bank risks (De Young, 1998; Peek, et. al., 1999; Berger, et. al., 2000). Flannery and Nikolova (2004) provide a detailed overview of this market discipline literature. Although there are various ways to incorporate the marketplace into the monitoring process, the most popular proposal envisages using banks themselves as monitors to other banks. In a well-functioning interbank market, lending banks perform a monitoring role on the borrowing banks and therefore supplement existing bank regulation and supervision (Wells, 2004). The point is that banks are likely to be particularly good at identifying the riskiness of other banks.

Interbank markets exist at a wide range of maturities. However, the market monitoring function is generally thought to be most effective in the overnight interbank market. In the overnight market, a high proportion of lending is based on credit lines and is unsecured. Collateralisation is costly and inflexible for loans that are expected to be repaid within less than 24 hours (Välimäki, 2006; Neyer and Wiemers, 2004). However, the practise does vary from country to country. In Kenya all overnight lending is unsecured, as it is in the US

Federal Funds market. In the UK, some overnight lending is done on a secured basis, and this is true of other countries. The essential distinction in lending therefore is between secured and unsecured loans. If the loan is not secured, the lender has to take steps to be assured of the liquidity and solvency of the borrower and, it is argued, banks are the institutions best placed to do this with one another. From a market point of view, if most of the lending is secured, the monitoring function in that market is more limited. The overnight market is the one where most lending is typically unsecured, and the market monitoring function will therefore be at its clearest. Moreover, since <u>all</u> overnight interbank lending in Kenya is unsecured, this market offers a particularly sharp and clear setting to study the nature and impact of market disciplining activities, both in the African context and more generally.

There are plausible theoretical arguments for the use of interbank relationships as incentives for banks to monitor each other on condition that lenders believe that an interbank transaction exposes them to potential losses (see, in particular, Rochet and Tirole, 1996). Even if the loan is unsecured, there may be only limited potential loss if, for example "too big to fail" is implied. Several papers have studied the relationship between market discipline and public policy in bank regulation (Furfine, 2001; King, 2008; Dinger and Von Hagen, 2009; Huang and Ratnovski, 2011). In this context, the interbank market represents market discipline in terms of strong built-in incentives that encourage banks to operate soundly and efficiently. The idea is that banks accept the obligation to conduct their business in such a way as to take into account the risks that may eventually affect depositors and other stakeholders. For example, by participating in the interbank market, banks are obliged to improve transparency and disclosure, including the release of timely information on their assets, liabilities and general financial information. The information reduces uncertainty and promotes the function of the interbank market as an exchange between lending and borrowing banks.

The seminal empirical work by Furfine (2001) examines the pricing of interbank lending agreements in the federal funds market as an indicator of the ability of banks to monitor their interbank borrowers. Since loans in the federal funds market are large and uncollateralized, they expose lending institutions to significant credit risk. This creates incentives for the lending banks to monitor their counterparties in the transactions and price their loans as a function of the credit risk of the borrowing bank. Furfine (2001) finds that banks with higher profitability, fewer problematic loans and high capital ratios pay lower interest rates when they borrow overnight. King (2008) shows that banks that are more risky will borrow less in the federal funds market. Together, these studies suggest that there is both a price and a quantity effect in the monitoring process. Ashcraft and Bleakley (2006) argue that focusing on the correlation of prices with risk may confound supply and demand effects. To resolve this issue, they use exogenous shocks to a bank's liquidity position to trace out the credit supply curve. However, only weak evidence of market discipline is documented. This may be due to their focus on a highly developed banking market, where interbank exposures are mostly caused by short-term liquidity needs (Dinger and Von Hagen, 2009). In developed markets, short-term interbank exposures may not work as effectively as other monitoring tools since they can be quickly abandoned by both counterparties (Rochet and Tirole, 1996). Dinger and Von Hagen (2009) focus more directly on the risk taking of the banks participating in interbank transactions. They employ data from 296 banks of 10 Central and Eastern European countries from 1995 to 2004, and explore the impact of interbank transactions when exposures are long term and borrowers are restricted to small banks so as to avoid the "too big to fail" concern. Overall, their results show that long-term interbank exposures are associated with lower risks of the borrowing bank. Hence, market discipline through the interbank market can potentially play an important role in supplementing formal regulation to monitor the safety and soundness of the banking system.

2.3. The dark side of the story – contagious interbank market exposures

The second development that motivates this paper relates to the new literature and policy concerns about the undesirable side of the interbank market: Contagion. It is argued that the structure of the interbank market is a potentially important driving factor in the risk and impact of interbank contagion. There are two main building blocks for this argument. First is that, if the interbank market is to perform a market monitoring function lending must be largely unsecured and this creates contagion risk. Second is that central bank regulators are not able to identify or prevent contagion in practise.

In an unsecured market like Kenya's overnight interbank market, daily transactions are influenced by the liquidity position and requirements of individual banks and of the banking system as a whole. Large flows of funds at the clearing, such as during IPOs, can create substantial imbalances in liquidity among different banks (Green, et al., 2017). A network of interbank exposures may lead to domino effects, where the failure of one bank results in the failure of other banks not directly affected by the initial shock. The insolvency of a single institution may trigger multiple bank failures due to direct credit exposures via the interbank network. As explained by Allen and Gale (2000), if there is no aggregate uncertainty, the first-best allocation of risk sharing can be achieved. However, this allocation is financially fragile because a small liquidity preference shock can spread by contagion throughout the entire sector. The possibility of contagion in this case depends strongly on the completeness of the structure of claims in the interbank market. The dynamics and scope of the interbank market, including access to the market, are driven by a number of factors, the most important of which are the relationships among the participating banks.

Cocco et al. (2009) use a unique dataset containing information on all direct loans in the Portuguese interbank market over the four-and-a-half-years ending August 2001. They show that relationships are an important determinant of banks' ability to access interbank market liquidity, and that these relationships allow banks to insure liquidity risk in the presence of market frictions such as transaction and information costs. At the same time, the market may be a channel allowing a single bank default to spread to other banks. Using UK data, Wells (2004) suggests that when the failure of a single bank does result in knock-on effects, their severity depends on the maintained assumptions about the distribution of interbank loans and the level of loss in the event of default.

Overall, the literature suggests that interbank markets are not only pivotal for liquidity management purposes of banks but they are also complex networks connecting all the interlinked institutions in the financial system (Iori et al, 2006; Green, et. al., 2016). They provide potential monitoring and supervisory tools to complement the traditional financial regulations. On the other hand, the markets also have the danger of potential contagion through interbank linkages, which has important implications for the stability of the whole financial system (Nier, et al., 2007). Both the bright and the dark side of interbank markets have important implications for policy makers.

3. Model and data

3.1. Determinants of bank risk: Monitoring and contagion

To examine the effect of interbank activities on bank risk, we employ an empirical model of the relation between interbank borrowing and lending and bank risk, which is:

$$BANKRISK_{it} = \alpha_0 + \alpha_1\, IBP_{it} + \alpha_2\, (IBP)^2_{it} + \alpha_3\, BANK_{it} + \alpha_4\, MACRO_t + \mu_{it} \qquad \ldots(1)$$

Where, $BANKRISK_{it}$ is a measure of the risk incurred by bank i at time t; IBP_{it} denotes the interbank position of bank i at time t; $BANK_{it}$ is a vector of control variables at the individual bank level; $MACRO_t$ is a vector of macroeconomic fundamentals common to all banks which also serve as control variables at time t; μ_{it} is the error term. A list of the variables used in the model and their definitions are shown in Table 1.

[Table 1 about here]

We measure the riskiness of a bank's business following Dinger and Von Hagen (2009), using three variables which are widely used in the literature: the ratio of loan loss reserves to gross loans; the ratio of loan loss provisions to gross loans; and the log of the ratio of net charge-offs to equity (LOGNCO). In Kenya, the first two of these are only available at an annual frequency. Our dataset is quarterly for each bank and for the macro variables. Therefore our investigation concentrates on the last measure: LOGNCO.

