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Stirling Economics Discussion Paper 2009-23

November 2009

Online at http://www.economics.stir.ac.uk

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[#] We thank the African Development Bank for financial support. Useful comments on the preliminary version of the paper were received from Kups Mlambo, Mthuli Ncube, Taoufik Rajhi and participants at the African Development Bank Workshop on "Competitiveness of the Financial Services Sector in Africa", held at Wits Business School, Johannesburg, on 25-26 June 2009. We retain responsibility for surviving errors.

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Abstract

We propose a three-stage procedure for investigating the interrelationships among bank competition, risk taking and efficiency. The procedure is applied to Nigeria's banking reforms (1993-2008). Stage I measures bank productive efficiency, using Data Envelopment Analysis, and the evolution of bank competition, using Conjectural Variations (CV) methods. Stage II uses the CV estimates to test whether regulatory reforms influence bank competition. Stage III investigates the impact of the reforms and concomitant changes in competition on bank behaviour. The evidence suggests that deregulation and prudential re-regulation influence bank risk taking and bank productive efficiency directly (direct impact) and via their impact on competition (indirect impact). Further, it is found that as competition increases, excessive risk taking decreases and efficiency increases. Overall, the evidence affirms policies that foster bank competition, at least in the Nigerian context.

Keywords: bank competition; bank efficiency; risk-taking; Nigeria

JEL Classification Nos: G21; D43; C51

1. Introduction

The public policy paradigm on banking regulation and supervision has shifted from "economic regulation" to deregulation and concomitant prudential re-regulation (Padoa-Schioppa, 2001)[1]. Competition plays a crucial role in the overall design of such a policy framework. On the one hand, the economic justification of financial deregulation is based on the presumption that deregulation fosters bank competition, which in turn has a positive effect on bank productive efficiency. Specifically, bank competition is seen as a stimulus to exert downward pressure on costs, reduce managerial slack and even incentivise technology innovation (Nickell, 1996). On the other hand, concern about the adverse impact of increased competition on bank risk taking behaviour has motivated the adoption of prudential re-regulation alongside deregulation. Competition is viewed as the driving force to erode banks' monopoly profits, reduce the opportunity cost of going bankrupt, and increase banks' incentives to take excessive risk. Although it is designed to mitigate excessive risk taking and foster stability, prudential re-regulation imposes higher regulatory costs and may hamper competition. In general, therefore, such a mixed process of deregulation and prudential re-regulation may have opposite effects upon bank behaviour with respect to competition, risk taking and production efficiency, at least in theory.

It is curious that there appears to be hardly any clear empirical evidence on what, in theory, are opposite effects of policy reforms on some key aspects of bank behaviour. While there are numerous papers which evaluate the impact of financial reforms on bank efficiency and productivity, or the impact of reforms on competition, or the relationship between competition and banks' risk taking, the evidence is inconclusive (as shown in Section 2). Moreover, the existing literature tends to look at each one of the three aspects of bank

[1] The "economic regulation" regime comprises measures of a structural nature by limiting competition. The regulators prescribe specialisation and prices, and take responsibility for potential prudential problems. Prudential activities by banks are less important. In contrast, a prudential re-regulation regime focuses on market efficiency, by relaxing structural rules and encouraging incentive-based prudential behaviour by banks.

performance separately. The inextricable intertwined relation among the 'trinity' of bank performance (i.e., bank competition, risk taking and production efficiency), has not been investigated empirically. In addition, there is little understanding of the role played by the implementation of prudential re-regulation in financial reform processes. Moreover, since the issue of regulation and its effect on competition, productive efficiency and financial stability is complex and multi-faceted, careful consideration of all the factors at work is essential for a sound empirical analysis of the effectiveness of policy (Allen and Gale, 2004).

This paper aims to investigate whether and how such mixed policies of deregulation and prudential re-regulation affect the important interrelated aspects of bank performance, namely competitive conduct, risk taking and productive efficiency. The main contributions of the paper are threefold. First, it aims to fill the above gaps in the literature, with particular reference to Nigeria's banking reform experiments, implemented during 1993-2008 (detailed in Section 3). The study of Nigeria's commercial banking reforms over an important period of recent economic history complements a large, mostly qualitative, literature on banking sector development in Africa. Second, our methodological innovation is that in order to carry out our analysis, we develop a three-stage modelling procedure. In the first stage, we measure productive efficiency of banks using non-parametric Data Envelopment Analysis (DEA). We estimate the evolution of the degree of competition over time through the conjectural variations (CV) approach in line with the New Empirical Industrial Organization (NEIO) literature. In the second stage, we use the time-varying CV estimates of competition to test whether and how the change in the regulatory environment influences competitiveness conditions in the market place. In the third stage, we investigate the impact of the change in regulatory environment and the associated changes in the degree of competition on bank risk taking and bank productive efficiency. To the best of our knowledge, such a three-stage analysis has not been used in the existing banking literature. Third, we find new evidence that

deregulation and prudential re-regulation influence bank risk taking and bank productive efficiency directly (direct impact) and via their impact on competition (indirect impact). The evidence also suggests that as competition increases, excessive risk taking decreases and efficiency increases. Overall, the new evidence affirms policies that foster bank competition, at least in the context of Nigeria's bank regulatory reforms.

The rest of the paper is structured as follows. Section 2 discusses previous research on the effects of financial reforms on bank production efficiency and competition, and on relationship between competition and risk taking behaviour. Section 3 briefly reviews the experiment of banking sector reforms implemented in Nigeria during 1993-2008. Section 4 explains the empirical methodology, including the choice of variables and data issues. Estimation results are presented and discussed in Section 5. Section 6 concludes.

2. Literature review

Orthodox microeconomic theory predicts that deregulation positively affects bank efficiency and productivity by reducing regulatory costs imposed on market participants. Also, deregulation relaxes the regulatory restrictions on banking activities and promotes competition. A considerable body of the empirical literature has examined the impact of financial reforms on banks' production performance, measured either by efficiency or productivity, without accounting for the effects through competition and risk-taking. Overall, the evidence appears to be mixed, with some studies reporting improvements in productivity and others suggesting little, no, or even negative productivity growth (Zhao *et al.,* 2008). Controversy exists not only on whether deregulation stimulates productivity growth, but also on the sources of productivity growth. While some studies show that productivity growth is due to technological progress (e.g. Reztis, 2006; Tortosa-Ausina *et al.,* 2008), others attribute it to efficiency improvement (e.g. Worthington, 1999; Isik and Hassan, 2003).

However, empirical findings suggest that the general belief that deregulation promotes competition cannot be demonstrated empirically always. There is a vast body of literature on the link between the observable market structure and performance, in the Structure-Conduct-Performance (SCP) context. However, there is no conclusive evidence on how regulatory changes in the late 1990s affected the structure, conduct and performance relationship in the financial sector (Canoy *et al.,* 2001). Alternative techniques, from the NEIO literature, depart from the SCP paradigm and attempt to infer the degree of competition by analysing banks' conduct, without referring to the observable market structure. The empirical evidence derived from the NEIO approach also appears to be controversial. While some studies document a positive link between deregulation and competition (e.g. Angelini and Cetorelli, 2000; Canhono, 2004; Claessens and Laeven, 2004), there is no evidence of an increase in competition following the rapid deregulation and market liberalisation processes in the EU area (Maudos and Fernandez De Guevara, 2004; Fernandez De Guevara *et al*., 2005), or UK banking market (Matthews *et al*., 2007), or the Uruguayan banking sector (Spiller and Favaro, 1984). The reasons of the conflicting evidence are not clear. Among other reasons, the oligopolistic banking market structure could be a contributory element. As banking sectors are generally characterized by high concentration, collusive behaviour is not uncommon (Demetriades and Luintel, 1996). In a highly concentrated oligopolistic market, the freedom granted by deregulation over both interest rates and credit allocation may give more scope for collusive behaviour by banks to achieve maximum monopoly profit (Park and Kim, 1994). Clearly, in a highly concentrated oligopolistic market, incumbents will be in a better position to reorganise their interests to face the threat posed by potential entrants (Roland, 2008). Indeed, the empirical evidence has shown that a bank cartel stepped in to fix interest rates whenever the authorities relaxed their control over lending or deposit rates (Demetriades and Luintel, 2001). Moreover, regulatory reforms are often a mixed process of deregulation and

prudential re-regulation and the role played by the implementation of prudential re-regulation alongside deregulation on competition has not been well understood (Carletti *et al.,* 2008; Matthews *et al*., 2007). To correct for banks' risk taking incentives, prudential re-regulation encompasses new requirements in the input mix and production procedures to produce outputs. Changes in banks' production and exchange relationship may impact on the entry and exit conditions of the banking industry. The risk-weighted capital adequacy ratio, the fulcrum of a prudential approach to regulation, for example, would limit the development of competitive market forces since the increase of mandatory capital requirement acts as one of the entry barriers (Neuberger, 1998). In contrast with the traditional view, Schargrodsky and Sturzenegger (2000) theoretically demonstrate and empirically show that a tightening of capital requirement facilitates competition because it induces exit from the industry, and leads banks to choose a lower degree of specialization along geographical and sectoral dimensions. Market segmentation is reduced, which intensifies price competition among banks.

The parallel research on the effect of financial reforms and competition on banks' risk taking behaviour, again, yields contentious results. Relaxing restrictions on banking activities may encourage banks' risk-taking by giving banks more opportunities to take on greater risk. Yet, as well, it may weaken the risks banks are taking, by increasing the scope for diversification and removing barriers for cost-saving and revenue-generating (Gonzalez, 2005). The increase in the number of market participants may lead to riskier bank portfolios and higher failure probabilities; because interbank rivalry gives lower-quality borrowers more opportunities to get a loan since they can go to another bank once their loan application is rejected at one bank (Shaffer, 1998). Yet, also, interbank rivalry may be undermined by inducing banks to avoid winning bad borrowers through competitors. Although there exists evidence to support the idea of a negative relationship between competition and stability, some recent studies have suggested that the perverse link between competition and risk taking

is not robust when the bank-borrower relationship and banks' monitoring function in the provision of loans are taken into account explicitly (Allen and Gale, 2004; Boyd and De Nicolo, 2005). While it may erode the charter value of the banking system by squeezing out abnormal returns associated with anti-competitive conduct, increased competition would speed up the reallocation of charter value across banks, fuelling the incentives of banks to differentiate themselves by dealing with asymmetric information (Boot and Thakor, 2000). While Rhoades and Rutz (1982), Keeley (1990) and Dick (2006) show that deregulation and competition destabilize the banking system, others studies, for example, Boyd and De Nicolo (2005), Boyd *et al.* (2007) and Yeyati and Micco (2007), indicate that banks tend to behave more prudentially in a more competitive environment with less regulatory restrictions.

