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Abstract

Minimum capital requirements are often implemented under the notion that increased capital improves bank safety and stability. However, an unintended consequence of higher capital requirements could arise if increasing capital induces banks to invest in riskier assets. Several researchers have examined this relationship between bank capital and risk among conventional banks, and interest around this topic has intensified since the 2007-2008 financial crisis. However, the findings are rather mixed. Moreover, very few studies have focused on Islamic banks, which differ greatly from their conventional counterpart's due to their need to be Shariah-compliant. In this paper a sample of 22 Islamic banks is analyzed over a seven year period from 2007-2013. The empirical approach is fully parametric and Bayesian utilizing techniques developed by Kessler and Munkin (2015) and building on previous banking research by Shrives and Dahl (1992) and Jacques and Nigro (1997). Some evidence is found suggesting that increases in total capital positively affect the levels of asset risks among Islamic banks.

JEL Codes: C11, C32, G21, G28.
Keywords: Islamic Banks; Asset Risks and Total Capital; Panel Data with Endogenous Treatment; MCMC.

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1 Introduction

Banks maintain a minimum capital requirement because it provides a buffer against negative shocks and acts as insurance against the risk of insolvency. However, the financial crisis of 2007–2008 exposed the fact that many of the world's largest banks held insufficient capital and were not able to cover all of their losses. This apparent mismatch between the 'minimum regulatory capital requirement' and its resulting impact on 'bank solvency' has promoted an intense debate among policymakers, bankers, and academics on the question: "how much capital should banks hold in order to cover their potential losses?" In most countries, the minimum capital requirement is 8% of risk-weighted assets, and is expected to increase to 10.5% under the Basel III accord (Basel Committee on Banking Supervision, 2010).[1] As of today, the debate is still active on how much capital banks should hold.

Capital requirement can be a double-edged sword. While increased capital enhances bank safety, it might induce a bank to assume greater risks. If the latter effect outweighs the former, even well-capitalized banks may face the risk of insolvency. There is a large literature in financial economics studying the relationship between risk-taking and the capitalization of banks. The theoretical literature suggests that risk and capital decisions are simultaneously determined and interrelated.[2] For instance, Gennotte and Pyle (1991) show that an increase in the capital requirement may induce a bank to simultaneously decrease the size of its portfolio and increase its asset risk in hopes of earning higher returns. Diamond and Rajan (2000) offer a model that simultaneously rationalizes the asset and the liability sides of banks. They show that while greater capital reduces the probability of financial distress, it also reduces liquidity creation. The empirical literature focuses on testing various predictions of the banking theory with data primarily from the United States and Europe. Conversely, in this paper we examine the financial decisions made by Islamic banks and whether they differ from their conventional counterparts. A brief overview of the empirical studies is provided in the next section.

The minimum capital requirements recommended by the Basel Committee apply for conventional banks and do not make any allowance for Islamic banks. However, the Islamic Financial Services Board (IFSB), the Islamic equivalent of the Basel Committee, is responsible for setting regulatory standards that are in par with Basel standards for conventional banks. The

[1] Table 1 provides an overview of the capital requirements under Basel II and Basel III.

[2] The literature is vast and comes to contradicting results. For a survey of the theoretical and empirical literature, see Stolz (2007).

Basel rules on 'capital adequacy ratio' (CAR) have become the cornerstone of safety in modern banking. A bank's CAR is computed by dividing the total capital by total risk-weighted assets. However, unlike their conventional counterparts, defining the denominator (i.e., risk-weighted assets) of the CAR for Islamic banks is not straightforward.[3] This is because of the unique risk profile Islamic banks have with respect to their products and services, which need to be *Shariah*-compliant. For instance, in the case of financing projects using the profit-sharing investment accounts (PSIAs) contracts (e.g., the *Mudharabah* and *Wakala* investment accounts), Islamic banks are reluctant to share losses with their customers because of the fear that disappointed customers might move their funds elsewhere. Thus, although PSIAs provide a buffer in theory, in practice Islamic banks are very sensitive to displaced commercial risk. Furthermore, the higher the level of PSIAs in the capital structure is, the higher are the agency (monitoring) costs faced by Islamic banks. All else equal, higher agency costs will reduce the bank's expected return on assets, which in turn might induce them to increase the riskiness of their portfolios after the imposition of capital requirements (Besanko and Kanatas, 1996; Muljawan et al., 2002).