To measure the interbank position we focus on the gross amounts outstanding. This is therefore a quantity measure rather than a price measure, although we do include the average interbank borrowing rate as an additional bank-specific explanatory variable. Following Liedorp, et al. (2010), we distinguish between interbank lending and interbank borrowing. Huang and Ratnovski (2009) show that funding risk can be of equal importance to lending risk. If banks rely on clustered wholesale funding from a few large counterparties in the interbank market, a sudden shock due for example to a noisy public signal can induce lending banks to limit or withdraw credit lines, especially as such interbank exposures are short-term. This can lead borrowing banks into fire sales of assets at steep discounts, which could jeopardise the stability of the banking system. The global financial crisis provides firm evidence in this regard. Therefore it is important to consider interbank borrowing and lending separately when considering bank risk.

In order to investigate the impact of interbank transactions on bank risk, model (1) is estimated separately using first interbank liabilities and second interbank assets to measure interbank market activity. In the first case, each bank's interbank borrowing is measured by the ratio of its aggregate interbank liabilities to total assets (IBL_TA). In the second case, each bank's interbank lending is measured by the ratio of its aggregate interbank assets to total assets (NIA_TA). In either case, a positive coefficient (α_1>0) would provide support to the contagion hypothesis: larger interbank exposures are associated with increased riskiness of a bank. A negative coefficient (α_1<0) would support the contrary peer monitoring hypothesis. Larger interbank exposures provide facilities for banks to monitor their peers; hence the improvements in transparency and peer pressure along with larger exposures are associated with reduced riskiness of a bank.

The squared interbank exposure term used in both versions of the model, IBP^2_{it}, captures the possible conflict between peer monitoring and contagion. Our basic hypothesis is that, if there is a conflict as we might expect, then α_1 and α_2 should have opposite signs, implying a possible reversal of sign in the impact of *IBP* as the size of the interbank exposure changes, since $\partial(BANKRISK)/\partial(IBP) = \alpha_1 + \alpha_2 IBP$. Specifically, for small values of *IBP* we expect the peer monitoring effect to dominate; so that: $\alpha_1 < 0$, $\alpha_2 > 0$ and $\alpha_1 + \alpha_2 IBP < 0$. Since the hypothesized relationship is quadratic, as *IBP* increases, there is a switch-point at which the overall effect of *IBP* will become positive ($\alpha_1 + \alpha_2 IBP > 0$) and the contagion effect will be dominant. In other words, if interbank exposure is sufficiently large, the risk of contagion exceeds the monitoring effect. If indeed we find that $\alpha_1 < 0$ and $\alpha_2 > 0$, the key question then is whether the value of *IBP* at the switch-point is economically significant or plausible. We discuss this in the results section.

We turn next to bank-specific control variables. We hypothesise that the main channel through which the interbank market provides information about bank risk is the quantity channel. However, we also include a price variable as a further control: the interbank borrowing rate (IBBR). We would expect the cost of funds to reflect mainly a peer-monitoring effect, so that a higher cost of funds is associated with banks incurring greater risks, implying a positive sign for IBBR.

The next bank-specific factor is size. We would expect larger banks to be better able to diversify the risks in their balance sheets. However, when size increases beyond a certain threshold, this effect may go into reverse, because overly large banks are insufficiently transparent for peer monitoring to be effective. Such banks may also be viewed as too big to fail and therefore never under pressure of a bank run. Hence large banks may take excessive risks knowing that no effective peer monitoring is in place and there is implicit insurance from government and regulators. Bank size is measured by the logarithm of bank total assets (SIZE_LOGTA), which is hypothesized to have a negative coefficient. Possible sign reversal is again modelled by a squared term (SIZE_LOGTA2 = SIZE_LOGTA^2), which is expected to have positive coefficient to allow for a 'U'-shape relationship between bank size and riskiness. CBK separately classifies Kenyan commercial banks into three size-related groups (small, medium, large) using a weighted composite index that comprises assets, deposits, capital, number of deposit accounts and loan accounts. Therefore as a robustness check we reran the regressions using dummies to correspond to CBK's classification scheme. The results of this exercise are given in appendix tables A3 and A4.

It is generally agreed that ownership affects bank performance, although the nature of the effect is not wholly agreed as previously noted. Some studies suggest that large foreign banks have established management expertise and can customize and apply their systems effectively across borders (Kodongo, et al., 2015). The exposure of foreign banks in Kenya's interbank market is significantly larger than their domestic counterparts in both lending and borrowing. We therefore include a foreign ownership dummy (*FOREIGN*) in the model. We also include a dummy for publically-listed banks (*PUBLIC*), as these tend to be larger and better performing than private banks. We hypothesize that foreign and listed banks each have smaller risk exposure than other banks.

We also include a variable representing the age of each bank (*AGE*). Standard theory would suggest that the older the bank the more experience it has in risk management and therefore in reputation, although older banks could also build up more risky assets than younger ones. Hence the sign of the coefficient on age is determined empirically. *AGE* is defined as the difference between the sample year and the year of incorporation.

Further bank-specific characteristics are included, in line with the literature on interbank exposure and bank risk. A number of studies prior to the global financial crisis emphasized the role of liquidity and capital standards in preventing bank failure and safeguarding customers (Rochet, 1992; Hovakimian and Kane, 2000). Liquidity risk is measured by the liquid liability ratio (LLR) given by the ratio of deposit and interbank liabilities to total assets. The lower the ratio, the lower the direct funding risk as the bank can more easily fulfil withdrawal requests, so a positive coefficient is expected. Capital adequacy is measured by the ratio of total equity to total assets (CAPITAL) with an expected negative sign: the greater the capital buffer, the less risky is the bank. The ratio of total loans to total assets (LOANS) measures the extent to which a bank relies on traditional intermediation activities as opposed to activities that generate fee income or capital income through trading in securities. Increased LOANS indicates more credit risk but lower market risk therefore the sign of the coefficient is determined empirically.

Finally, Beck and Fuchs (2004) argued that bank overheads are one of the most important components of the high interests rate spreads common in Kenyan banks. Analysis of the overheads showed that they were driven by staff wage costs which were comparatively higher than other banks in Sub-Saharan Africa. High overheads may be reflective of managerial inefficiencies. We therefore measure managerial efficiency by the ratio of overhead costs to total asset (OVERH_TA); and hypothesize that the lower the managerial efficiency (the higher is OVERH_TA), the higher will be bank risks.

In addition to bank-specific variables, some macroeconomic variables are included to control for cyclical effects on bank risk: including inflation (INFL) and the growth rate of real GDP per capita (GROWTH). In addition, total interbank lending in Kenya was dominated by small banks in 2003-2005, but subsequently by larger banks (Green, et al., 2017). We include a *BREAK* dummy (equal to unity after 2005) to capture any structural break in effects on risk.

3.2. Monitoring and contagion effects across different bank groups

We next investigate more finely any differences in monitoring and contagion effects for different types of banks. For this purpose we estimate an extended version of the basic model by adding an interaction term between interbank exposure and a group of bank-specific characteristic dummies:

$$BANKRISK_{it} = \alpha_0+\alpha_1 IBP_{it} +\alpha_2(IBP)^2_{it} +\alpha_3 BANK_{it} +\alpha_4 MACRO_t +\alpha_5(IBP_{it}\times BANK_{it})+\mu_{it} \quad \ldots(2)$$

The general form of the interaction term is $(IBP_{it}\times BANK_{it})$. The characteristic dummies consist of *AGE*, *SIZE*, *PUBLIC* and *FOREIGN*. For this purpose we use as an alternative age measure a dummy variable (AGE_DUM) is which is equal to unity if $AGE \geq 30$ years, and zero otherwise. The size dummies are based on CBK's 3-way classification of bank size rather than the continuous size variable (SIZE_LOGTA). Equation (2) is again estimated twice, first using first interbank liabilities and second using interbank assets to measure interbank market activity. Each dummy is interacted with interbank liabilities or assets to identify whether the peer monitoring or contagion effects vary cross different bank groups. According to the discussion in Section 3.1, if large and well-performing banks have smaller risks and there is peer monitoring effect, then we would expect $(IBP_{it} \times BANK_{it})$ to have a positive coefficient. This implies that for less risky banks, the risk reduction effect due to peer monitoring is smaller.