In addition to the disagreement in the existing literature on the relationship either among deregulation, competition and production performance, or among deregulation, competition and risk taking, a systematic examination on the interaction among financial reforms, competition, risk taking and production performance is missing. Taking advantage of the deregulation and prudential re-regulation experience of the Nigerian commercial banking sector between 1993 and 2008, this paper brings together the three branches of literature in order to study the impact of those reform initiatives on banks' productive efficiency and risk taking, including the direct and indirect impact through competition.

3. Key reforms in the Nigeria banking sector

Nigeria has the second largest financial sector in Africa in terms of bank assets, market capitalization, and the number of listed companies in the stock market, after South Africa. The banking sector is the main source of financing in the Nigerian financial sector. Bank loans are the predominant source of debt financing.

Nigeria embarked on a Structural Adjustment Program (SAP) in 1986, of which deregulation of the banking sector was an integral element. The objective was to enhance bank

efficiency in savings mobilization and financial intermediation, through increased competition. Deregulation also promoted market determined interest rates and credit allocation. Restrictions on foreign exchange and capital movement were relaxed. However, the reforms of 1986 to 1993, in general, were not sustainable and suffered several reversals. It has been argued that the new entrants were attracted by trading in foreign exchange rather than intermediation, as evidence by the co-existence of the increase in the number of market participants and increased disintermediation (Beck et al., 2005). The combination of weak skills (e.g. credit scoring, risk assessment) and ethical issues (e.g. corruption, insider lending) contributed to the deterioration of banks loan portfolio (Brownbridge, 1998). The dramatic increase in the number of banks over-stretched the capacity of regulation. The poor performance of banks had been accumulating, but was well disguised due to the absence of prudential supervision; perhaps, it was even encouraged by the regulatory neglect and forbearance. It was finally brought into light with the classification of financial reporting under the 1990-1991 prudential regulation guidelines (Lewis and Stein, 1997). The economic recession and political instability hastened the decline; by mid-1993, half of the licensed banks were distressed or insolvent, placing at risk two-thirds of assets and close to 75% of deposits.

Further new reforms were introduced post-1993. The mandatory capital level was increased up to N500 million, while the statutory minimum risk-weighted capital ratio remained at 8% in 1997. The period of 1998-2004 witnessed aggressive re-deregulation. Interest rate deregulation is re-implemented in 1997 and entry restriction was again relaxed in 1999. Universal banking was adopted from 2001. Banks were allowed to undertake various financial service activities which encompassed both money and capital markets as well as insurance business. There was no geographical restriction either. The adoption of universal banking in Nigeria necessitated the Central Bank of Nigeria (CBN) to strengthen the

regulatory and supervisory framework. The requirement of capital base was increased to N2 billion in 2002, while the risk-weighted capital ratio was raised to 10%.

Beginning in 2004 to date, the new phase was labelled "big bang". CBN announced a new 13-point reform agenda in July, 2004. As a whole, the new reform agenda is intended to promote soundness, stability and efficiency of the Nigerian banking system and to enhance its competitiveness in the African regional and global financial system. Of those 13 points, one is to demands all commercial banks (i.e. universal banks) to raise the minimum capital base to N25 billion within approximately 18 months (i.e. by December 2005) with the statutory minimum risk-weighted capital ratio maintaining at 10%. When the new reform agenda was announced, of 89 banks operating in the banking market, about 5-10 banks' capital base were already above the N25 billion; 11-30 banks' capital base was within the N10 to N20 billion; the remaining 50 to 60 banks were quite below the N10 billion. The attempt to meet the minimum capital base triggers the merger and acquisition[2] in the industry. Further, banks raise capital from domestic capital market and through foreign direct investment. This leads to the increase of the share of the Nigerian banking industry's capitalization as a percentage of stock market capitalization from 24% in 2004 to 38% by 2006, directly contributing to the growth of the market capitalization and the market's liquidity during 2005-2006. At the end of the 18 months given by the CBN, only 25 out of 89 banks were standing[3]. With 21 private publicly quoted banks, 4 foreign banks, and there is no government-owned bank.

The reform approaches ranging from deregulation to prudential re-regulation have brought about the changes in the size, structure and operational characteristics of the Nigerian banking system. As seen in Figure 1, the three development indicators measured as a percentage of GDP, namely the total saving (i.e. the sum of saving and time deposits) with

[2] Mergers and outright acquisition/takeover is specified as the only legal model of consolidation in the guidelines for the consolidation issued by the CBN.
[3] 14 banks accounting for 6.5 percent of deposits failed to meet the recapitalization criteria and had their licenses revoked in 2005.

commercial banks, the credit to private sector granted by the commercial banks and the total assets of the commercial banking, commonly had a downward trending during 1993-1997, and reversed into increasing 1997 onwards at the time when the deregulation policy was re-introduced. This suggests that the commercial banking sector has gained increased importance in economic growth despite that the disclosure of distressed banks and the exit of banks that can not meet the increased requirement on capital base in 2005.

[insert Figure 1 about here]

It is shown that the difference between total assets as a percentage of GDP and credit to private sector as a percentage of GDP becomes larger, especially after 1997, suggesting that the growth of credit to private sector lags behind that of total assets, an evidence of the restructure and reorientation of banks' business focus. Similarly, the difference between the ratio of credit to private sector over GDP and that of saving over GDP also increased, mainly after 2001. This indicates that commercial banks are able to raise alternative financial resource in addition to saving and time deposits to provide financing support to the private sector. Presumably, the increase of the required capital base is one of alternative channels.

In terms of the market structure and performance indicators (Table 1), although the number of banks dramatically decreased after 2005, because of policy induced consolidation and exit, the number of branches appears to be stable. This implies that the remaining 25 banks represent the hub of the financial intermediation of the Nigerian commercial banking and the strength of its branch network to raise deposit from society has not been negatively affected by the "big bang". This also corresponds to the continuous increase of the ratio of saving raised by the commercial banking sector over GDP and the ratio of credit to private sector over GDP 2004 onwards. The three-bank concentration ratio (CR3) shows that the decrease of the number of banks is accompanied by the decrease of concentration, indicating the increase of the market size of the banking system on one hand and the reshuffling of the

market share among the market participants on the other. Overhead cost as a percentage of total assets, an indicator of non-financial cost of intermediation, is decreasing. The profitability, measured by pre-tax profit divided by financial capital, also appears to be downward trending, so does net interest margin.

[insert Tables 1 and 2 about here]

In terms of the quality of loan portfolio (Table 2), non-performing loans (NPLs) as a percentage of total credit consistently decrease over time, suggesting that the quality of loan portfolios in relative terms improves. What is noteworthy is that the decrease of NPL ratio seems to go hand by hand with the increase of the absolute amount of NPLs. The only exception is 2006, which mainly contributes to the cleaning up of the balance sheet of the remaining 25 banks due to the "big bang". The increase in the absolute amount of NPLs implies that the increment of NPLs has been higher than the recovery of NPLs. The finding that the NPL burden was accumulated although NPLs in percentage terms decrease sheds light on the likely "window dressing" of banks: banks bring down their NPLs ratio not through the recovering NPLs but rather through inflating their loan portfolio. Indeed, the correlation coefficient of natural logarithm of total credit and that of NPLs is 0.969. The correlation coefficient of natural logarithm of NPL ratio and that of NPL is -0.682. The results depict an interesting interrelationship among these three factors. The increase of the absolute amount of NPLs is not positively but rather negatively related to NPLs ratio since it is accompanied by the increase of the amount of loans which dilutes NPLs in percentage terms.

Finally, in terms of the risk-weighted capital adequacy ratio (CRAR) (Table 3), data show that it increases significantly after the "big bang", although the "big bang" only applies to minimum capital base while the 10% statutory CRAR unchanged. However, given the fact that the required minimum capital base was increased from N2 billion in 2004 to N 25 billion in 2005, i.e. 12.5 times, the increase of CRAR from 14.17% to 22.6% may not as

impressive as it looks like. There is a concern that the increase of capital base is accompanied by the increase of risk-weighted assets, as suggested by Table 3.

[insert Table 3 about here]

4. Research methodology

4.1 Stage I: the measurement of bank productive efficiency and competitive conduct

The research methodology is designed as a three stage procedure. The first stage is the measurement of bank productive efficiency as well as bank competitive conduct.

4.1.1 The measurement of bank productive efficiency

To measure bank productive efficiency, we use non-parametric DEA with an output-maximization orientation.[4] DEA constructs a piece-wise linear convex frontier from a linear combination of the best observed practices in the sample at a point in time. By taking the constructed frontier as a proxy for available production technology, DEA assesses the efficiency of each bank, benchmarked against the frontier. Compared to the competing parametric techniques, non-parametric DEA works well on small sample size and it avoids errors caused by inappropriate assumptions about the functional form of the production process and the distribution of the inefficiency term. The measure of output-oriented productive efficiency reflects the extent to which outputs can be improved from a given level of inputs, without changing the output mix. We choose an output-maximisation orientation mainly because the purpose of this paper is to study the impact of financial reforms and competition in Nigeria's banking sector on the ability of banks to raise deposits and intermediate them into loans and other earning assets.