Islamic banks also face higher liquidity risk than conventional banks because of the dominance of asset-based financing and lack of short-term traditional instruments like repurchase agreements and certificates of deposit. The lumpy nature of asset-based financing makes it difficult for Islamic banks to exit from these transactions in times of emergency. Indeed, prior to the global financial crisis nearly half of Islamic banks' assets were backed or linked to real estate, and were therefore slashed following the burst of the real estate bubble in the Gulf Cooperation Council (GCC) countries (Al Monayea, 2012). Furthermore, although market, credit, and operational risks are easy to measure according to the specific rules of Pillar I of the Basel II/III, other aspects of risks that are also important to Islamic banks, such as liquidity, concentration of funding, and fiduciary risks are examined in a more subjective manner under Pillar II (Al Monayea, 2012). These risks, which are uniquely important for Islamic banks, make it a challenging task to calculate risk-weighted assets and the resulting capital adequacy ratios cited in the rules of Basel II/III (Ariss and Sarieddine, 2007).

Against the backdrop of Islamic banks' capital buffers to unique risks, we examine the effect of changes in total capital on asset risks for 22 Islamic banks over the period of 2007 through

[3] A recent survey of Islamic bankers suggests that a number of different practices are used to adjust the denominator of the CAR formula (Song and Oosthuizen, 2014).

2013. The relationship between bank capital and risk has gathered pace since the 2007–2008 financial crisis, and a debate has developed over how to prevent a reprise of the recent financial crisis.[4] However, compared to conventional banks, existing evidence on the relationship between capital and risk among Islamic banks is lacking or, at best, slowly emerging. There is, therefore, a need for empirical analysis of the capital-risk relationship to fill the void in the Islamic banking literature.

The empirical tests of bank capital and bank risk, however, are marred by issues of simultaneity biases (i.e., endogeneity) because the level of capital and the amount of risk that a bank can undertake are interdependent (see, e.g., Gennotte and Pyle, 1991; Diamond and Rajan, 2000). In addition, risk and capital are functionally related to each other through the presence of risk-weighted assets in both definitions. To account for the endogeneity between risk and capital, most existing studies have considered traditional simultaneous equation methods such as two- or three-stage least squares (2SLS/3SLS) estimators.

Our empirical model builds on the approach employed by Shrives and Dahl (1992) and Jacques and Nigro (1997) who utilize a simultaneous equation framework in order to study the effects of new bank regulations on commercial banks in developed countries. However, our paper differs from earlier studies in that we follow the method proposed by Kessler and Munkin (2015), who developed an endogenous treatment estimation procedure for a panel data simultaneous equation model. As will be elaborated below, this procedure has a number of advantages over the 2SLS/3SLS estimators. Furthermore, we rely on a Bayesian method to estimate the model's parameters, thereby allowing for model parameters to assume random distributions. Banks differ in preferences for risk, uncertainty, and capitalization, which might eventually result in a systematic variation in risk parameters across banks (Firestone and Rezende, 2013). However, to date, there has been insufficient attention to potential distributional variation of parameters in the literature on bank capital and risk. Accounting for this is important in making empirical claims and specific suggestions.

The rest of the paper is organized as follows. Section 2 provides a brief overview of the theoretical and empirical literature, with particular attention to empirical studies on the risk-capital relationship under Islamic banking. Section 3 discusses model specification and outlines its estimation. Section 4 presents the empirical results and Section 5 concludes the paper. Steps of the Bayesian Markov Chain Monte Carlo (MCMC) algorithm are given in Appendix 1

[4] See the collection of articles in Danielsson (2015) for a glimpse of this debate.

and a numerical example where the data generating process is known and consistent with the introduced model is presented in Appendix 2.

2 Related Literature

A large body of theoretical literature on how banks adjust their holdings after an increase in the minimum regulatory capital requirements sends mixed signals, predicting that bank capital and risk are both negatively and positively related. For example, Koehn and Santomero (1980) predict a higher risk of failure for the banking industry after a forced increase in capital, because banks will reduce their risk exposure and therefore lower the expected returns to their portfolio. Similarly, Furlong and Keeley (1989) argue that stronger capital requirements actually reduce the gains of holding riskier assets, and therefore dissuade banks from increasing the riskiness of their asset portfolios. Conversely, Milne and Whalley (2001) show that following an increase in regulatory capital, banks first increase capital and decrease asset risk but as soon as they obtain a desired capital buffer, both capital and risk may become positively related.

A few studies have theoretically analyzed the risk-capital relationship for Islamic banks. Al Deehani et al. (1999) demonstrate that because Islamic banks rely extensively on the use of investment accounts for financing, they can increase both their market value and portfolio returns without increasing the bank's risk. This contradicts Modigliani-Miller's irrelevance theorem, which states that the market value of a firm is unaffected by how the firm is financed. They also find support for their theory in a sample of 12 international Islamic banks. Muljawan et al. (2002) argue that the Islamic banks should maintain adequate capital buffers to cushion against the risk emanating from the inherent agency problems associated with PSIA contracts. However, Toumi et al. (2012) argue that agency conflicts are far less important for Islamic banks than for their conventional counterparts, since speculation and excessive risk taking are prohibited in Islamic finance.