3.3. Data and estimation

We use official documents and data from the CBK in our empirical investigation. The data, summarised in Tables 2 and 3, are quarterly and include 43 banks participating in interbank transactions in Kenya during the period 2003-Q1 to 2011-Q1. The dataset forms an unbalanced panel, corresponding to the entry and exit of banks from the banking market in Kenya. Table 2 shows the composition of the sample by three categories: the ownership status (foreign and local); the shareholder ownership (private and public); and the three CBK-defined size groups (large, medium and small). We see for example that 79% of the banks that participated in Kenya's interbank market during the sample period were local banks: mainly small private banks.

[Table 2 about here]

Table 3 presents summary statistics of the variables used in the model, broken down into the same three categories. The summary statistics are based on the values averaged across banks and across the whole sample period. Similar to the Dutch interbank market, foreign banks operating in Kenya have higher and more variable interbank exposures on average than those of their local counterparts. Private banks also have higher and more variable average exposures. The relationship between exposure and size is however more ambiguous. Foreign banks and public banks tend to be larger than their domestic and private counterparts when size is measured by the log of total assets. Foreign and private banks have a somewhat higher capitalization ratio (equity/total assets) and, perhaps not surprisingly, smaller banks tend to be better capitalised on this ratio than do larger banks. LLR measures the direct funding risks of banks, and we see that foreign banks have much higher direct funding risk than do local banks. Large and medium banks have a lower liquid liability ratio than do small ones. A correlation matrix of the variables is shown in Appendix Table A2.

[Table 3 about here]

Interbank borrowing may be determined in part by bank risk as well as *vice-versa*, for example, if the demand for funds by borrowing banks is price-sensitive as lending banks price risk, or if lending banks ration more risky borrowers (Dinger and Von Hagen, 2009). Therefore, we first estimate a baseline model by OLS excluding the interbank exposure variables (*IBP* and IBP^2). We then apply an iterative GMM estimator to all the model variants of (1) and (2) above[4]. The instruments for GMM should be correlated with a bank's incentive to borrow in the interbank market but not with the bank's risk. In Kenya, where banks lack a widespread network for deposit mobilization at low cost, they are obliged to raise funds at a somewhat higher cost in the interbank market. Hence we would expect the

[4] As a robustness check we also estimated these models by Two-Stage-Least-Squares controlling for heteroskedasticity and autocorrelation. The results of this exercise were in line with the GMM estimates and are available from the authors on request.

net interbank position to be correlated with the difference between the interbank lending and borrowing rates (the interbank spread). This can be interpreted as measuring the asymmetry between lending and borrowing rates in the market. The net interbank position can also be affected by the current liquidity position of the bank. Hence, in line with previous literature (Dinger and Von Hagen, 2009), we use as instruments: the interbank spread (IBSPREAD) and the ratio of total deposits to total loans (RDL) as well as the logarithm of loan loss reserves (RESERVES) and one lag of NIA_TA and IBL_TA. See Table 1.

4. Empirical results

4.1. Determinants of bank risks

Table 4 shows the estimates of equation 1: the baseline OLS regression excluding *IBP* and IBP^2, and the GMM estimates explaining interbank liability and asset exposures respectively, together with some diagnostics. The GMM C statistic (Hayashi, 2000) and Wooldridge's (1995) score test are both significant suggesting that *IBL_TA* and *NIA_TA* are endogenous. The weak instrument test results suggest that the instruments have strong explanatory power.

[Table 4 about here]

In the GMM regressions, IBL_TA and NIA_TA both have significant negative coefficients as we expect, consistent with the peer-monitoring hypothesis. Moreover, the quadratic terms, IBL_TA2 and NIA_TA2, both have significant positive signs. This suggests that if a bank continues to increase its aggregate interbank borrowing and lending, it will reach a level where the impact on bank risk is reversed from risk-reducing to risk-increasing. This may be related to the contagion hypothesis to the extent that larger exposures imply an increased sensitivity of a bank's risk to relatively larger reliance on interbank activities.

[Table 5 about here]

There are several ways of assessing if (positive) peer-monitoring may turn into (problematic) contagion. The first is to calculate the turning point at which the impact of *IBP* switches from negative (peer-monitoring) to positive (contagion). This can be done from (1) using:

$$\frac{\partial BANKRISK_{it}}{\partial IBP_{it}} = \alpha_1 + 2\alpha_2 IBP_{it} = 0 \qquad \ldots(3)$$

or: $IBP_i^* = -\alpha_1 / 2\alpha_2$ …(4)

In (4), IBP_i* is the value of *IBP* at which its total impact on the risk incurred by a bank turns from negative to positive. A second possibility is to calculate directly the total impact of *IBP* on *BANKRISK* $\left(\frac{\partial BANKRISK_{it}}{\partial IBP_{it}} = \alpha_1 + 2\alpha_2 IBP_{it} \right)$ at some particular value of *IBP*, and its statistical significance at this point. The results of these calculations are shown in Table 5. First it seems clear that the point at which peer-monitoring turns into contagion in Kenya is well above the mean and median values of IBP, although it is less than the maximum value in the sample suggesting that at least some banks are or have been potentially exposed to the risk of contagion. Second, the risk of contagion is, on average, low, as the total impact of *IBP* on *BANKRISK* evaluated at the mean of *IBP* is negative and strongly significant (ie different from zero)[5]. However, these calculations could be used by regulators as useful rules of thumb as an aid to delving more deeply into the risks and other circumstances of any individual bank at a point in time.

5 The impact is also negative and strongly significant if evaluated at the median of *IBP*.

Other results shown in table 4 for bank-specific variables are consistent with one another and generally in line with our hypotheses. They show that size matters: *SIZE_LOGTA* is highly significantly negative and the quadratic form, *SIZE_LOGTA2*, has positive effect on bank risk. This supports the 'too big to fail' idea: as bank size increases, beyond a certain point, bank riskiness increases rather than decreases. In the context of the interbank market, this may be because beyond a certain size the largest banks tend to lie outside the peer monitoring process and thus size may be a disadvantage for them. The results are essentially similar when the alternative size dummy measure is applied as a robustness check (Appendix Table A3). We can assess the possibility that large well-diversified ("low-risk") banks grow into opaque monsters that are too big to fail ("high-risk") in the same way as we calculated the conditions under which peer-monitoring would turn into contagion (table 5). We see that the size at which "well-diversified" turns into "too-big-to-fail" is relatively large within the context of the sample. However, the total impact of size evaluated at the mean is relatively small and barely significant. This suggests that there is a greater degree of uncertainty about the impact of size on risk-taking, than there is about the impact of interbank market exposure. Size *per se* is not such a clear indicator of the potential riskiness of the bank.

The remaining bank-specific control variables all have the expected signs and are generally highly significant in either the liability or asset exposure equation, or in both. The *FOREIGN* dummy is highly significant with a negative coefficient, implying that foreign-owned banks are regarded as safer *ceteris paribus* than domestic banks; but the *PUBLIC* dummy does not have a consistent sign and is not significant suggesting that listing is not as important in risk-reduction as might be expected. This could be is because size is an important factor in the decision to list and, as we have seen, the SIZE variables are uniformly significant and with the expected signs.