The DEA frontier shifts over time, which needs to be taken into account in order to derive information on trends in bank production performance, particularly when the time span

[4] DEA is a mathematical linear programming tool, based on Farrell (1957) and Charnes *et al.* (1978, 1981).

is relatively long or if the examination is undertaken after financial reforms. Since reforms are characterised by changes in incentives and constraints, their impact on banks' production performance includes efficiency change and technology change (Wheelock and Wilson, 1999). It is possible to calculate changes in banks' production performance using DEA-type Malmquist index, but a relatively large sample size is required to calculate the DEA frontier and evaluate efficiency on a yearly basis. We have a limited sample size and need to preserve the degrees of freedom, so we follow Bhattacharyya *et al.,* (1997) and adopt a "grand DEA frontier approach". Specifically, we use DEA to identify a single grand frontier which envelops the pooled input-output data of all sample banks in all sample periods. Hence, the grand DEA frontier provides a single benchmark over the pooled sample against which to assess production performance; the productive efficiency scores derived contain information on the change in production performance over time.

We model the bank production process to comprise three inputs, $x^{it} = (x_1{}^{it}, x_2{}^{it}, x_3{}^{it}) \geq 0$ (interest expense, x_1, non-interest expense, x_2, and financial capital, x_3), and three outputs, $y^{it} = (y_1{}^{it}, y_2{}^{it}, y_3{}^{it}) \geq 0$ (loans, y_1, other earning assets, y_2, and deposits, y_3). The DEA output-oriented productive efficiency of bank *i* (*i* is the bank) in year *t* (*t* is the time period), $E(x^{it}, y^{it})$, against the single frontier envelopment surface from the pooled input-output data of all sample banks in all sample periods, is given by:

$$
\begin{aligned}
&\max_{\theta,\lambda} \ \theta = [E(x^{it}, y^{it})]^{-1} \\
&s.t. \quad \theta y_m{}^{it} \leq \sum_{i=1}^{F}\sum_{t=1}^{T} \lambda^{it} y_m{}^{it}, \qquad \mathrm{m} = 1,2,3, \\
&\qquad \sum_{i=1}^{F}\sum_{t=1}^{T} \lambda^{it} x_n{}^{it} \leq x_n{}^{it}, \qquad \mathrm{n} = 1,2,3, \qquad (1) \\
&\qquad \lambda^{it} \geq 0, \qquad \mathrm{i} = 1,\ldots\ldots,\mathrm{F}, \ \ \mathrm{t} = 1,\ldots\ldots,\mathrm{T}, \\
&\qquad \sum_{i=1}^{F}\sum_{t=1}^{T} \lambda^{ft} = 1.
\end{aligned}
$$

The objective of equation (1) is to search θ (i.e. the reciprocal of the productive efficiency score for the *i*th bank in the sample) and λ (i.e. the weights used by the identified best practice banks to construct the same input level as the *i*th bank being analyzed). Equation (1) is solved for each bank at each sample period. $E(x^{it}, y^{it})$ is the scalar productive efficiency score in $0 < E(x^{it}, y^{it}) \leq 1$. Values of $E(x^{it}, y^{it})$ equal to 1 indicate efficiency: the *ith* bank is a technically productive efficient bank which is located on the grand frontier of the output possibility set from a given level of inputs. Values of $E(x^{it}, y^{it})$ smaller than 1 indicate inefficiency: the minimum radial expansion of all outputs of a particular inefficient bank without changing its input level to reach the projected points on the grand frontier, which is equivalent to a $\{[1/E(x^{it}, y^{it})]-1\}*100$ percentage change. Table 4 summarises the definitions of inputs and outputs used in Equation (1).

[insert Table 4 about here]

4.1.2 The measurement of competitive conduct

To measure the degree of competition, we adopt a CV approach. The approach is based on the principle that, in short-run equilibrium, profit-maximizing banks choose prices or quantities where marginal cost equals marginal revenue. The degree of competition in the market place reflects banks' competitive conduct in an oligopolistic setting, without reference to the observable market structure. We prefer the CV approach, to the reduced-form analysis of the SCP paradigm and the Panzar and Rosse method, because it has several important advantages. First, it is a structural approach, which captures the demand, cost, and profit-maximizing conditions faced by banks. Hence, not only does it offer a measure of competition but it also provides insight into the sources of the estimated competitive conduct (Kadiyali et al., 2000). Second, it is more suitable than the Panzar and Rosse H-statistics for exploring factors associated with the variation of the estimated competitive conduct (Shaffer, 2004). The

estimated CV parameters can be treated as continuous variables, representing any form of oligopolistic behaviour, arising from a static or dynamic game. Moreover, CV provides information on changes in the degree of competition in the industry over time. Third, although the CV approach assumes short-run profit maximization equilibrium, the association between the estimated CV parameters and the deviation from marginal cost pricing remains. It is a valid technique for characterizing the outcome relative to the perfectly competitive, socially optimal benchmark, under marginal cost pricing (Shaffer, 2004).

Specifically, we jointly estimate the following three equation system (2-5) using seemingly unrelated regression (SUR), following Uchida and Tsutsui (2005) and Brissimis *et al.,* (2008). Equation (2) is a translog cost function. The revenue equation in (3) is obtained from the first-order profit maximization condition of banks with respect to the quantity of loans. Equation (4) is an inverse loan demand function. Hence:

$$\ln C_{it} = b_o + b_1 \ln q_{it} + 1/2 * b_2 (\ln q_{it})^2 + b_3 \ln d_{it} + 1/2 * b_4 (\ln d_{it})^2 + b_5 \ln w_{it} + 1/2 * b_6 (\ln w_{it})^2 + b_7 \ln q_{it} \ln w_{it} + b_8 \ln q_{it} \ln d_{it} + b_9 \ln d_{it} \ln w_{it} + \delta_{it}^{\ c} \quad (2)$$

$$R_{it} - E_{it}(q_{it} / d_{it}) = \omega_o + (-\frac{\theta_t}{\eta_t}) R_{it} + C_{it}(b_1 + b_2 \ln q_{it} + b_7 \ln w_{it} + b_8 \ln d_{it}) + C_{it} * \frac{q_{it}}{d_{it}} (b_3 + b_4 \ln d_{it} + b_8 \ln q_{it} + b_9 \ln w_{it}) + \delta_{it}^{\ s} \quad (3)$$

$$\ln p_{it} = \rho_o + (\frac{1}{\eta_t}) \ln q_{it} + \rho_1 gdp_t + \rho_2 \ln totalassets_{it} + \rho_3 \ln cap_{it} + \delta_{it}^{\ p} \quad (4)$$

In Equation (2), after omitting the subscripts *i* and *t* for brevity, *C* is the total non-interest expense, measured by total cost minus total interest expense; *q* is the quantity of loans; *d* denotes total loanable funds, measured by the sum of total deposits and total money market funding; and *w* is banks' cost, measured by the ratio of total non-interest expense over the sum of loans and total loanable funds. Linear homogeneity of degree one in input prices is obtained by dividing *C* and w by w before taking logs. Following standard practice, we normalise each output quantity and input price variable using its geometric mean, such that, the

estimated first-order coefficients can be explained directly as the cost elasticity at the sample mean. Consequently, both b_1 and b_3 are positive as required by the positivity of marginal cost.

In equation (3), the dependent variable is the difference between interest income (*R*) and interest expense (*E*), weighted by the ratio of loans to total loanable funds. In equation (4), *p* is the implicit price of loans, calculated as the ratio of interest income (on loans) to total loans; and *gdp* is real GDP growth rate, which captures the demand for financial services on the price of loans (a positive relationship is expected because higher demand for financial services induces higher prices). The total assets variable, *totalassets*, is used to capture the size effect. Capitalization (*Cap*) is measured by capital divided by total assets; it represents differences in risk attitude across banks. The industry price elasticity is given by $\eta_t < 0$. The CV parameter to be estimated is given by: $\theta_t = (\partial \sum_{i=1}^{F} q_{it} / \partial q_{it}) * (q_{it} / \sum_{i=1}^{F} q_{it})$. It represents the elasticity of total industry output (i.e., $\sum_{i=1}^{F} q_{it}$) with respect to the output of the ith bank (i.e. q_{it}), and it indicates the degree of competition in the market place in each year. The higher the magnitude of the estimated CV elasticity, the lower is the degree of competition, and *vice versa*. If the market structure is characterised by Cournot competition, θ_{it} is the market share of the *i*th bank (i.e. $q_{it} / \sum_{i=1}^{F} q_{it}$). In the case of perfect competition, $\theta_{it} = 0$; under pure monopoly, $\theta_{it} = 1$; and, $\theta_{it} < 0$ implies pricing below marginal cost, due to non-optimizing behaviour by banks. The $\theta it < 0$ case may reflect, as well, a super-competition condition as found by Shaffer (1993) in Canadian banking and Gruben and McComb (2003) in Mexican banking. For the sake of tractability, we impose the restriction that $\theta_{it} = \theta_t$ in Equation (3).

Hence, θ_t indicates the industry average of the degree of competition at time t[5]. To investigate the short-term changes in the degree of competition, we estimate yearly θ, using year dummy variables, while to estimate η, we use dummy variables for every two years. We cannot use year dummy variables to estimate η, because they are linearly dependent on the time-specific control variable, *gdp*. Table 5 summarises the definitions of variables in Equations (2)-(4).

[Insert Table 5 about here]

4.2 Second stage analysis: financial reforms and competitive conduct

In Stage II, we examine the impact of deregulation and prudential re-regulation on the degree of competition, controlling for other factors. Specifically, we estimate the following model:

$$\theta = \alpha_0 + \alpha_1 deinterest + \alpha_2 bigbang + \alpha_3 universal + \alpha_4 CR3 + \alpha_5 gdp + e \qquad (5)$$

The dependent variable, θ, is the banking industry average of the degree of competition (derived from Stage I). We focus on three important regulatory initiatives. First, the re-implementation of interest rate deregulation in 1997, is measured using a dummy variable, *deinterest*. It takes the value of one for the period 1993-1996, and zero otherwise. The second initiative, the removal of the regulatory barrier between merchant and commercial banking in 2001, is captured using a dummy variable, *universal*. The dummy takes the value of zero till 2001 and one thereafter. The third element relates to the 'big bang' measures, which were announced in July 2004. The reforms included a dramatic increase of minimum capital base requirement from N2 billion to N25 billion, with the requirement that banks had to fully comply before December 2005 otherwise they would be de-licensed, which led to a remarkable reduction of the number of banks from 89 in 2004 to 25 in 2005. The dummy, *bigbang*, is used to capture the measures; it takes the value of zero till 2004 and one thereafter.