An early empirical contribution testing the hypothesis of whether banks increase or decrease asset risk when faced with higher capital requirements is in Shrieves and Dahl (1992). They show that risk exposure and capital levels are simultaneously related, and that the majority of banks mitigate the effects of increases in capital levels by increasing asset risk posture, and vice versa. Subsequently, Jacques and Nigro (1997) modified the framework used in Shrieves and Dahl (1992) by employing a three-stage least squares model in order to recognize the relationship between bank capital, portfolio risk, and the risk-based capital standards. In contrast to Shrieves and Dahl (1992), their results suggest that the risk-based capital standards were effective in increasing capital ratios and reducing portfolio risk in conventional commercial banks. These two studies used data on US commercial banks for their empirical analysis. Rime (2001) provided similar evidence for Switzerland, indicating that regulatory requirements led banks to increase their levels of capital but did not affect their level of risk.

Several studies also document an inverse relationship between bank capital and risk (e.g., Das and Ghosh, 2004; Stolz, 2007; Ahmad et al., 2009). For example, based on supervisory micro data for German savings and cooperative banks, Stolz (2007) finds that for banks with low capital buffers, adjustments in capital and risk are negatively related. Whereas, capital and risk tend to be positively related for banks with high capital buffers.

Fast forward to recent years, the financial crisis of 2007–08 has brought renewed interest to the study of risk and capital among commercials banks. Kochubey and Kowalczyk (2014) analyze the simultaneous relationship between capital, risk, and liquidity decisions among US commercial banks from 2001 to 2009. They find that during the pre-crisis period short-term adjustments in bank capital inversely affect short-term adjustments in bank risk and vice versa. However, during the financial crisis lower risk implies higher capital, but higher capital induces more risk taking. Tanda (2015) provides a review of the main empirical research on the impact of regulation on capital and risk.

All of the aforementioned papers concern conventional commercial banks, which are based in developed countries. There are only a few studies that focus on Islamic banks. Hussain and Hassan (2005) found that, similar to conventional banks, when capital regulations are imposed undercapitalized Islamic banks are forced to increase capital. However, they did not find any evidence of Islamic banks increasing risk in their asset portfolio, even though they adjusted to higher capital requirements. Ghosh (2014) finds that in response to regulatory pressure Islamic banks increase their capital more than conventional banks, and also increased their risk as their capital rose.

Lately, a few studies have analyzed the effects of the financial crisis on the relative performance of Islamic banks. For example, Bourkhis and Nabi (2013) found that the global financial crisis affected the Islamic banks no differently than their conventional counterparts. Their results echo the findings of a famous study by Beck et al. (2013), who also found no noticeable difference between Islamic and conventional banks' profitability and stability (z-scores) in normal times, during local crises, or during the global financial crisis.[5] Although distinguished, these papers did not address the question of how the global financial crisis has impacted the relationship between bank capital and asset risk in the context of Islamic banks.

3 Model

This section opens with a description of the simultaneous equations model developed by Shrieves and Dahl (1992) and later modified by Jacques and Nigro (1997). We further modify their model in order to address the econometrics challenges associated with the main economic question under consideration. The original model employs observed changes in the measures of bank capital and risk levels, defined respectively as capital adequacy ratios (CAR) and the credit risk ratio (RISK) using the following formulas:

$$\begin{aligned} CAR &= \frac{TC}{RWA} \\ RISK &= \frac{RWA}{TA} \end{aligned} \tag{1}$$

where TC measures total capital and is comprised primarily of Tier 1 capital,[6] TA measures total bank assets, and RWA measures risk-weighted assets.[7] Finally, risk is measured as the ratio of risk-weighted assets to total assets.

In any period, banks may not be able to adjust their desired capital and risk levels instantaneously and therefore the observed levels of these dependent variables may deviate from the target levels which are not observable, but are assumed to depend upon some set of observable variables. This gives rise to a model in which simultaneity of the dependent variables is coupled with exogenous covariates. The model is specified in terms of changes over time as

$$\Delta CAR_{it} = \rho_1 \Delta RISK_{it} + X_{it}\beta_1 + Z_{1it}\gamma_1 + \varepsilon_{1it}, \tag{2}$$

$$\Delta RISK_{it} = \rho_2 \Delta CAR_{it} + X_{it}\beta_2 + Z_{2it}\gamma_2 + \varepsilon_{2it}, \tag{3}$$

[5] It should be noted here that their study found some significant difference between the two banking models. See Beck et al. (2013) for further details.