AGE has a positive sign suggesting that older banks are more risk-taking. In the Kenyan context, the banking system has historically been relatively conservative; so recent reforms may have enhanced the willingness of more established banks to lend on riskier projects. As expected, liquidity risk (*LLR*) is positive and significant in the asset equation and in the baseline model, confirming that overall funding risks do play a positive role in determining the risk-taking behaviour of Kenyan banks. Likewise the greater the capital buffer (*CAPITAL*), the less risky is the bank. *LOANS* is highly significant and positively related to bank risk, especially in the assets equation. It suggests that traditional intermediation activities expose Kenyan banks to credit risk, which could be due partly to interbank lending activities. Finally, we also find that the lower is managerial efficiency (the higher is *OVERH_TA*), the higher will be bank risks.

The macroeconomic variables, *GROWTH* and *INFL* have a positive impact on bank risks, although they are significant mainly in the interbank assets equation. During economic booms, increased inflation and growth are both linked to increasing bank risk. The BREAK dummy is also significant only in the assets equation and would suggest that as larger banks came to be more important in the interbank market after 2005, bank risk increased.

Overall, there are some minor anomalies in the signs of the coefficients, compared with our hypotheses, in the liability equation, but not in the asset equation. In addition, we see that the fit of the estimated model and the significance of the coefficients are both generally much better in the asset equation than in the liability equation. This could imply that in Kenya lending risk is either more important or perhaps better understood than funding risk, as the underlying behavioural implications of the estimates are seen more precisely in the lending risk model (asset exposure equation).

[Table 6 about here]

4.2. The interbank market monitoring effect across different bank groups

This section presents and discusses the results of equation (2). Table 6 shows that the interaction between interbank liabilities and size (*LOGTA_IBL*) has a significant positive coefficient, even though size itself (*SIZE_LOGTA*) still has a significant negative coefficient on the linear term as in equation (1) (Table 4). Together these results imply first, that the larger the bank, the smaller are bank risks, subject to the possibility of reversal for very large (too-big-to-fail) banks, but also second, that for those banks with smaller risks, the risk reduction effect due to interbank peer monitoring is smaller as well. The same is true for the interaction between interbank assets and size (*LOGTA_NIA*) although this coefficient is not significant. The rest of the results are consistent with Table 3. Appendix Table A4 shows that when using the alternative size measure (a single size dummy) the results still hold.

[Table 7 about here]

Table 7 shows that the interactions between interbank liability or asset exposures and the *FOREIGN* dummy have significant positive coefficients. As expected, it suggests that for those foreign banks with relatively smaller risks, the risk reduction effect due to interbank peer monitoring is also smaller. The *PUBLIC* dummy was not significant in the main model (equation (1)), but when it is interacted with interbank exposure (Table 8), both the dummy and the interaction are significant in the liability exposure equation: the dummy has a negative coefficient as expected and its interaction is positive. (Neither the dummy nor its interaction with interbank assets is significant in the asset equation.) This suggests that for those publicly listed banks, which have relatively smaller risks, the risk reduction effect due to interbank peer monitoring is smaller than that for private banks. Finally, in Table 9 we show the results of the interaction between the *AGE* dummy and interbank exposures.

[Tables 8 and 9 about here]

In this form, the estimates suggest that older banks have relatively lower risks than younger banks. Hence the risk reduction effect due to interbank peer monitoring is smaller for these older banks as well. Interestingly, we see that the interaction results are mostly significant for interbank liability positions and less so for interbank asset positions. This is in contrast to the results for equation (1) where there are no interactions. In the basic model without interactions, it is the interbank asset exposures that provide the more precise results in terms of signs and significance. This in turn would suggest that the risk reduction effects due to peer monitoring become smaller when less risky larger, foreign, listed or older banks are the borrowers.

5. Conclusion and policy implications

This paper provides the first ever empirical study on the interbank market in a developing financial system in Africa, by investigating whether the interbank market in Kenya is effective as a peer monitoring and market discipline device and can thus complement official bank regulation. The paper applies GMM to a unique quarterly dataset consisting of a panel of individual Kenyan banks including their interbank exposures during almost a decade.

In general, the empirical evidence is consistent with earlier literature that the interbank market can be an effective market disciplining device, as the riskiness of the bank can be mitigated by the volume of interbank trading activity even when one controls for common bank risk determinants; more specifically, the evidence uncovers four new and interesting findings. First, banks' aggregate lending and borrowing in Kenya's interbank market do have the expected peer monitoring effect, in that greater reliance on the interbank market is associated with reduced exposure to risk. The asset exposure (lending) effect can be estimated with greater precision than the liability exposure (borrowing) effect, suggesting that lending risks figure more prominently in banks' calculations than do funding (borrowing) risks. In addition, as the volume of lending and borrowing rises, the peer monitoring effect is progressively moderated by a contagion effect. Beyond a certain threshold, the contagion effect effectively replaces the peer monitoring effect so that larger exposures imply an increased sensitivity of banks' risk to relatively larger reliance on interbank activities. The point at which contagion is estimated to become important is well above mean interbank exposures in Kenya. However, it would be interesting to investigate more closely the risk of contagion in individual bank positions from year-to-year. Second, size matters. Larger banks are exposed to smaller risks, probably because they are better diversified than smaller banks, but this advantage is reversed when bank size reaches a certain threshold. Beyond this point, large banks may take excessive risks in their profit maximizing business activities, as they are perceived as too-big-to-fail, and they know that there is no effective peer monitoring in place, but there is implicit insurance from government and the financial authorities to prevent a potential bank run. Third, after grouping banks by different characteristics, we have identified that larger, foreign, public (listed) or older banks have relatively smaller risks compared to their counterparts, and that the risk reduction effect due to interbank peer monitoring is smaller for these banks when they are borrowers in the interbank market. Fourth, the results also show that the usual bank risk determinants in terms of capitalization, credit risk, liquid liabilities, managerial efficiency and macroeconomic variables identified in the literature can also be applied to Kenyan banks.

Overall, these new empirical findings have important public policy implications, especially specifically for Kenya. The interbank market in Kenya provides a mechanism for peer monitoring and discipline among banks participating in the market. Such market discipline complements the usual regulatory oversight of the central bank and private monitoring agencies. In principle, regulators can use the time-varying degree of interbank borrowing and lending volume as market signals to identify banks that are perceived as risky by their peers. During the recent economic developments in Kenya there were discussions to explore further the transition to Basel III. Given the above evidence on the relationship between bank risks and bank specific characteristics, Kenya may be able to side-step the 'one size fits all' element of Basel III regulations, and leave open the option of exploiting interbank market discipline as a complementary regulatory tool. Capitalization is negatively linked with bank risks, which also has implications for the role of capital adequacy and the Basel III regulatory codes. However, by emphasizing the market discipline role of the interbank market in this study, we do not advocate an over-reliance on capital adequacy as a regulatory device. Given the U-shape relationship between interbank exposure and bank risk, the official regulator does have a role to play in terms of monitoring potential contagion implicit in the interbank network. Overall, it is important to bear in mind that in this paper we study the peer monitoring role of Kenya's interbank market as an example, which may hold lessons for the East African regional block and also for other countries at a relatively early stage of financial development. In this context, our paper provides adequate motivation for further research to investigate cross-border interbank networks, banking risk and contagion in the East Africa region, effectively extending the research findings of this study as well as new work on cross-border banking by Kodongo, et al. (2015), Tonzer (2015) and Aldasoro and Alves (2018).