[5] As in Shaffer (2004) for the restriction $\theta_i = \theta$, θ measures the competitive conduct of the average firm. In the case of a dominant firm (or cartel) plus a competitive fringe, the estimated value of θ represents a weighted average of the perfectly competitive and collusive values, and is larger than the perfectly competitive value.

Further, we take into account the impact of market structure, which is measured using a three-bank concentration ratio (CR3), on the degree of competition. The traditional SCP paradigm indicates that the presence of a few larger banks restricts competition; it predicts a negative relation between concentration and competition. In contrast, the efficiency structure hypothesis predicts that concentration is induced by the increase of market share gained by more efficient banks, which suggests that concentration is not a reliable indicator of the degree of competition (Demsetz, 1973). Also, we introduce real GDP growth rate (*gdp*). The motivation to control for economic growth earlier in Equation (3) differs from the present case in Equation (5); here, it is intended to capture the impact of the change in economic fundamentals on the dynamics of competition. As argued by Sudhir *et al.* (2005) and Barnea and Kim (2007), the change in economic fundamentals affects expectations of market participants about the future level of demand, which may change the competitive interactions between market participants. Moreover, it is useful to distinguish between fundamentals-driven and conduct-driven components of competitive interactions. Furthermore, Haltiwanger and Harrington (1991) and Kandori (1991) indicate that these oligopolistic dynamics crucially depend on whether market participants' competitive strategy is long-term forward looking or myopic. Specifically, if future demand is expected to grow (fall), the cooperation between market participants is easier (more difficult) because their competitive strategy has a long-term outlook. On the other hand, if the market participants' competitive strategy is myopic, the opposite is true. The definition of variables used in Equation (5) is summarized in Table 6.

[Insert Table 6 about here]

4.3 Stage III: Direct and indirect effects of financial reforms on bank behaviour

Our final stage is to investigate the impact of financial reforms on bank risk taking and bank productive efficiency, taking into account both the direct effect of policy actions and the indirect impact through competition. We specify the following model:

$$Risk\text{-}taking_{it} = f(competition_t, reform\text{-}initiatives_t, economic\text{-}conditions_t, bank\text{-}specific\text{-}characteristics_{it}) \quad (6)$$

$$Productive\text{-}efficiency_{it} = f(competition_t, reform\text{-}initiatives_t, economic\text{-}conditions_t, bank\text{-}specific\text{-}characteristics_{it}) \quad (7)$$

In equations (6) and (7), the dependent variables measure credit risk of bank *i* at time *t* and productive efficiency of bank *i* at time *t*, respectively. Bank risk taking is measured using a proxy variable, the loan loss provisions to loans ratio, as an ex-post indicator of credit risk. Bank-specific productive efficiency is derived from the first-stage analysis using DEA. It is predicted that financial reforms affect bank productive efficiency and bank risk taking through the direct impact as well as indirect impact through competition. We therefore control for the competitiveness condition and banking sector reforms in the bank risk taking and bank productive efficiency equations. The degree of competition is given by the CV parameters estimated from the first-stage. Reform initiatives refer to the three important financial reforms in Nigeria, using the dummy variables *dinterest*, *universal* and *bigbang*, as previously defined. We also consider the influence of macroeconomic conditions, measured by real GDP growth rate. An increase in aggregate economic activity is expected to increase borrowers' cash flow and decrease the probability of loan default, hence a negative effect of real GDP growth rate on loan losses is predicted (Salas and Saurina, 2003). The expected sign of the relation between macroeconomic conditions and bank productive efficiency, however, is ambiguous. Although higher economic growth may stimulate demand for financial services, it also allows banks to charge higher margins. Since banks operate in an imperfectly competitive market, the two effects would offset each other, and the net effect is an empirical issue.

Regarding the bank-specific determinants of bank risk taking and bank productive efficiency, we use slightly different sets of variables, taking into account the association between the two important aspects of bank performance. In the bank-risk taking equation, we

take into account the size effect, measured by total assets (taking natural logarithm). The literature presents a dichotomous view on the relationship between size and bank-risk taking: on the one hand, larger banks tend to diversify and hence reduce risk; on the other hand, larger banks may take higher risk if they are motivated by the too-big-to-fail incentive. We also consider bank capitalization, measured by the ratio of capital to total assets. While the objective of the implementation of capital requirement along with deregulation is to enhance the stability of the banking system, the relationship between capital ratio and risk taking is controversial. The increase of risk goes commensurably with the increase of capital if the purpose of the imposition of higher capital requirement is to enhance the ability of banks to internalize risk taking (Altunbus, *et al.,* 2007). Indeed, literature has indicated that banks comply with mandatory risk-weighted capital requirement ratio via: increasing the capital level; decreasing the risky assets; or increasing the capital level and risky assets simultaneously (Santos, 2001). Alternatively, higher capitalization may induce banks to behave prudentially since the option value of deposit insurance is decreasing in bank's leverage, leading to a negative relationship between capital and risk taking (Konishi and Yasuda, 2004). We also control for the degree of specialization. Diversification by jointly producing different types of outputs may lead to a decrease of risk. However, asymmetric information in the loan market may make specialization beneficial for risk management, since screening and monitoring are easier and more effective (Mukherjee *et al.,* 2001). We follow Mukherjee *et al.,* (2001), among others, and measure the degree of specification by the Herfindahl index of the outputs, i.e., $SP = \sum_{i=1}^{2} S_i^{\,2}$, and $S_i = y_i / \sum_{i=1}^{2} y_i$. Since our concern is on the impact of the degree of specialization on credit risk, here, we use an interest-income (y_1)/non-interest income (y_2) frame to categorize bank on-balance sheet and off-balance sheet activities. SP =1 means that a bank is totally specialized, and SP=0.5 implies that a bank produces totally diversified outputs (i.e., interest income and non-interest income have the

equal share in total income). We finally introduce net interest margin, measured by net interest income divided by total interest earning assets. Arguably, net interest margin is negatively associated with bank credit risk since banks with higher net interest margin face higher bankruptcy cost and may behave more prudentially (Salas and Saurina, 2002). However, if the higher interest margin is due to higher risk premium associated with higher expected possibility of default, a positive net interest margin and credit risk taking is expected.

With respect to the bank productive efficiency equation, we also consider the size effect. Policy initiatives to promote larger banks usually assume the existence of economies of scale. Larger banks are expected to yield higher productive efficiency because size facilitates the rationalization of human capital, network and back-office and economizes the utilization of inputs. Also, larger banks are expected to enjoy larger consumer-bases and wider distributional channels and hence produce more output from a given level of inputs. In addition, we consider bank capitalisation. Capital adequacy requirement is used by regulators as the central prudential re-regulation instrument during financial reforms. However, it is not clear precisely how capitalization influences bank production efficiency. On the one hand, well-capitalized banks have higher productive efficiency because they face less constraint to expand outputs. On the other hand, well-capitalized banks tend to set more demanding conditions on the supply of loans due to a more cautious attitude towards output expansion (Bolt and Tieman, 2004). We finally allow for the interrelationship between bank productive efficiency and bank-risk taking. Indeed, since risk management is the inherent component of bank intermediation process, banks with poor senior management may have problems in monitoring both their output and their loan customers (Berger and DeYoung, 1997). Table 7 summarises the definitions of variables in equations (6) and (7).

[Insert Tables 7 and 8 about here]

4.4 Data

We retrieve from BankScope annual balance sheet and income statement data on Nigerian commercial banks over 1993-2008. We start with the universe of all commercial banks and after checking the data for completeness, we obtain a final unbalanced panel sample of 91 banks with a total of 630 observations. Real GDP growth rate over 1993-2008 is collected from IMF International Financial Statistics Database. All variables used in our analysis are either expressed as ratios or measured in real terms, using GDP deflator with 2000 as the base year. Table 8 provides summary statistics for the variables.

5. Estimation and testing results

5.1 Results of first-step analysis

5.1.1 DEA productive efficiency scores

We applied DEA, as in Equation (1), to 630 bank/year observations to construct a grand frontier. The average productive efficiency and standard deviation of output-oriented productive efficiency are presented in Table 9 and illustrated in Figure 2. Overall, our results indicate a general improvement in output production from a given input level, especially after 2004; the mean of productive efficiency post-2004 is higher than the average mean for 1993-2008. The dispersion of productive efficiency measured by its standard deviation appears to be stable up to 2004; for each of 2006 and 2007, it is lower than the average for 1993-2008.

[insert Table 9 and Figure 2 about here]

5.1.2 The degree of competition: the estimated CV parameters

The equations (2)-(4) are estimated simultaneously using SUR and the results are reported in Table 11. All of the 35 parameters are highly significant (at 10% or less). Our estimated cost function meets the non-negative marginal costs regularity condition, as b_1 and b_3 are positive.

As for the demand equation, the estimated industry demand elasticity (η) is negative, as required by economic theory. The evidence (ρ_1) also indicates that higher GDP growth rate is associated with higher implicit interest rates, suggesting that higher demand for financial services allows banks to charge higher loan rates. Further, the estimates for the size effect (ρ_2) and capitalization (ρ_3) indicate that each is positively associated with the implicit interest rate on loans. The positive size-price relation may due to the wider distribution channel of larger banks, which gives bigger banks higher bargain power in the provision of loans. The positive capitalization-price relationship indicates that well-capitalized banks are more risk averse and thus require a higher margin in order to cover the higher costs of equity financing compared to external financing (Maudos and Fernandez de Guevara, 2004). Indeed, as noted by Kim et al., (2005) and De Jonghe and Vennet (2008), the capitalization level and the ability of banks to diversify horizontally could be strategic variables banks use to differentiate themselves from their rivals to soften competition.