[6] Due to the prohibition of interest payments, only a small part of Tier II capital (e.g. impairment and deductible allowance) is used by Islamic banks. As a result, Islamic banks already meet the "enhanced quality of capital" provision under Basel III.

[7] Banks calculate their risk-weighted assets by first assigning their assets to the appropriate risk-weight category (ranging from 0% to 100% for most assets, but up to 200% for some mortgage exposures and 600% for certain equity exposures), and then summing the dollar value of each asset multiplied by its corresponding risk weight (Jacques and Nigro, 1997; Federal Deposit Insurance Corporation, 2012).

where

$$\Delta CAR_{it} = CAR_{it} - CAR_{it-1},$$
$$\Delta RISK_{it} = RISK_{it} - RISK_{it-1},$$

and where X_{it} is a set of exogenous variables, Z_{1it} and Z_{2it} are exclusion restrictions which include the lagged values CAR_{it-1} and $RISK_{it-1}$ respectively, and ε_{1it} and ε_{2it} are the idiosyncratic error terms. Note, that these equations do not include individual specific effects as defined by Jacques and Nigro (1997). The underlying assumption is that this model is linear and the individual specific effects get eliminated by taking the first differences. This model is not robust to misspecification of linearity in which case controlling for individual specific effects is still necessary even for the differenced model.

Our modification of this model is partially driven by the following concerns:

1. The two dependent variables as defined by (1) are not only related, but they are functionally dependent of one another through the presence of RWA. In a statistical sense, this might be an additional or even the only reason for CAR and $RISK$ to simultaneously affect each other. Therefore, the two stage lease squares (2SLS) and the three stage least squares (3SLS) methods are utilized in Shrieves and Dahl (1992) and Jacques and Nigro (1997) to establish a linear relationship between two inversely related variables where the linear relationship might not even exist.

2. The way these two dependent variables, CAR and $RISK$, are defined makes it difficult if not impossible to identify a proper causal relationship between total capital and asset risks. For example, a bank under the regulation constraint can improve its capital ratio by, say, moving its assets from safer long term Treasury bonds to short term higher risk commercial loans with higher potential returns. Such a substitution would increase asset risks while its required capital level would decrease, which may result in a negative correlation between changes in capital and changes in risk. However, this correlation is a result of the shifts in the structure of bank assets, and would not mean that in general increasing capital would lead to lower risks.

3. Finally, the 2SLS and 3SLS estimation procedures rely on proper exclusion restrictions. However, since the dependent variables are related through RWA it is difficult to defend

any potential instrument that would affect the measure of risk but would not affect the capital adequacy ratio since RWA enters into both definitions. Therefore, identification would rely on the lagged dependent variables as the instruments which would not be valid in the first difference model specification where variables ΔCAR_{it} and $\Delta RISK_{it}$ technically depend on the lagged variables CAR_{it-1} and $RISK_{it-1}$.

The objective of our study is to identify the treatment effect of total capital on the risks of bank assets. Therefore, we propose two alternative measures of total capital and risk which, as we argue, are more appropriate for our analysis:

$$\begin{aligned} TcTa &= \frac{TC}{TA} \\ RwaTa &= \frac{RWA}{TA} \end{aligned}$$

Instead of a simultaneous model in which both dependent variables affect each other we specify an endogenous treatment model to study the effect of total capital on the levels of risks of bank assets. After the financial crisis Islamic banks in our data set enjoyed unusually large increases in the levels of total assets and total capital. Our assumption is that a great share of those increases are exogenously determined by global factors rather than affected by endogenous determinants at the bank level. Therefore, the specified model is

$$\begin{aligned} y_{1it} &= \rho_1 y_{2it} + X_{it}\beta_1 + Z_{1it}\gamma_1 + \alpha_{1i} + \varepsilon_{1it}, && (4) \\ y_{2it} &= X_{it}\beta_2 + Z_{2it}\gamma_2 + \alpha_{2i} + \varepsilon_{2it}, && (5) \\ i &= 1, ...N, \ t = 1, ..., T. \end{aligned}$$

where y_{1it} is the dependent variable $RwaTa_{it}$, and y_{2it} is the potentially endogenous treatment variable $TcTa_{it}$, X_{it} is a set of exogenous variables which are the same for both equations, Z_{1it} and Z_{2it} are exclusion restrictions which include $RwaTa_{it-1}$ and $TcTa_{it-1}$ respectively, and α_{1i} and α_{2i} are the individual specific random effects which are distributed normally as $\alpha_{1i} \overset{i.i.d.}{\sim} N\left(0, \sigma^2_{\alpha_1}\right)$ and $\alpha_{2i} \overset{i.i.d.}{\sim} N\left(0, \sigma^2_{\alpha_2}\right)$. Finally

$$(\varepsilon_{1it}, \varepsilon_{2it})' \overset{i.i.d.}{\sim} N\left((0,0)', \sum\right),$$

where

$$\sum = \begin{pmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{pmatrix}.$$