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Table 1 Definition and hypotheses of variables

vector	variable	measurement	sign
BANKRISK	LOGNCO	Log of the ratio of net charge-offs to equity	
	LOGNCO(t-1)	LOGNCO lagged one quarter	+
IBP = the interbank position	NIA_TA	The ratio of a bank's interbank assets (NIA) to total assets (TA)	+/-
	IBL_TA	The ratio of a bank's interbank liabilities (IBL) to total assets (TA)	+/-
	NIA_TA2	$(NIA\_TA)^2$	-/+
	IBL_TA2	$(IBL\_TA)^2$	-/+
BANK: bank-specific characteristics	IBBR	Interbank borrowing rate	+
	SIZE_LOGTA	log of total asset	-
	SIZE_LOGTA2	$(SIZE\_LOGTA)^2$	+
	SIZE_DUM	Size dummy = 3 for size = large; 2 for size = medium; 1 for size = small	-
	FOREIGN	Dummy variable = 1 if at least 51% of CAPITAL is owned by FOREIGN shareholders and zero otherwise	-
	PUBLIC	Dummy variable = 1 for publicly listed bank and zero otherwise	-
	AGE	The difference between sample year and the year of corporation	+/-
	AGE_DUM	Dummy variable = 1 for AGE ≥ 30 years and zero otherwise	-/+
	LLR	Liquid liability ratio	+
	CAPITAL	The ratio of total equity to total assets	-
	LOANS	The ratio of total LOANS to total assets	+/-
	OVERH_TA	The ratio of overheads cost to total assets	+
MACRO	INFL	Percentage change in the Consumer Price Index (CPI)	+
	GROWTH	Percentage change in real GDP per capita	+
	BREAK	Dummy = 1 from Q1 2006 through Q3 2011; zero otherwise	+
Interaction terms (IBPit ×BANKit)	SIZE_IBL	interaction between SIZE_DUM and IBL_TA	+
	SIZE_NIA	interaction between SIZE_DUM and NIA_TA	+
	LOGTA_IBL	interaction between SIZE_LOGTA and IBL_TA	+
	LOGTA_NIA	interaction between SIZE_LOGTA and NIA_TA	+
	AGE_IBL	interaction between AGE_DUM and IBL_TA	-/+
	AGE_NIA	interaction between AGE_DUM and NIA_TA	-/+
	PUBLIC_IBL	interaction between PUBLIC and IBL_TA	+
	PUBLIC_NIA	interaction between PUBLIC and NIA_TA	+
	FOREIGN_IBL	interaction between FOREIGN and IBL_TA	+
	FOREIGN_NIA	interaction between FOREIGN and NIA_TA	+
Instrumental Variables	IBSPREAD	interbank lending rate - interbank borrowing rate	
	RESERVES	the logarithm of loan loss RESERVES	
	RDL	The ratio of total deposit to total loan	
	IBL_TA(t-1)	IBL_TA lagged one quarter	
	NIA_TA(t-1)	NIA_TA lagged one quarter	

Key: Sign refers to predicted sign (+ or -) denoting the hypothesized impact of the explanatory variable on the endogenous variable.

Table 2 Panel data composition

Panel A: Sample composition by three categories									
	Freq.	%	Freq.	%		Freq.	%	Freq.	%
	foreign owner		**local owner**			**private bank**		**public bank**	
public bank	6	66.67	9	26.47	**local owner**	25	89.29	9	60.00
private bank	3	33.33	25	73.53	**foreign owner**	3	10.71	6	40.00
small size	5	55.56	17	50.00	**small size**	18	64.29	4	26.67
medium size	2	22.22	13	38.24	**medium size**	9	32.14	6	40.00
large size	2	22.22	4	11.76	**large size**	1	3.57	5	33.33
total	9	20.93	34	79.07	**total**	28	65.12	15	34.88

Table 3 Summary statistics by categories on the bank average value across the sample

	Obs.	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
		LOGNCO				**NIA_TA**			
foreign owner	9	-1.531	0.783	-5.400	0.080	0.791	1.063	0.000	10.451
local owner	34	-0.991	0.758	-3.370	0.500	1.478	2.503	0.001	33.137
public bank	15	-1.322	0.846	-5.400	0.470	0.684	1.099	0.000	10.451
private bank	28	-1.046	0.762	-3.460	0.500	1.546	2.501	0.001	33.137
large size	6	-1.470	0.459	-3.370	-0.630	0.332	0.420	0.000	2.281
medium size	15	-1.715	0.608	-5.400	-0.300	0.673	0.865	0.001	10.451
small size	22	-0.618	0.657	-4.500	0.500	2.010	2.856	0.005	33.137
AGE<30	34	-0.981	0.806	-4.500	0.500	1.590	2.510	0.001	33.137
AGE<=30	12	-1.516	0.698	-5.400	-0.300	0.568	0.876	0.000	10.451
		IBL_TA				**SIZE_LOGTA**			
foreign owner	9	0.515	0.693	0.000	4.212	9.548	1.249	7.103	12.099
local owner	34	0.673	0.995	0.000	9.115	9.047	1.230	6.058	12.386
public bank	15	0.477	0.614	0.000	4.608	10.059	1.306	7.103	12.386
private bank	28	0.697	1.024	0.000	9.115	8.741	0.956	6.058	11.632
large size	6	0.502	0.523	0.001	2.373	11.056	0.937	7.945	12.386
medium size	15	0.684	0.848	0.000	4.485	9.608	0.877	6.954	11.147
small size	22	0.618	1.062	0.000	9.115	8.256	0.551	6.058	9.594
AGE<30	34	0.651	1.018	0.000	9.115	8.781	0.972	6.980	12.075
AGE<=30	12	0.531	0.631	0.000	4.212	10.344	1.191	7.969	12.386
		CAPITAL				**LOANS**			
foreign owner	9	0.155	0.093	0.013	0.769	0.438	0.199	0.000	1.037
local owner	34	0.172	0.096	0.064	0.744	0.566	0.184	0.000	1.245
public bank	15	0.155	0.090	0.013	0.769	0.518	0.183	0.000	1.068
private bank	28	0.173	0.097	0.065	0.744	0.534	0.204	0.000	1.245
large size	6	0.124	0.039	0.064	0.274	0.515	0.084	0.255	0.671
medium size	15	0.140	0.061	0.013	0.456	0.477	0.183	0.008	0.802
small size	22	0.203	0.115	0.075	0.769	0.574	0.222	0.000	1.245
AGE<30	34	0.180	0.095	0.013	0.742	0.578	0.199	0.000	1.245
AGE<=30	12	0.129	0.066	0.016	0.456	0.412	0.152	0.103	0.802
		LLR				**OVERH_TA**			
foreign owner	9	0.539	0.406	0.050	5.540	0.032	0.027	-0.001	0.220
local owner	34	0.418	0.202	-0.440	2.550	0.085	0.236	-0.033	1.621
public bank	15	0.454	0.370	-0.440	5.540	0.132	0.330	-0.004	1.621
private bank	28	0.455	0.232	0.050	4.420	0.037	0.027	-0.033	0.187
large size	6	0.420	0.125	0.170	0.780	0.046	0.026	0.006	0.117
medium size	15	0.398	0.170	-0.440	0.890	0.035	0.027	-0.001	0.187
small size	22	0.509	0.369	0.050	5.540	0.105	0.286	-0.033	1.621
AGE<30	34	0.436	0.258	0.050	4.420	0.084	0.242	-0.033	1.621
AGE<=30	12	0.498	0.229	-0.440	0.940	0.034	0.023	-0.001	0.113
		IBBR							
foreign owner	9	4.990	2.639	0.290	10.390				
local owner	34	4.956	2.633	0.400	10.130				
public bank	15	4.948	2.683	0.290	10.390				
private bank	28	4.978	2.608	0.400	9.920				
large size	6	5.004	2.739	0.290	10.390				
medium size	15	4.971	2.636	0.350	9.050				
small size	22	4.952	2.597	0.400	9.920				
AGE<30	34	4.955	2.637	0.350	9.920				
AGE<=30	12	4.818	2.661	0.290	10.390				