Regarding the changes in the degree of competition over our sample period (1993-2008), Figure 3 shows the estimated values of θ_t together with their 95% confidence interval. It is shown that, over the period, the results reject $\theta = 1$, pure monopoly, except for 2008. The competitive conditions in years 1996 and 1998 are characterized by a super competition situation, while the conditions in 1995 and 1997 reflect perfect competition; for the rest of the sample period, Nigerian commercial banking demonstrates a certain level of oligopoly. Overall, the estimated CV parameters suggest the change in the degree of competition in Nigerian commercial banking are phased into three sub-periods: an increase in the degree of competition during 1993-1998; a decrease in the degree of competition during 1998-2001; and an increase in the degree of competition during 2001-2008.

[insert Table 10 and Figure 3 about here]

5.2 Results of stage II analysis: financial reforms and competitive conduct

The estimation results for equation (5), regarding the impact of financial reforms on the degree of competition, are reported in Table 11.

[insert Table 11 about here]

The results show that *deinterest*, the proxy for the reimplementation of interest rate deregulation, is positive and statistically significant at 7% level. *Universal*, the proxy for the adaptation of universal banking, is also positive and significant (1% level). This evidence suggests that the deregulation of interest rate and the expansion opportunities into universal banking do not promote competition but rather nurture collusion. This result is consistent with the view that deregulation over both interest rates and banking business lines essentially give more scope for collusive behaviour of banks in an oligopolistic market. In addition, the coefficient of *bigbang,* is negative; however, the result is not statistically significant.

The market share occupied by the largest three banks, *CR3*, has a statistically significant positive coefficient, suggesting that increased concentration increases the degree of collusion in the market place, in line with the prediction of the traditional SCP paradigm. Further, the estimated coefficient of *gdp* is not statistically significant; indicating the difficulty for market participants to formulate representative expectations about future demand, given the overall unstable macroeconomic conditions during the sample period.

5.3 Stage III results: Direct and indirect effects of financial reforms

We investigate the impact of financial reforms on bank risk taking and bank productive efficiency by estimating equations (6) and (7), respectively. We also take into account several econometric issues. The endogenous variable is limited (or censored) in the sense that the productive efficiency scores derived from the grand DEA frontier can be measured only within the range from zero to one. Conventional Ordinary Least Squares (OLS) method is

likely to yield inconsistent parameter estimates. Hence, we use a censored Tobit regression model to handle the problem. However, the inclusion of bank risk taking as an explanatory variable in the productive efficiency regression model may lead to potential endogeneity problems, because productive (in)efficiency also affects risk taking. To deal with this concern, we test for the endogeneity of bank-risk taking using the approach proposed by Smith and Blundell (1986). We fail to reject the exogeneity of bank-risk taking[6], hence the standard Tobit model and a separate estimation of bank-risk taking seem to be plausible specifications. Further, we take into account the panel feature of our dataset. We perform likelihood-ratio tests comparing a random Tobit against a pooled Tobit model of the bank productive efficiency equation. Our results indicate that a random Tobit model is a more suitable choice. We perform a Breusch and Pagan Lagrangian multiplier test for random effects against pooled model and further a Sargan-Hansen statistic test to decide whether to use the fixed effects or the random effects specification of the bank risk taking model[7]. Our evidence is in favour of the random effects model. The results are reported in Table 12.

[insert Table 12 about here]

First, we focus on results for the bank risk taking equation. Regarding the direct impact of financial reforms on bank risk taking, the evidence reported in Table 12 shows that interest rate deregulation and the adaptation of universal banking both negatively and significantly affect bank risk taking. The negative relation between interest rate deregulation and bank risk taking suggests that deregulation of interest rate opens up opportunities for banks to use pricing as a risk management tool, i.e. banks are able to price risk according to the expected default risk. The negative impact of the adaptation of universal banking on bank-risk taking reflects the risk diversification benefit across different business lines. In contrast, the results

[6] The instruments we use are net interest margin and the degree of competition, which are included in the bank risk taking equation but not in the bank productive efficiency equation.
[7] The Sargan-Hansen test has advantages over the Hausman fixed-versus-random effects test, because it is robust to arbitrary heteroskedasticity and within-group correlation.

show a positive and statistically significant coefficient of *"big bang"*, indicating that the dramatic increase of the minimum capital base requirement is positively related to bank risk taking. These results seem to suggest that the increase of the minimum regulatory capital base may have induced a proportionate increase of risk taking, which is consistent with the statistics we presented in Table 4. Further, with respect to the impact of competition, the estimated coefficient is statistically significant and positive, which implies that an increase in competition yields lower risk taking, as proposed by the "competition-stability" view.

Regarding the bank-specific characteristics, the results indicate that banks with higher capitalization have lower risk taking, confirming our previous argument that well-capitalized banks are more risk averse. This result does not conflict with our results of positive relation between the "big bang" on bank capital requirement and bank-risk taking as the latter is a policy on the level of capital not on the ratio of capital to total assets. Moreover, the estimated coefficient of the "big bang" refers to the average impact on the industry, without accounting for the heterogeneity cross banks[8]. Our results also show that higher net interest margins are associated with higher risk taking, implying that banks that charge higher risk premium (associated with higher expected probability of default) face higher ex-post credit risk. In addition, the estimated coefficient of the degree of diversification is negative, which concurs the view that diversification by jointly producing different types of bank outputs may lead to a decrease of risk. Finally, the size effect, measured by total assets, indicates the risk benefit of economies of scale, although it is not statistically significant.

Second, we consider the regression results for the bank productive efficiency model. In terms of the direct impact of reform initiatives, our results indicate a substantial gain in bank productive efficiency following the reimplementation of interest rate deregulation, the

[8] To test for this, we introduce the interaction term between capitalization and dummy variable for the "big bang", and re-run the regression. The estimated coefficient of the interaction term is negative but not significant. The coefficient of the policy dummy remains significantly positive (0.65%), while the coefficient of capitalization keeps significantly negative (1%). The estimated results are available from the authors on request.

adaptation of universal banking and the significant tightening of capital requirement, as the coefficients on three reforms dummies are all positive and statistically significant. Although these three important events in the Nigerian banking reforms all appear to stimulate productive efficiency, there are three further interpretations of the propagation mechanisms of these reforms. First, with respect to interest rate deregulation, it may be the case that the freedom of banks to raise interest rate on deposits and loans enhances banks' operational flexibility in providing financial services. Banks are able to carry out financial intermediation that might not have been profitable under the regime of regulated interest rate. Second, regarding the adaptation of universal banking, the evidence may be interpreted to reflect the cross-selling behaviour of banks i.e., banks sell existing and new products to the additional consumers brought about by the expansion of business lines, which enable banks to produce more outputs from a given level of inputs. Third, the positive outcome of the "big bang" suggests a reshuffle of the market share, resulting into an increase of outputs for the existing market participants. The results may also be interpreted in terms of positive synergy effect of consolidation as a result of recapitalization.

Regarding the impact of competition on bank productive efficiency, the significant and negative coefficient confirms that an increase of competition may enhance bank production performance, as predicted by the microeconomic theory. Macroeconomic conditions, measured by real GDP growth rate, appear to be negatively associated with bank productive efficiency, suggesting that banks production performance decreases in a more favourable economic environment. This result suggests that more favourable macroeconomic conditions may induce an increase of the demand for financial services on the one hand and an increase of banks' ability to charge higher interest rate, on the other. Indeed, the estimated results of the demand equation (4) did suggest that higher GDP growth rate is associated with higher implicit interest rate (ρ_1 in Table 11). Since banks operate in an imperfectly competitive

market, the two effects on banks production performance may offset each other. The negative relationship between real GDP growth rate and bank productive efficiency seems to suggest that the expected improvement in productive efficiency induced by the increase of demand is outweighed by the decrease in the quantity of production due to the increase of interest rate.

Regarding the influence of bank risk taking on bank productive efficiency, our results indicate that the increase in bank risk taking is inversely related to bank productive efficiency, as expected. In terms of other bank-specific characteristics, the results show a positive and statistically significant coefficient for total assets, which suggests that banks enjoy economies of scale. The negative estimated coefficient of capitalization indicates that well-capitalized banks have a lower bank productive efficiency, which probably reflects a more conservative attitude of well-capitalized banks towards expansion of production.

Although the failure to reject the exogeneity of bank risk taking rules out the instrumental simultaneous estimation of bank productive efficiency and bank risk taking equations, there is a possibility that bank productive efficiency and bank risk taking are subject to common shocks which we did not fully consider in our specification, leading to contemporaneous correlation of disturbances from the two equations. Hence, risk taking and risk management are central to banks' production process, and are governed by banks' overall operational philosophy, analysis and control. To accommodate this, we also estimate the risk-taking and productive efficiency equations simultaneously using a full-information maximum likelihood (FIML) estimator as a check for robustness. The results are reported in Table 13.

[insert Table 13 about here]

As shown in Table 13, the simultaneous estimation results do not change the central findings from single equation estimation in Table 12. The deregulation of interest rate and the adaptation of universal banking are still positively related to bank-risk taking while the opposite is true for the imposition of "big bang". Moreover, the increase of competition seems

to enhance safety of the loan portfolio. The magnitudes of the estimated coefficients are similar to the ones in Table 13, and the results are significant as well. With respect to productive efficiency, all three important reforms appear to promote productive efficiency, although the result for adaptation of universal banking is not significant. The increase of competition, again, positively contributes to the increase of productive efficiency. Finally, the result also suggests that banks with higher risk taking have lower productive efficiency, although it is only significant at 19% level.