The correlation parameter σ_{12} allows for potential endogeneity of the treatment variable. To allow for greater flexibility and robustness to model misspecification we include the individual specific random effects. Instead of using changes in the dependent variables as in (2) and (3) we use the actual levels. Without loss of generality we can use the level variables in our model, provided that the lagged variables are included on the right hand sides of equations (4) and (5).

Our estimation approach is fully parametric and Bayesian, and we use MCMC methods, specifically the Gibbs sampler, to estimate the posterior distribution of the model parameters (see Geman and Geman, 1984).

In order to simplify the MCMC algorithm we decompose the joint bivariate normal distribution of $(\varepsilon_{1it}, \varepsilon_{2it})$ as the conditional distribution $\varepsilon_{1it}|\varepsilon_{2it} \overset{i.i.d.}{\sim} N(\delta_{12}\varepsilon_{2it}, \delta_1)$ and the marginal distribution $\varepsilon_{2it} \overset{i.i.d.}{\sim} N(0, \delta_2)$ where

$$\begin{aligned} \delta_1 &= \sigma_1^2 - \frac{\sigma_{12}^2}{\sigma_2^2}, \\ \delta_2 &= \sigma_2^2, \\ \delta_{12} &= \frac{\sigma_{12}}{\sigma_2^2}. \end{aligned}$$

There is a one-to-one correspondence between the set of parameters $(\sigma_1^2, \sigma_{12}, \sigma_2^2)$ and $(\delta_1, \delta_{12}, \delta_2)$.

Further we divide all of the parameters into the following blocks

$$\begin{aligned} \theta_1 &= [\rho_1, \beta_1, \gamma_1, \delta_{12}]; \\ \theta_2 &= [\rho_2, \beta_2, \gamma_2]; \end{aligned}$$

and

$$\sigma_{\alpha_1}^2, \sigma_{\alpha_2}^2, \delta_1, \delta_2.$$

The corresponding data are denoted as

$$\begin{aligned} W_{1it} &= [y_{2it}, X_{it}, Z_{1it}, \varepsilon_{2it}]; \\ W_{2it} &= [y_{1it}, X_{it}, Z_{2it}], \end{aligned}$$

and are assigned the following conjugate priors:

$$
\begin{aligned}
\theta_1 &\sim \mathbf{N}\left(\underline{\theta}_1, \underline{\mathbf{H}}_1^{-1}\right); \\
\theta_2 &\sim \mathbf{N}\left(\underline{\theta}_2, \underline{\mathbf{H}}_2^{-1}\right); \\
\delta_{12} &\sim N(\underline{\delta}_{12}, \underline{H}_{\delta_{12}}^{-1}) \\
\sigma_{\alpha_1}^2 &\sim IG(a_{\alpha_1}, b_{\alpha_1}); \\
\sigma_{\alpha_2}^2 &\sim IG(a_{\alpha_2}, b_{\alpha_2}); \\
\delta_1 &\sim IG\left(a_{\delta_1}, b_{\delta_1}\right); \\
\delta_2 &\sim IG\left(a_{\delta_2}, b_{\delta_2}\right).
\end{aligned}
$$

Then the full posterior density can be written as a product of the likelihood function

$$
\begin{aligned}
&\prod_{i=1}^{N}\prod_{t=1}^{T}\frac{1}{\sqrt{2\pi}|\delta_1|^{1/2}}\exp\left[-.5\delta_1^{-1}(y_{1it} - W_{1it}\theta_1 - \alpha_{1i} - \delta_{12}\left(y_{2it} - W_{2it}\theta_2 - \alpha_{2i}\right))^2\right] \times \\
&\prod_{i=1}^{N}\prod_{t=1}^{T}\frac{1}{\sqrt{2\pi}|\delta_2|^{1/2}}\exp\left[-.5\delta_2^{-1}(y_{2it} - W_{2it}\theta_2 - \alpha_{2i})^2\right] \times \\
&\prod_{i=1}^{N}\frac{1}{\sqrt{2\pi}\sigma_{\alpha_1}}\exp[-.5\alpha_{1i}'\sigma_{\alpha_1}^{-2}\alpha_{1i}] \times \prod_{i=1}^{N}\frac{1}{\sqrt{2\pi}\sigma_{\alpha_2}}\exp[-.5\alpha_{2i}'\sigma_{\alpha_2}^{-2}\alpha_{2i}]
\end{aligned}
$$