Table 4 Empirical results, model 1: The determinants of bank risks

	baseline model			interbank liability exposure			interbank asset exposure		
LOGNCO	**Coef.**	**t-stat**		**Coef.**	**z-stat**		**Coef.**	**z-stat**	
IBL_TA (α_1)				-2.865	[-3.76]	***			
IBL_TA2 (α_2)				0.482	[2.32]	**			
NIA_TA (α_1)							-0.177	[-5.2]	***
NIA_TA2 (α_2)							0.004	[3.57]	***
IBBR	-0.019	[-2.49]	**	0.005	[0.27]		-0.011	[-1.32]	
AGE	0.004	[3.55]	***	0.005	[2.03]	**	0.003	[2.69]	***
FOREIGN	-0.393	[-8.03]	***	-0.441	[-3.51]	***	-0.418	[-7.72]	***
PUBLIC	0.039	[0.67]		-0.261	[-1.58]		0.038	[0.69]	
SIZE_LOGTA ($\alpha_{3,1}$)	-2.806	[-8.79]	***	-1.773	[-2.5]	**	-3.424	[-9.75]	***
SIZE_LOGTA2 ($\alpha_{3,2}$)	0.126	[7.58]	***	0.076	[2.08]	**	0.155	[8.69]	***
LLR	0.710	[6.65]	***	-0.144	[-0.42]		0.910	[4.68]	***
CAPITAL	-2.987	[-9.46]	***	-2.011	[-2.77]	***	-3.009	[-7.22]	***
LOANS	1.443	[12.14]	***	-0.365	[-1.25]		1.573	[7.88]	***
OVERH_TA	0.472	[4.59]	***	1.550	[4.63]	***	0.422	[5.98]	***
GROWTH	1.468	[4.03]	***	0.095	[0.1]		1.588	[4.34]	***
INFL	1.283	[1.55]		2.923	[1.26]		1.697	[2.04]	**
BREAK	0.073	[1.61]		0.098	[0.84]		0.165	[3.8]	***
constant	13.214	[8.44]	***	10.225	[2.96]	***	16.361	[9.13]	***
Adj R^2		0.506							
GMM C statistic chi2(1)					0.950			4.434	**
1st stage regression sum stat	**Partial R^2**				0.003			0.383	
	Robust F(1,862)				15.176	***		15.7607	***

Notes:

1. Refer to Table 1 for variable definitions.
2. GMM C (difference-in-Sargan) statistic---Test of endogeneity (orthogonality conditions), H0: variables are exogenous; GMM C statistic chi2(1) report all first-stage goodness-of-fit various statistics that measure the relevance of the excluded exogenous variables. By default, if the model contains one endogenous regressor, then the first-stage R-squared, adjusted R-squared, partial R-squared, and F statistics are reported.
3. Instruments: for IBL_TA is RDL and for NIA_TA is NIA_TA(t-1)
4. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 5 Non-linearities in determinants of bank risk

		interbank liability exposure IBL_TA	**interbank asset exposure NIA_TA**
***IBP*: Peer-Monitoring (-) versus Contagion (+)**			
1	$IBP_i^* = -\alpha_1/2\alpha_2$	2.97	21.64
2	IBP: Sample mean	0.62	1.26
3	IBP: Sample median	0.26	0.54
4	IBP: Sample maximum	9.12	33.14
5	IBP: Sample minimum	0.0003	0.0002
6	$\frac{\partial BANKRISK_{it}}{\partial IBP_{it}} = \alpha_1 + 2\alpha_2 IBP_{it}$	-2.26	-0.17
7	z-stat	5.97***	5.24***
***SIZE_LOGTA*: Well-diversified (-) versus Too Big to Fail (+)**			
8	$SIZE_i^* = -\alpha_{3,1}/2\alpha_{3,2}$	11.73	11.07
9	SIZE_LOGTA: Sample mean	9.19	9.19
10	SIZE_LOGTA: Sample median	8.92	8.92
11	SIZE_LOGTA: Sample maximum	12.39	12.39
12	SIZE_LOGTA: Sample minimum	6.06	6.06
13	$\frac{\partial BANKRISK_{it}}{\partial SIZE_{it}} = \alpha_{3,1} + 2\alpha_{3,2} SIZE_{it}$	-0.38	-0.584
14	z-stat	-0.60	-1.84*

Notes:
Row 1 of table 5 shows the values of IBP_{it} (=IBP_i*) at which the sign (impact) of *IBP* switches from negative (peer-monitoring) to positive (contagion). Relevant sample values of *IBP* are shown in rows 2-5. Row 6 shows the total impact of *IBP* on *BANKRISK* evaluated at the overall mean of *IBP* (ie calculated across all banks and time periods). The z-stat (row 7) is an approximate (linearized) test of the hypothesis that:

$$\frac{\partial BANKRISK_{it}}{\partial IBP_{it}} = \alpha_1 + 2\alpha_2 IBP_{it} = 0$$ calculated at the mean of *IBP*.

Rows 8-14 give the same statistics for the impact of *SIZE_LOGTA*. Hence row 8 shows the values of *SIZE_LOGTA*$_{it}$ (=*SIZE_LOGTA*$_i$*) at which the sign (impact) of *SIZE* switches from negative (size implies better diversification) to positive (too big to fail). Rows 13 and 14 show respectively the total impact of *SIZE* on *BANKRISK* evaluated at the overall mean of *SIZE*, and an approximate test of the significance of this impact.
*** significant at the 1% level. * significant at the 10% level.

Table 6 Empirical results, model 2: Interbank exposures interacted with size (SIZE_LOGTA)

	interbank liability exposure			interbank asset exposure		
LOGNCO	**Coef.**	**z-stat**		**Coef.**	**z-stat**	
IBL_TA	-14.391	[-4.67]	***			
IBL_TA2	0.150	[2.14]	**			
NIA_TA				-2.630	[-1.09]	
NIA_TA2				0.000	[0.08]	
SIZE_LOGTA	-1.159	[-6.93]	***	-0.612	[-2.62]	***
LOGTA_IBL	1.546	[4.61]	***			
LOGTA_NIA				0.306	[1.06]	
AGE	0.008	[3.07]	***	0.014	[2.39]	**
FOREIGN	-0.680	[-5.55]	***	-0.483	[-4.9]	***
PUBLIC	0.385	[2.45]	**	-0.057	[-0.79]	
LLR	0.114	[0.37]		0.909	[3]	***
LOANS	-0.546	[-1.5]		2.559	[2.99]	***
OVERH_TA	0.815	[3.84]	***	0.303	[1.84]	*
GROWTH	0.651	[0.79]		1.336	[3.12]	***
constant	9.573	[5.97]	***	2.528	[1.73]	*
GMM C statistic chi2(1)		0.926			4.15215	**
1st Stage regression sum stat	**Partial R-sq.**	0.003		**Partial R-sq.**	0.012	
	Robust F(1,866)	28.2251	***	**Robust F(1,893)**	1.63955	

Notes:

1. Refer to Table 1 for variable definitions.
2. GMM C (difference-in-Sargan) statistic---Test of endogeneity (orthogonality conditions), H0: variables are exogenous; GMM C statistic chi2(1) report all first-stage goodness-of-fit various statistics that measure the relevance of the excluded exogenous variables. By default, if the model contains one endogenous regressor, then the first-stage R-squared, adjusted R-squared, partial R-squared, and F statistics are reported.
3. Instruments: for IBL_TA is RDL and for NIA_TA is NIA_TA(t-1)
4. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 7 Empirical results, model 2: Interbank exposures interacted with foreign ownership (FOREIGN)