To summarize, we find that financial reforms influence bank competition and through competition affect bank risk taking and bank productive efficiency; this is the indirect effect. In addition, financial reforms have a direct impact on bank risk taking and bank productive efficiency. The relationship between competition and bank risk taking is negative, suggesting that banks behave more prudentially in an increasingly competitive environment. The relationship between competition and bank productive efficiency, however, is positive, implying that banks make effort to catch up with the best practices in view of an increase in competition. We also find evidence suggesting a negative association between bank risk taking and bank productive efficiency.

Additionally, our results suggest that deregulation and prudential re-regulation affect bank risk taking and bank productive efficiency in different ways in terms of both direct impact and indirect impact through competition. The deregulation initiatives offer banks the opportunity to price risk and to diversify their business lines, which promote both productive efficiency of banks as well as the safety of banks' loan portfolio. The decrease of risk taking tends to further reinforce the increase of productive efficiency. However, the positive outcome of deregulation on both bank-risk taking and bank productive efficiency may be offset by the negative impact on the degree of competition. In contrast, the implementation of tightening minimum capital base brings about the increase of bank risk taking as well as the increase of

bank productive efficiency. Moreover, there is a concern that the increase of risk taking may counterbalance the increase of bank productive efficiency. Unlike the impact of deregulation initiatives, the impact of tightening minimum capital base on bank risk taking and bank productive efficiency seems to be exclusively associated with its direct impact. Its impact on the degree of competition is insignificant (see Table 12). Figures 4, 5, 6 graphically demonstrate those relationships.

[insert Figures 4, 5, 6 about here]

6. Conclusion

Despite the fact that recently the process of deregulation (and concomitant prudential re-regulation) has been a dominant feature in financial markets of developed and developing countries, the empirical work on the impact of such policy reforms on bank competition and performance is limited and inconclusive. To explore this issue further, we develop a three-stage procedure and perform a systematic investigation of the interaction among variables that proxy financial reforms, bank competition, bank risk-taking and bank production efficiency. We apply the procedure to the reform experience of the Nigerian commercial banking sector during the period 1993-2008.

Our empirical results suggest that deregulation and prudential re-regulation influence bank risk taking and bank productive efficiency directly (direct impact) as well as through their impact on bank competitive conditions (indirect impact). We find evidence to suggest that the increase in bank competition is beneficial for a well-functioning banking sector because increased competition is associated with reduction in bank risk taking and enhanced bank productive efficiency. As a result, our findings lend support to policy initiatives that foster bank competition, at least in the context of the banking reform experiments that were undertaken in Nigeria during 1993-2008.

Finally, in line with Allen and Gale (2004), our analysis shows the multiple dimension of the issue of regulation and its effect on competition, on productive efficiency and financial stability. We recommend that future research on banking reforms should carefully account for all the factors at work in order to enhance the empirical relevance for policy implications.

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Figure 1: The development of commercial banking sector, 1993-2007

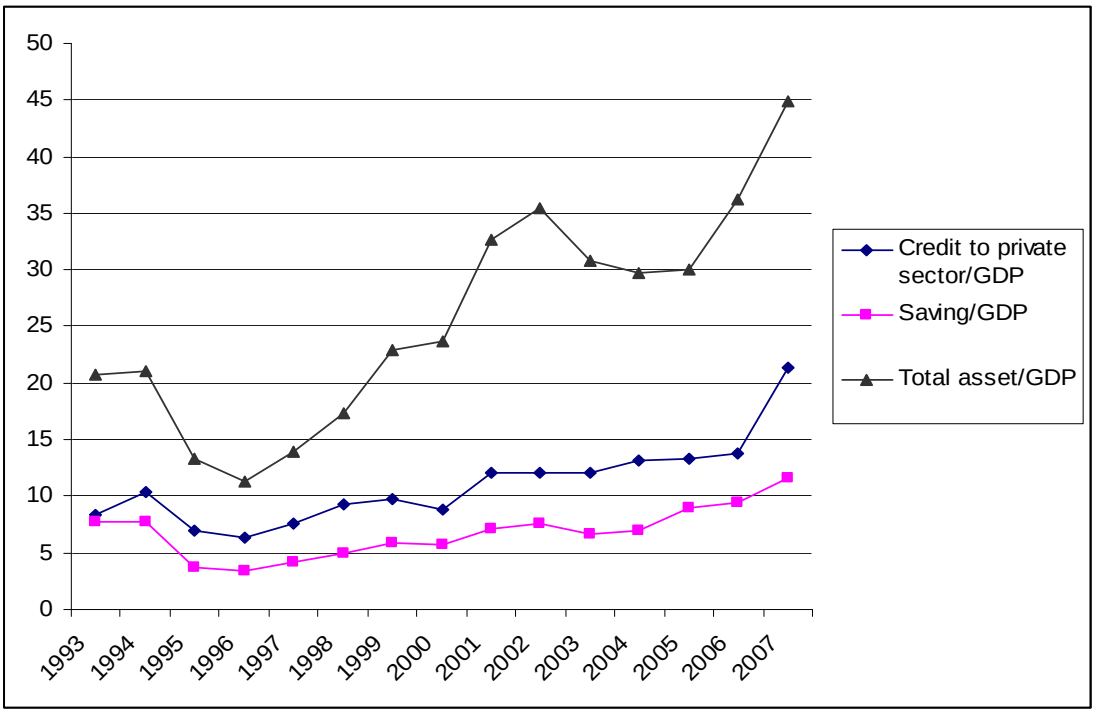

Table 1: Selected market structure and performance indicators, 1993 – 2007

Year	number of banks [b]	Number of branches [b]	CR3 [a]	Roe [a]	Net interest margin [a]	Overhead cost/total assets [a]
1993	66	2358	0.892	0.269	0.088	0.089
1994	65	2403	0.794	0.313	0.061	0.076
1995	64	2368	0.647	0.291	0.079	0.098
1996	64	2407	0.478	0.315	0.073	0.095
1997	64	2330	0.451	0.445	0.105	0.091
1998	51	2107	0.386	0.307	0.100	0.085
1999	57	2234	0.408	0.25	0.079	0.075
2000	90	2234	0.414	0.325	0.085	0.082
2001	90	3247	0.388	0.225	0.107	0.092
2002	90	3247	0.391	0.091	0.103	0.09
2003	90	3010	0.387	0.207	0.092	0.091
2004	89	3247	0.388	0.204	0.085	0.078
2005	25	3492	0.445	0.154	0.064	0.054
2006	25	3004	0.511	0.191	0.055	0.048
2007	24	3897	0.399	0.183	0.054	0.044

Data source: [a] collected from A New Database on Financial Development and Structure, World Bank.
[b] collect from CBN.

Table 2: Profile of the NPLs in Nigerian commercial banking, 1993-2007

Year	NPL ratio (%)	NPL	Total credit
1993	38.7	18597.67	48056
1994	38.1	35289.74	92624
1995	29.5	41638.07	141146
1996	32.7	55342.13	169242
1997	24.9	57419.4	230600
1998	20.3	55397.69	272895
1999	26.4	93213.38	353081
2000	21.5	109284.9	508302
2001	16.9	134551.7	796164
2002	21.3	203335.8	954628
2003	20.45	247451.7	1210033
2004	21.6	328156.3	1519242
2005	24.1	479866.2	1991146
2006	8.77	221380.8	2524297
2007	8.44	406258.4	4813488

Data source: Adam (2002), Onaolapo (2008) and CBN

Table 3: Risk-weighted capital adequacy, 2004-2007

	CRAR (%)	Qualify capital base	Risk-weighted assets
2004	14.17	351021	2477212
2005	17.86	554520	3104815
2006	22.6	1041000	4606195
2007	20.9	1711000	8186603

Data source: CBN

Table 4: input-output specification in Equation (1)

Inputs	Outputs
X1: Interest expense	Y1: Loans
X2: Non-interest expense	Y2: Other earning assets
X3: Financial capital	Y3: Deposits

Table 5: the definition of variables in Equation (2) –(4)

Variables	***Description***
Translog cost function (2)	
• Total non-interest expense (C_{it})	= total cost – total interest expense
• The quantity of loans (q_{it})	= The book value of loans
• Total loanable fund (d_{it})	= total deposits + total money market funding
• Total non-interest expense price (w_{it})	= total non-interest expense/(loans + total loanable fund)
Revenue equation (3)	
• Total interest income (R_{it})	= total interest income received
• Total interest expense (E_{it})	= total interest expenditure
• The ratio of total loans to total loanable fund (q_{it} / d_{it}))	= total loans/total loanable fund
The inverse demand equation (4)	
• Implicit interest rate of loans (p_{it})	= total interest income/total loans
• Real GDP growth rate (*gdp*)	= real GDP growth rate
• Size effect (*total assets*)	= total assets
• Capitalization (*cap*)	= financial capital/total assets

Table 6: The definition of variables in Equation (5)

Variables	***Description***
Dependent variable	
competition (θ_t)	The conjectural variations parameters derived from jointly estimation of Equation (2) – (4)
Explanatory variables	
• *Deinterest*	Set equal to 1 for 1997-2008, 0 otherwise
• *Bigbang*	Set equal to 1 for 2005-2008, 0 otherwise
• *Universal*	Set equal to 1 for 2001-2008, 0 otherwise
• CR3	Three-bank concentration ratio
• *Gdp*	Real GDP growth rate

Table 7: The definition of variables in bank productive efficiency and bank risk taking equation

Variables	***Description***
Dependent variable	
• Bank-specific productive efficiency	Derived from the first-stage using DEA
• Bank-specific credit risk	= loan loss provisions/total loans
Independent variable shared by both equations	
Industry wide variables: competition, reforms and economic condition	
• Competition	The conjectural variations parameters derived from jointly estimation of Equation (2) – (4)
• Reforms	A vector of three dummy variables: (1). deinterest: set equal to 1 for 1997-2008, 0 otherwise; (2). Universal: set equal to 1 for 2001-2008, 0 otherwise (3). Bigbang: set equal to 1 for 2005-2008, 0 otherwise
• Economic condition	Real GDP growth rate
bank-specific characteristics	
• Size effect	= total assets
• Capitalization	= financial capital/total assets
Independent variable specific for bank risk taking equation	
• The degree of specification	$SP = \sum_{i=1}^{2} S_i^{\,2}$, $S_i = y_i / \sum_{i=1}^{2} y_i$, y_1: interest-income; y_2 :non-interest income
• Net interest margin	= (total interest income-total interest expense)/(loans + other earning assets)
Independent variable specific for productive efficiency equation	
• Credit risk	= loan loss provisions/total loans