and the prior distributions for all of the parameters outlined above (i.e., $\theta_1, \theta_2, \sigma_{\alpha_1}^2, \sigma_{\alpha_2}^2, \delta_1, \delta_2$). The steps of the MCMC procedure are derived as a combination of the Gibbs sampler with data augmentation (Tanner and Wong, 1987), and are outlined in Appendix 1. A Monte Carlo simulation, showing that the proposed MCMC algorithm produces reliable estimates is presented in Appendix 2.

4 Application

A data set for 22 Islamic banks was derived from the Bankscope Data Base for the period from 2007 to 2013. Since we use lagged variables the actual number of observations for our analysis is reduced by one year for each bank which totals to 22 times 6 or 132 observations. With only 132 observations, the fixed effects model could potentially suffer from the problem of having to estimate too many parameters most of which would be nuisance fixed effects parameters. Therefore, our choice is the random effects model. We estimate the endogenous treatment random effects panel data model for the endogenous treatment variable $TcTa$, which is defined as the ratio of total capital (Tier 1 and Tier 2) over total assets, and the dependent variable $RwaTa$, which is defined as the ratio of risk-weighted assets over total assets. More specifically the model is

$$\begin{aligned} RwaTa_{it} &= \rho_1 TcTa_{it} + X_{it}\beta_1 + Z_{1it}\gamma_1 + \alpha_{1i} + \varepsilon_{1it}, && (6) \\ TcTa_{it} &= X_{it}\beta_2 + Z_{2it}\gamma_2 + \alpha_{2i} + \varepsilon_{2it}. && (7) \end{aligned}$$

The set of exogenous variables X_{it} is the same for both equations. It includes the ratio of total equity to total assets $TeTa_{it}$ and the ratio of bank loans to total assets $LoanTa_{it}$.

Variables Z_{1it} and Z_{2it} are the exclusion restrictions including $RwaTa_{it-1}$ and $TcTa_{it-1}$ respectively. Additionally Z_{1it} includes the lagged ratio of nonperforming loans (i.e. the total amount of loans in default) to total asset $NonTa_{it-1}$. Variable Z_{2it} also includes the bank's operating income which is defined as the lagged average return on assets $ROAA_{it-1}$. These two variables $NonTa_{it-1}$ and $ROAA_{it-1}$ have been previously used as exclusion restrictions by other studies including Zhang et al. (2008). Even though the validity of these instruments can be questioned we follow the existing literature. Another common variable to include is the natural log of total assets, however, in the case of our model specification the endogenous variables are already normalized by TA. The means and standard deviation of the variables used in the analysis are given in Table 2. The summary statistics are given for the entire time period and for each year. It can be noticed that total assets, total capital, and risk-weighted assets display unusually high increases from 2009 to 2010. We argue that this could be reflection of a substitution effect with some customers potentially moving their accounts and deposits to Islamic banks after the 2007–2008 global financial crisis.

Random variables α_{1i} and α_{2i}, the individual specific random effects, are assumed to be normally distributed as $\alpha_{1i} \overset{i.i.d.}{\sim} N\left(0, \sigma^2_{\alpha_1}\right)$ and $\alpha_{2i} \overset{i.i.d.}{\sim} N\left(0, \sigma^2_{\alpha_2}\right)$. In the specification of the random effects model the random effects are not allowed to be correlated with the regressors but in practice they could be. Therefore, we have tried alternative model specifications including a Chamberlain adjustment model, whereby the relationship between the random effects and explanatory variables are formalized through a distributional assumption. However, we find that this adjustment would not lead to efficiency gains. In addition, the Chamberlain's adjustment does not produce any evidence of the random effects being correlated with the regressors (the results are available upon request). Therefore, we concentrate our analysis on the more straightforward random effects model specification.

We choose proper priors for all parameters and, in fact, very tight priors for the variance parameters as it is known that assigning loose priors to the covariance parameters of the random effects panel data could result in an improper posterior:

$$\begin{aligned}
\theta_1 &\sim \mathbf{N}(0, \mathbf{10I}); \\
\theta_2 &\sim \mathbf{N}(0, \mathbf{10I}); \\
\delta_{12} &\sim \mathbf{N}(0, 10); \\
\sigma^2_{\alpha_1} &\sim IG(3, 50); \\
\sigma^2_{\alpha_2} &\sim IG(3, 50); \\
\delta_1 &\sim IG(3, 50); \\
\delta_2 &\sim IG(3, 50).
\end{aligned}$$

The posterior means and standard deviations of the parameters of the estimated model are reported in Table 3. The results are based on Markov chains run for 20,000 replications after discarding the first 5,000 draws of the burn-in-phase. The chains display very good convergence properties.