LOGNCO	interbank liability exposure Coef.	z-stat		interbank asset exposure Coef.	z-stat	
IBL_TA	-2.629	[-4.57]	***			
IBL_TA2	0.414	[2.71]	***			
NIA_TA				-0.165	[-5.06]	***
NIA_TA2				0.004	[3.38]	***
AGE	0.003	[1.12]		0.004	[3.49]	***
FOREIGN_IBL	1.591	[5.72]	***			
FOREIGN_NIA				0.121	[1.96]	**
FOREIGN	-1.262	[-6.81]	***	-0.538	[-7.4]	***
PUBLIC	-0.033	[-0.24]		0.040	[0.72]	
SIZE_LOGTA	-1.604	[-2.55]	**	-3.477	[-10]	***
SIZE_LOGTA2	0.067	[2.1]	**	0.157	[8.96]	***
LLR	-0.411	[-1.45]		0.972	[4.77]	***
CAPITAL	-1.803	[-2.81]	***	-2.950	[-7.89]	***
LOANS	-0.314	[-1.3]		1.670	[8.16]	***
OVERH_TA	1.344	[4.63]	***	0.401	[5.68]	***
GROWTH	0.080	[0.1]		1.336	[3.92]	***
BREAK	-0.102	[-1.05]		0.154	[3.86]	***
constant	9.670	[3.14]	***	16.504	[9.3]	***
GMM C statistic chi2(1)		0.947			4.365	**
1st Stage regression sum stat	**Partial R-sq.**	0.004		**Partial R-sq.**	0.398	
	Robust F(1,863)	21.325	***	**Robust F(1,890)**	19.7443	***

Notes:

1. Refer to Table 1 for variable definitions.
2. GMM C (difference-in-Sargan) statistic---Test of endogeneity (orthogonality conditions), H0: variables are exogenous; GMM C statistic chi2(1) report all first-stage goodness-of-fit various statistics that measure the relevance of the excluded exogenous variables. By default, if the model contains one endogenous regressor, then the first-stage R-squared, adjusted R-squared, partial R-squared, and F statistics are reported.
3. Instruments: for IBL_TA is RDL and for NIA_TA is NIA_TA(t-1)
4. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 8 Empirical results, model 2: Interbank exposures interacted with public ownership (PUBLIC)

LOGNCO	interbank liability exposure Coef.	z-stat		interbank asset exposure Coef.	z-stat	
IBL_TA	-2.632	[-4.99]	***			
IBL_TA2	0.414	[2.8]	***			
NIA_TA				-0.157	[-4.64]	***
NIA_TA2				0.003	[3.05]	***
SIZE_LOGTA	-1.254	[-2]	**	-3.443	[-9.75]	***
SIZE_LOGTA2	0.051	[1.61]		0.156	[8.72]	***
BREAK	-0.180	[-1.81]	*	0.152	[3.67]	***
AGE	0.007	[3.36]	***	0.003	[3]	***
FOREIGN	-0.333	[-3.41]	***	-0.429	[-7.79]	***
PUBLIC	-1.207	[-6.12]	***	0.042	[0.71]	
PUBLIC_IBL	1.768	[6.22]	***			
PUBLIC_NIA				0.002	[0.05]	
LLR	-0.521	[-2.31]	**	0.928	[4.74]	***
CAPITAL	-1.662	[-2.64]	***	-2.880	[-7.95]	***
LOANS	-0.294	[-1.33]		1.605	[8.09]	***
OVERH_TA	0.884	[7.32]	***	0.409	[4.84]	***
GROWTH	0.545	[0.72]		1.311	[3.82]	***
constant	7.879	[2.55]	**	16.385	[9.1]]	***
GMM C statistic chi2(1)		0.948			4.964	**
1st Stage regression sum stat	**Partial R-sq.**	0.004		**Partial R-sq.**	0.394	
	Robust F(1,866)	25.0571	***	**Robust F(1,893)**	19.6254	***

Notes:
1. Refer to Table 1 for variable definitions.
2. GMM C (difference-in-Sargan) statistic---Test of endogeneity (orthogonality conditions), H0: variables are exogenous; GMM C statistic chi2(1) report all first-stage goodness-of-fit various statistics that measure the relevance of the excluded exogenous variables. By default, if the model contains one endogenous regressor, then the first-stage R-squared, adjusted R-squared, partial R-squared, and F statistics are reported.
3. Instruments: for IBL_TA is RDL and for NIA_TA is NIA_TA(t-1)
4. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 9 Empirical results, model 2: Interbank exposures interacted with age (AGE_DUM)

	interbank liability exposure			interbank asset exposure		
LOGNCO	**Coef.**	**z-stat**		**Coef.**	**z-stat**	
IBL_TA	-2.633	[-4.23]	***			
IBL_TA2	0.417	[2.58]	***			
NIA_TA				-0.157	[-5.02]	***
NIA_TA2				0.003	[3.29]	***
AGE_DUM	-0.884	[-4.52]	***	-0.165	[-2.16]	**
AGE_IBL_TA	1.646	[5.47]	***			
AGE_NIA_TA				0.201	[2.87]	***
FOREIGN	-0.564	[-4.92]	***	-0.394	[-7.18]	***
PUBLIC	0.052	[0.37]		0.069	[1.22]	
SIZE_LOGTA	-1.995	[-3.31]	***	-3.906	[-11.21]	***
SIZE_LOGTA2	0.090	[3.02]	***	0.183	[10.45]	***
LLR	-0.381	[-1.23]		1.038	[4.62]	***
CAPITAL	-2.023	[-2.93]	***	-3.057	[-7.72]	***
LOANS	-0.405	[-1.5]		1.542	[7.42]	***
OVERH_TA	1.326	[4.6]	***	0.414	[5.73]	***
GROWTH	0.397	[0.5]		1.296	[3.78]	***
INFL	2.765	[1.43]		1.878	[2.32]	**
constant	11.272	[3.78]	***	18.478	[10.34]	***
GMM C statistic chi2(1)		0.939			4.021	**
1st Stage regression sum stat	**Partial R-sq.**	0.004		**Partial R-sq.**	0.406	
	Robust F(1,866)	19.4557	***	**Robust F(1,893)**	19.9694	***

Notes:
1. Refer to Table 1 for variable definitions.
2. GMM C (difference-in-Sargan) statistic---Test of endogeneity (orthogonality conditions), H0: variables are exogenous; GMM C statistic chi2(1) report all first-stage goodness-of-fit various statistics that measure the relevance of the excluded exogenous variables. By default, if the model contains one endogenous regressor, then the first-stage R-squared, adjusted R-squared, partial R-squared, and F statistics are reported.
3. Instruments: for IBL_TA is RDL and for NIA_TA is NIA_TA(t-1)
4. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Appendix

Table A1 Important events in Kenya interbank market from 2007-2011

Date	Reform	Purpose
June 2007	Monetary Policy Advisory Committee (MPAC) adjusted repo maturity to range between 3 days and 90 days compared with previous maturities of 7 and 40 days	Lengthening maximum maturity to signal to banks that repos could be considered as an alternative investment; shortening the minimum maturity reduced the period during which banks hold excess balances to meet clearing obligations
Aug. 2007	Repo amount threshold reviewed downwards from Ksh50 million to Ksh20 million	Increase flexibility in liquidity management
Sept. 2007	Late repo facility window to run from 2.00 p.m. to 2.30 p.m. introduced at 150 basis points below the day's weighted average repo rate derived from the competitive morning auction.	Capture excess cash reserves received by banks late in the day not drained in the early repo window to help CBK meet its reserve money targets
Dec. 2007	Late repo threshold amount lowered again to Ksh10 million and the margin on the late repo yield narrowed to 100 basis points	Increase participation in late repo window
May 2008	Term Auction Deposit Facility (TAD). Introduced: competitive auction bidding, maturity from 3 to 90 days, minimum threshold of Ksh20 million for the morning auction and Ksh10 million for the late auction, late deposit bid prices at 100 basis points below the weighted average TAD rate.	Increase scope for liquidity management after the stock of existing repo securities exhausted.
Sept. 2008	Introduction of the Horizontal Repurchase Agreements between commercial banks.	Deepen money markets and enhance distribution of liquidity in the interbank market
May 2009	Repo and TAD tenure fixed to 5 days	Improve liquidity management
July 2009	Repo and TAD tenure fixed to 7 days. Recourse by banks to reverse repo only after interbank and horizontal repo opportunities exhausted	Improve liquidity management
May 2011	Late repo tenure fixed at 4 days	Improve liquidity management