Table 8: Descriptive statistics of the variables

Variables	Obs	Mean	Std. Dev.	Min	Max	Median
Loans	630	29.442	148.741	0.001	1893.004	5.498
Other earning assets	630	64.601	431.621	0.118	7085.522	8.925
Deposits	630	49.278	172.682	0.014	2203.300	12.748
Interest expense	630	4.595	25.038	0.001	378.499	0.907
Non-interest expense	630	7.065	34.166	0.073	406.958	1.327
Financial capital	630	14.813	81.363	0.013	989.079	1.892
Loan loss provisions to total loan ratio	630	0.059	0.114	0.000	1.677	0.034
Capitalization	630	0.152	0.276	0.017	5.586	0.116
Net interest margin	630	0.076	0.053	-0.159	0.347	0.076
The degree of specification	630	0.598	0.096	0.500	0.980	0.568
Total loanable fund	630	49.241	173.147	0.014	2203.300	12.079
Non-interest expense price	630	0.088	0.077	0.005	1.688	0.080
Total interest income	630	11.024	63.619	0.001	880.380	2.080
Total assets	630	104.503	574.986	0.170	8354.947	17.200
Implicit interest rate on loans	630	0.477	0.562	0.002	8.582	0.370
CR3	16	0.487	0.155	0.386	0.892	0.412
Real GDP growth rate (%)	16	6.019	5.285	-0.307	21.180	5.356

Note: Data source: Bankscope and IMF International Financial Statistics Database.
Data, if not expressed in ratio, are measured in Naira mill and are deflated by GDP deflator using 2000 as the base year.

Table 9: DEA estimates of output-oriented productive efficiency, by year

Year	Mean	Std. Dev.
1993	0.371	0.262
1994	0.389	0.234
1995	0.396	0.210
1996	0.423	0.209
1997	0.536	0.222
1998	0.534	0.204
1999	0.518	0.229
2000	0.474	0.210
2001	0.552	0.222
2002	0.468	0.209
2003	0.500	0.197
2004	0.506	0.194
2005	0.607	0.254
2006	0.780	0.165
2007	0.845	0.170
2008	0.776	0.349
Average 1993-2008	0.542	0.221

Figure 2: Year by year pattern of productive efficiency, 1993-2008

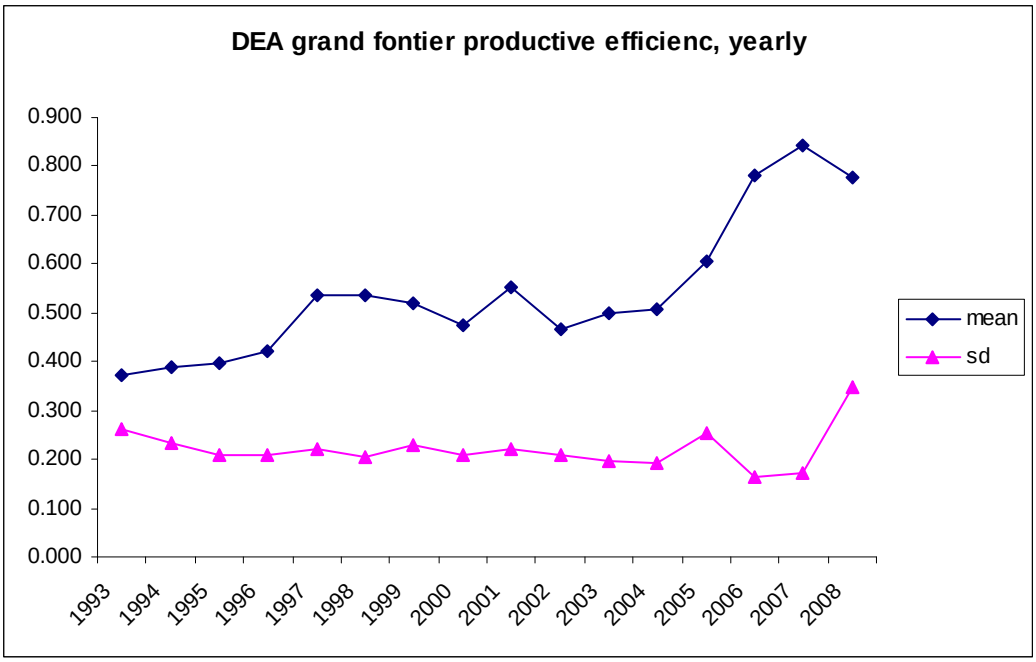

Figure 3: Estimated conjectural variations parameters, 1993-2008

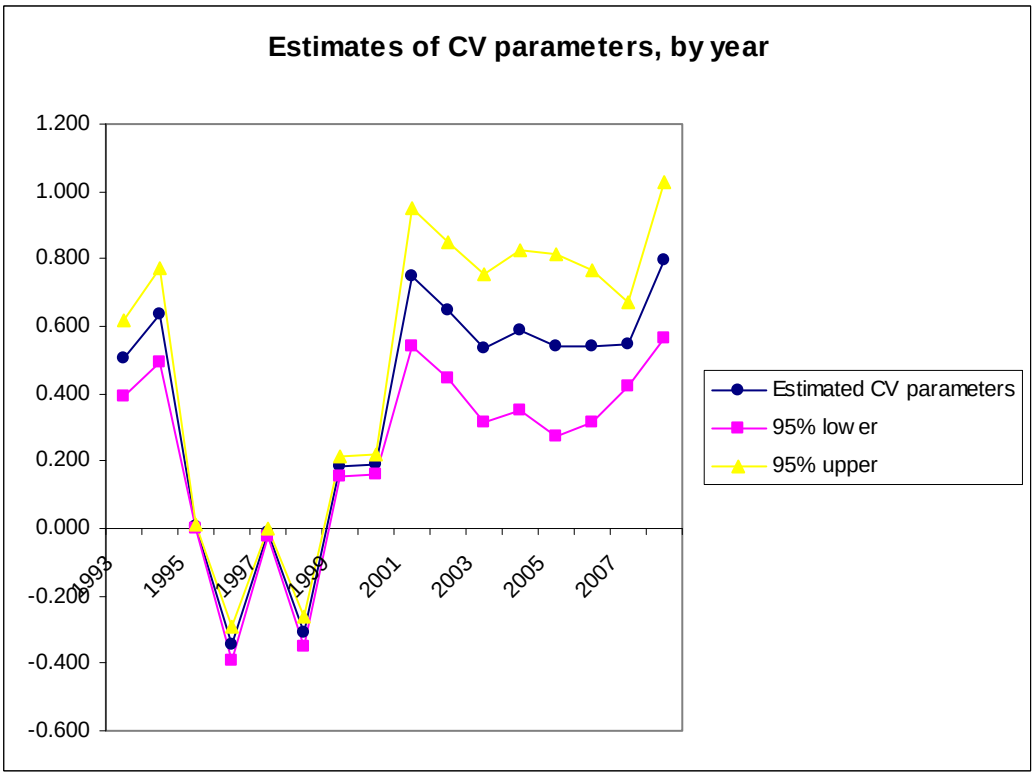

Table 10: Results of simultaneous estimation of Eqs, (2)-(4)

Parameters	Coef.	Robust Std.Err	P-value	95% lower	95% upper
b_0	2.883	0.002	0.000	2.880	2.886
b_1	0.345	0.009	0.000	0.328	0.362
b_2	0.133	0.005	0.000	0.124	0.142
b_3	0.648	0.010	0.000	0.629	0.667
b_4	0.119	0.002	0.000	0.116	0.122
b_8	-0.125	0.002	0.000	-0.130	-0.120
ω_0	0.414	0.076	0.000	0.264	0.564
θ 1993	0.506	0.057	0.000	0.394	0.618
θ 1994	0.634	0.071	0.000	0.494	0.774
θ 1995	0.006	0.004	0.102	-0.002	0.014
θ 1996	-0.344	0.026	0.000	-0.394	-0.294
θ 1997	-0.013	0.007	0.048	-0.026	0.000
θ 1998	-0.307	0.022	0.000	-0.350	-0.264
θ 1999	0.184	0.015	0.000	0.155	0.213
θ 2000	0.189	0.016	0.000	0.158	0.220
θ 2001	0.747	0.105	0.000	0.541	0.953
θ 2002	0.648	0.104	0.000	0.444	0.852
θ 2003	0.534	0.112	0.000	0.315	0.753
θ 2004	0.587	0.122	0.000	0.349	0.825
θ 2005	0.543	0.137	0.000	0.275	0.811
θ 2006	0.541	0.115	0.000	0.316	0.766
θ 2007	0.547	0.065	0.000	0.421	0.673
θ 2008	0.796	0.119	0.000	0.564	1.028
$1/\eta$ 93-94	-0.543	0.062	0.000	-0.664	-0.422
$1/\eta$ 95-96	-0.717	0.051	0.000	-0.818	-0.616
$1/\eta$ 97-98	-0.736	0.047	0.000	-0.828	-0.644
$1/\eta$ 99-00	-0.627	0.048	0.000	-0.722	-0.532
$1/\eta$ 01-02	-0.592	0.046	0.000	-0.683	-0.501
$1/\eta$ 03-04	-0.619	0.046	0.000	-0.709	-0.529
$1/\eta$ 05-06	-0.743	0.051	0.000	-0.842	-0.644
$1/\eta$ 07-08	-0.736	0.050	0.000	-0.834	-0.638
ρ_0	-1.236	0.138	0.000	-1.506	-0.966
ρ_1	0.007	0.004	0.084	-0.001	0.015
ρ_2	0.607	0.050	0.000	0.510	0.704
ρ_3	0.208	0.084	0.014	0.043	0.373
R-square for (2)					0.9993
R-square for (3)					0.9989
R-square for (4)					0.3861

Note: the standard error reported is White's (1980) heterogeneity adjusted.
Since linear homogeneity of degree one in input prices is imposed ex-ante estimation, the estimated coefficients of b4, b6, b7, and b9 are not reported.