It is interesting to note that the effects of the year dummies are insignificant. This is surprising since the dependent variables in the summary statistics display a changing dynamic especially when comparing values before and after the financial crisis of 2007–2008. However, the summary statistics only show the unconditional averages. When the dependent variables are modeled conditional on the independent variables using the regression model, the time effects are no longer present. In addition, the results show no evidence that the ratio of total capital to total assets ($TcTa$) is endogenous to risk, as measured by $RwaTa$, as the posterior mean of σ_{12} is centered very close to zero, at the estimated posterior mean of 0.00064 with a posterior standard deviation of 0.00096. This could also be the result of our exclusion restrictions being weak. The exclusion restrictions $NonTa$ and $ROAA$ do not have strong effects on $RwaTa$ or $TcTa$. However, the effect of $RwaTa_{t-1}$ on $RwaTa_t$ is very strong and significant. This implies serial correlation in our risk variable $RwaTa$, which is not surprising since it should take time for a bank to change the risk composition of its held assets. We also find that the variance for the random effects variables (i.e. $\sigma_{\alpha 1}$ and $\sigma_{\alpha 2}$) are small. As mentioned before we have also estimated a model with Chamberlain's adjustment which could potentially reveal that the random effects are correlated with some regressors. However, we find no evidence of that being the case. Overall our estimated results suggest that there are no unobserved factors driving total capital that would also affect risk, and only factors exogenous to risk impacted the large increases in the levels of total capital. However, this statement is only conditional on the validity of our instruments.

The effect of $TcTa$ on $RwaTa$ is centered at 0.165 with the standard deviation of 0.093 which suggests that it is not very strong with the mean being separated from zero by less than two standard deviations. However, Figure 1 shows that the posterior distribution of this parameter is not symmetric and calculating the p-value or the probability that the estimated coefficient is greater than zero would give us a better idea with regards to the effect strength of $TcTa$ on $RwaTa$. The calculated probabilities are given in the third column of Table 3 and for the effect of $TcTa$ on $RwaTa$ it is equal to 0.955 which corresponds to a p-value of 0.045. This is a significant effect at a 5% level of significance. The posterior distribution of this parameter can also be interpreted as follows: even though the average effect of $TcTa$ on $RwaTa$ over all Islamic banks in the data set is not separated from zero by more than two standard deviations, there is a considerable number of banks in the right tail of the support of the distribution for which the effect is clearly positive. This means that some Islamic banks in the data set did adjust their portfolio towards more risky assets with potentially higher returns. This is in line with the findings of Ghosh (2014) and Karim et al. (2014), who find higher exposure to risks by Islamic banks in response to an increase in capital requirements. From a policy perspective, such risk-taking need not be harmful for Islamic banks' capital position given their PSIA feature, although PSIAs tend to be more volatile than conventional products. However, compared to conventional markets, Islamic securities markets are much younger, shallower and less developed. As a result, Sharia-compliant high-quality liquid assets (HQLAs) are short in supply, thereby limiting opportunities for diversification for Islamic banks. In fact, this is a long-standing problem in the Islamic finance industry – see Vizcaino (2014) for further details.

The ratio of total equity to total asset (capital buffer, $TeTa$) has positive impacts on both $RwaTa$ and $TcTa$, though this effect is only statistically strong for the $TcTa$ equation with a p-value of 0.047. The positive impact is in line with capital buffer theory (Milne and Whalley, 2001), which predicts that banks' optimal capital buffer is positively related to asset risk. These findings are also consistent with the stylized facts that Islamic banks (i) maintain a large liquidity buffer to protect against deposit withdrawals (ii) restricted access to money markets (interbank) and lender-of-last resort and (iii) have low leverage as they promote asset-backed investments. Pappas et al. (2012) tied higher $TeTa$ ratios (or low leverage) of Islamic banks to greater survivorship and higher degrees of solvency, when compared with conventional banks.