Source: Central Bank of Kenya (2011)

Table A2 Correlation matrix of the key variables

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LOGNCO	**1**																		
IBL_TA	**2**	-0.07																	
IBL_TA2	**3**	-0.04	0.84																
NIA_TA	**4**	0.11	0.00	0.26															
NIA_TA2	**5**	-0.02	0.22	0.48	0.80														
IBBR	**6**	0.04	0.06	0.04	0.11	0.05													
AGE	**7**	-0.21	-0.05	-0.06	-0.20	-0.07	-0.02												
SIZE_LOGTA	**8**	-0.48	-0.08	-0.11	-0.32	-0.11	-0.10	0.59											
SIZE_LOGTA2	**9**	-0.46	-0.08	-0.11	-0.31	-0.11	-0.11	0.61	1.00										
LLR	**10**	0.05	-0.07	-0.04	0.04	0.02	-0.05	0.09	-0.16	-0.16									
CAPITAL	**11**	0.19	-0.04	-0.01	0.20	0.04	-0.03	-0.22	-0.44	-0.41	0.33								
LOANS	**12**	0.41	-0.13	-0.08	0.18	0.06	0.11	-0.27	-0.12	-0.11	-0.34	0.10							
OVERH_TA	**13**	0.29	0.06	0.03	0.00	-0.01	-0.01	-0.05	-0.12	-0.12	-0.06	0.07	0.25						
INFL	**14**	-0.03	0.07	0.06	0.04	0.05	0.00	0.02	0.09	0.08	0.00	-0.01	-0.01	0.02					
GROWTH	**15**	0.10	-0.02	0.00	0.01	0.00	-0.10	0.01	0.01	0.01	0.00	-0.07	0.01	0.05	-0.29				
BREAK	**16**	-0.19	0.00	-0.01	0.07	0.04	0.09	0.03	0.24	0.24	-0.06	0.02	-0.04	-0.02	0.21	-0.09			
IBSPREAD	**17**	-0.04	-0.03	-0.02	0.03	0.02	-0.15	0.03	0.04	0.04	0.00	-0.05	-0.05	0.01	-0.01	0.01	-0.03		
LOANS	**18**	0.04	-0.01	-0.01	0.00	0.00	-0.03	-0.01	-0.03	-0.03	-0.05	0.04	-0.10	-0.01	0.00	-0.01	0.02	0.02	-0.26

Note: Table A2 presents the correlation matrix of the key variables. The variables are defined in Table 1.

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Table A3 Robustness check of empirical model 1: alternative measure of size (SIZE_DUM)

LOGNCO	baseline model Coef.	t-stat		interbank liability exposure Coef.	z-stat		interbank asset exposure Coef.	z-stat	
IBL_TA				-2.511	[-3.18]	***			
IBL_TA2				0.422	[2.11]	**			
NIA_TA							-0.182	[-4.68]	***
NIA_TA2							0.004	[3.15]	***
IBBR	0.007	[1.06]		0.023	[1.31]		0.021	[3]	***
AGE	0.001	[1.56]		0.004	[1.78]	*	0.000	[0.33]	
FOREIGN	-0.313	[-6.86]	***	-0.403	[-3.29]	***	-0.324	[-6.27]	***
PUBLIC	0.021	[0.37]		-0.224	[-1.36]		-0.022	[-0.39]	
_ISIZE_DUM_2	-1.059	[-23.73]	***	-0.704	[-3.9]	***	-1.195	[-22.83]	***
_ISIZE_DUM_3	-0.850	[-10.74]	***	-0.811	[-4.33]	***	-0.942	[-13.56]	***
LLR	0.243	[2.43]	**	-0.323	[-0.97]		0.358	[1.99]	**
CAPITAL	-1.192	[-5.09]	***	-0.705	[-1.12]		-0.823	[-2]	**
LOANS	0.895	[8.27]	***	-0.497	[-1.93]	*	0.967	[5.06]	***
OVERH_TA	0.445	[4.73]	***	1.411	[4.25]	***	0.408	[5.65]	***
GROWTH	1.433	[4.33]	***	0.236	[0.28]		1.537	[4.79]	***
INFL	1.010	[1.34]		2.552	[1.24]		1.404	[2.15]	**
BREAK	-0.237	[-6.03]	***	-0.151	[-1.38]		-0.189	[-5.62]	***
constant	-0.952	[-8.68]]	***	0.684	[2.73]	***	-0.920	[-5.23]	***
Adj R2	0.592								
GMM C statistic chi2(1)					0.987`			4.112	**
1st stage regression				Partial R-sq.	0.0021		Partial R-sq.	0.3896	
sum stat				Robust F(1,862)	12.3754	***	Robust F(1,830)	15.7014	***

Notes:

1. Refer to Table 1 for variable definitions.
2. GMM C (difference-in-Sargan) statistic---Test of endogeneity (orthogonality conditions), H0: variables are exogenous; GMM C statistic chi2(1) report all first-stage goodness-of-fit various statistics that measure the relevance of the excluded exogenous variables. By default, if the model contains one endogenous regressor, then the first-stage R-squared, adjusted R-squared, partial R-squared, and F statistics are reported.
3. Instruments: for IBL_TA is RDL and for NIA_TA is NIA_TA(t-1)
4. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table A4 Robustness check of empirical model (2): Interbank exposures interacted with alternative size measure (SIZE_DUM)

	interbank liability exposure			interbank asset exposure		
lognco	**Coef.**	**z-stat**		**Coef.**	**z-stat**	
ibl_ta	-8.323	[-2.73]	***			
squ_ibl_ta	0.643	[2.28]	**			
nia_ta				-0.342	[-2.16]	**
squ_nia_ta				0.004	[2.44]	**
size_dummy	-2.650	[-3.75]	***	-0.842	[-9.91]	***
size_ibl	3.693	[2.75]	***			
size_nia				0.184	[1.54]	
break_dummy	-0.161	[-0.91]		-0.206	[-5.05]	***
Ib borrowing rate	-0.007	[-0.27]		0.009	[1.18]	
age	0.013	[3.28]	***	0.008	[5.75]	***
foreign_owner	-0.805	[-4.07]	***	-0.506	[-8.79]	***
public	0.888	[2.58]	***	0.121	[1.8]	*
LLR	1.123	[1.85]	*	0.580	[2.98]	***
capital				-0.748	[-1.65]	***
loans	0.425	[1.02]		1.402	[7.34]	***
overheads_ta	1.080	[1.95]	*	0.326	[4.42]	***
growth				1.394	[3.89]	***
constant	2.857	[2.48]	**	-0.597	[-2.84]	***
GMM C statistic chi2(1)		0944			4.08021	**
1st Stage regression sum stat	**Partial R-sq.**	0.001		**Partial R-sq.**	0.1527	
	Robust F(1,895)	10.4197	***	**Robust F(1,831)**	12.4941	***

Notes:

1. Refer to Table 1 for variable definitions.
2. GMM C (difference-in-Sargan) statistic---Test of endogeneity (orthogonality conditions), H0: variables are exogenous; GMM C statistic chi2(1) report all first-stage goodness-of-fit various statistics that measure the relevance of the excluded exogenous variables. By default, if the model contains one endogenous regressor, then the first-stage R-squared, adjusted R-squared, partial R-squared, and F statistics are reported.
3. Instruments: for IBL_TA is RDL and for NIA_TA is NIA_TA(t-1)
4. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.