Table 11: Effects on the degree of competition

	Coef.	Std. Err.	P value
Dinterest	0.429*	0.215	0.073
Bigbang	-0.117	0.165	0.493
Universal	0.641**	0.208	0.011
CR3	2.151***	0.589	0.004
Gdp	0.003	0.016	0.852
Constant	-1.317**	0.431	0.012
Prob> F(5, 10)	0.002		
R-squared	0.816		
Adj R-squared	0.725		
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	Prob > chi2 = 0.684		
Durbin's alternative test for autocorrelation	Prob > chi2 = 0.807		

Note: $\theta_t = \alpha_0 + \alpha_1 de\,\text{int}\,erest + \alpha_2 bigbang + \alpha_4 universal + \alpha_5 CR3 + \alpha_6 gdp$ is regressed via OLS. The number of observation is 16 (i.e. 1993-2008). The diagnostic test for heteroskedasticity and autocorrelation suggest the rejection of the null hypothesis.
*, **, ***, indicates significance at 10%, 5% and 1% levels respectively.

Table 12: Regression results of bank productive efficiency and bank-risk taking Equations

Dependent variable: bank risk taking (loan loss provision /total loans) [a]			
	Coef.	Robust Std. Err [b]	P>|z|
Deinterest [c]	-0.052***	0.016	0.001
Universal [c]	-0.038*	0.020	0.055
Bigbang [c]	0.068*	0.037	0.065
Conjectural variations (CV) parameters [d]	0.060**	0.027	0.028
Gdp	-0.000	0.001	0.830
Capitalization (financial capital/total assets)	-0.078***	0.013	0.000
Size (ln(total assets))	-0.003	0.006	0.646
Net interest margin	0.962***	0.210	0.000
The degree of specification	-0.133	0.100	0.184
Constant	0.432***	0.053	0.000
Sargan-Hansen statistic	0.432		
Dependent variable: bank productive efficiency [a]			
	Coef.	Std. Err.	P>|z|
Deinterest [c]	0.075***	0.018	0.000
Universal [c]	0.055*	0.029	0.057
Bigbang [c]	0.107***	0.026	0.000
Conjectural variations (CV) parameters [d]	-0.090***	0.028	0.001
Gdp	-0.005***	0.002	0.007
Risk (loan loss provision/total loans)	-0.203***	0.050	0.000
Capitalization (financial capital/total assets)	-0.088***	0.022	0.000
Size (ln(total assets))	0.086***	0.009	0.000
Constant	0.308***	0.035	0.000
Wald test of exogeneity	0.606		
Log likelihood	219.664		
Likelihood-ratio test of random Tobit V.s. pooled Tobit	0.000		

[a] The risk taking equation is estimated via random effect model and the productive efficiency model is estimated via random Tobit model. The two equation are estimated separately as the Wald test of exogeneity reject the endogeneity of risk taking in the productive efficiency model.

[b] Allowing for that the observations drawn from the same bank from different time periods are likely to be correlated, we use cluster corrected standard errors to account for clustering for the same bank.

[c] Bilateral dummy variables related to the policy actions

[d] Estimated conjectural variations parameters derived from the estimation of Eqs (2)-(4). A smaller value indicates a increase of the degree of competition.

*, **, and *** *: significant at 10%, 5% and 1% respectively

Table 13: Results of simultaneous estimation of bank risk taking and bank productive efficiency equations

Dependent variable: risk (loan loss provision /total loans) [a]			
	Coef.	Robust Std. Err.	P>|z|
Deinterest [c]	-0.053***	0.017	0.001
Universal [c]	-0.043**	0.020	0.035
Bigbang [c]	0.066**	0.033	0.044
Conjectural variations (CV) parameters [d]	0.062**	0.028	0.025
Gdp	-0.000	0.001	0.927
Capitalization (financial capital/total assets)	-0.074***	0.012	0.000
Size (ln(total assets))	-0.005	0.004	0.268
Net interest margin	0.934***	0.195	0.000
The degree of specification	-0.167*	0.097	0.086
Constant	0.461***	0.054	0.000
Dependent variable: productive efficiency [a]			
Deinterest [c]	0.072***	0.027	0.008
Universal [c]	0.042	0.028	0.142
Bigbang [c]	0.094***	0.030	0.002
Conjectural variations (CV) parameters [d]	-0.086**	0.036	0.017
Gdp	-0.004***	0.001	0.000
Risk (loan loss provision/total loans)	-0.396	0.301	0.188
Capitalization (financial capital/total assets)	-0.117***	0.041	0.005
Size (ln(total assets))	0.100***	0.008	0.000
Constant	0.343***	0.123	0.005

Note: the two equations are simultaneously estimated using cmp comment in STATA in which the productive efficiency model is considered as a censored Tobit. The standard error is robust to both heteroskedasticity and serial correlation for the same bank. *, **, and *** *: significant at 10%, 5% and 1% respectively

Figure 4: The interrelationship among deregulation of interest rate, competition, risk taking and productive efficiency

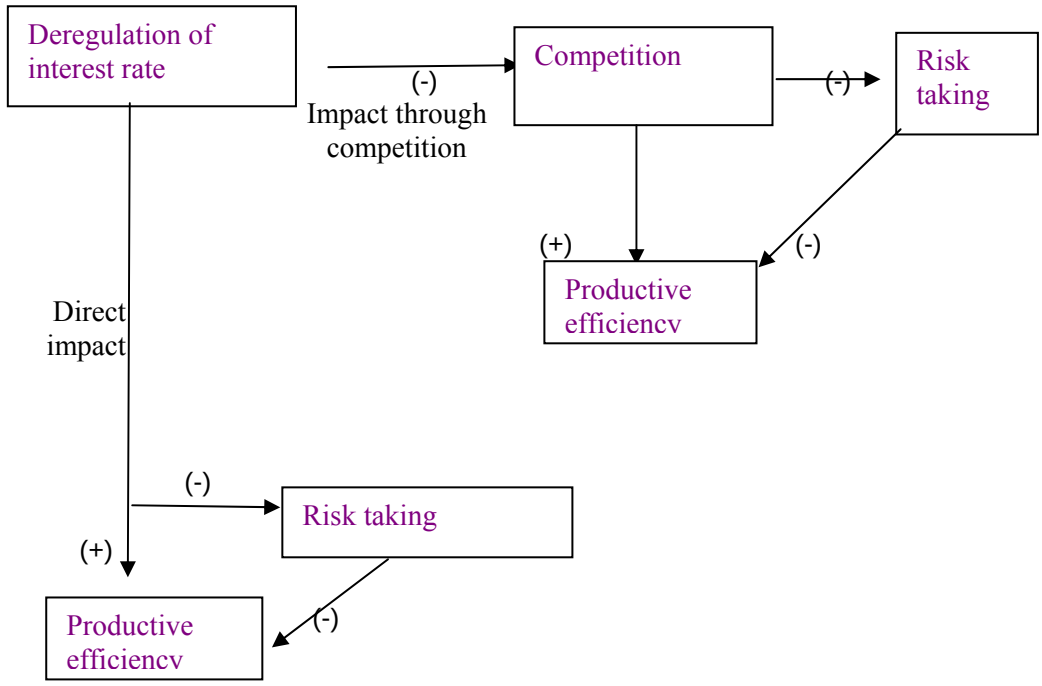

Figure 5: The interrelationship among adaptation of universal banking, competition, risk taking and productive efficiency

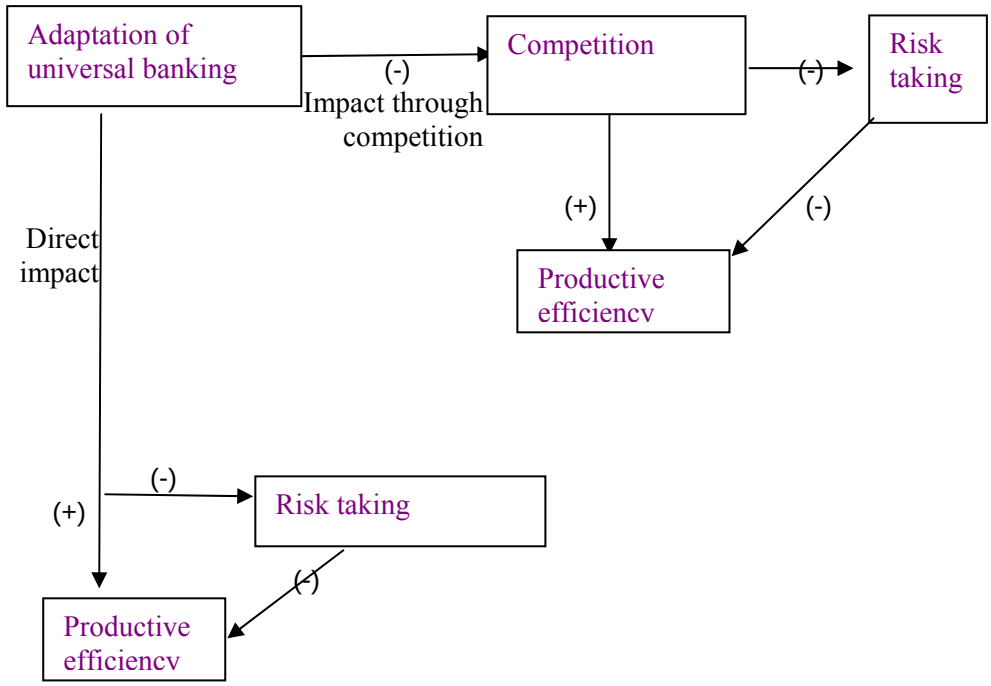

Figure 6: The interrelationship among the "big bang", competition, risk taking and productive efficiency