We also find that the ratio of bank loans to total assets ($LoanTa$) has a strong positive effect on $RwaTa$. Loans are the main source of revenue for Islamic banks. Since most of the loans are in the form of profit and loss sharing, the financial discipline imposed on entrepreneurs by debt contracts can be weak (Jensen and Meckling, 1976). This factor coupled with the equity-like character of their bank loans may increase Islamic banks' risks by raising the "uncertainty on depositors' return and increasing the likelihood of both uninformed and informed bank runs" (Beck et al., 2013, p. 435). This is exacerbated by the fact that, generally, during a liquidity crisis Islamic banks are less likely to cut lending compared to their conventional counterparts (Beck et al., 2013). While it can be argued that the discipline imposed by depositors mitigates risky bank lending (e.g., Diamond and Rajan, 2000) the reality is different for Islamic banks which may face a higher withdrawal risk than their conventional counterparts. To minimize such risk, on the liability side of the balance sheet Islamic banks tend to offer a competitive return to their deposit (investment) account holders, while on the asset side Islamic banks may rely more on non profit-sharing modes of finance (Abedifar et al., 2013). These actions—although a rational response in the face of weak contractual framework—make Islamic banks more alike to their conventional peers (Khan, 2010). It is worthwhile to mention here that after controlling for differences in bank-level, country-level macro and market indicators, and latent country effects, Islamic banks are shown to have a failure risk that is 55% lower than conventional banks (Pappas et al., 2012).

5 Conclusion

This paper analyzes the effect of changes in total capital on asset risks for 22 Islamic banks observed over a 7 year period from 2007-2013. The financial crisis of 2007-2008 resulted in substantial increases in the total asset and capital levels. Our estimation results suggest that these large changes in total capital have a noticeable effect on the levels of riskiness of the Islamic bank assets which become riskier. The use of $TcTa = \frac{TC}{TA}$ and $RwaTa = \frac{RWA}{TA}$ as measures of total capital and risk is another contribution of this paper as it enables us to avoid the direct functional dependence between measures of bank capital and risk used in prior studies, generated by the presence of risk weighted assets in both measures. Our approach is more likely to identify the true treatment effect rather than a spurious dependence. From a regulatory/supervisory perspective, our findings call to enhance the capital adequacy guidelines for Islamic banks to more accurately reflect their exposure to unique risks and their propensity to increase risk when faced with increased capital requirements. Moreover, since meeting the minimum capital required ratio is not a challenge for Islamic banks, greater emphasis should be given on how Islamic banks manage their liquidity risk amid new liquidity ratios (i.e., Liquidity Coverage Ratio and Net Stable Funding Ratio) under Basel III. We hope that these issues are explored in future research.

Appendix 1: MCMC Algorithm

The full posterior distribution can be written as

$$
\begin{aligned}
&\prod_{i=1}^{N}\prod_{t=1}^{T}\frac{1}{\sqrt{2\pi}|\delta_1|^{1/2}}\exp\left[-.5\delta_1^{-1}(y_{1it}-W_{1it}\theta_1-\alpha_{1i}-\delta_{12}\left(y_{2it}-W_{2it}\theta_2-\alpha_{2i}\right))^2\right]\times\\
&\prod_{i=1}^{N}\prod_{t=1}^{T}\frac{1}{\sqrt{2\pi}|\delta_2|^{1/2}}\exp\left[-.5\delta_2^{-1}(y_{2it}-W_{2it}\theta_2-\alpha_{2i})^2\right]\times\\
&\prod_{i=1}^{N}\frac{1}{\sqrt{2\pi}\sigma_{\alpha_1}}\exp[-.5\alpha_{1i}'\sigma_{\alpha_1}^{-2}\alpha_{1i}]\times\prod_{i=1}^{N}\frac{1}{\sqrt{2\pi}\sigma_{\alpha_2}}\exp[-.5\alpha_{2i}'\sigma_{\alpha_2}^{-2}\alpha_{2i}]\times\\
&(2\pi)^{-(1+k+h_1)/2}\,|\underline{\mathbf{H}}_1|^{\frac{1}{2}}\exp[-.5(\theta_1-\underline{\theta}_1)'\underline{\mathbf{H}}_1(\theta_1-\underline{\theta}_1)]\times\\
&(2\pi)^{-(1+k+h_2)/2}\,|\underline{\mathbf{H}}_2|^{\frac{1}{2}}\exp[-.5(\theta_2-\underline{\theta}_2)'\underline{\mathbf{H}}_2(\theta_2-\underline{\theta}_2)]\times\\
&\frac{1}{\Gamma(a_{\alpha1})b_{\alpha1}^{a_{\alpha1}}}(\sigma_{\alpha1}^2)^{-(a_{\alpha1}+1)}\exp\left(-\frac{1}{b_{\alpha1}\sigma_{\alpha1}^2}\right)\times\\
&\frac{1}{\Gamma(a_{\alpha2})b_{\alpha2}^{a_{\alpha2}}}(\sigma_{\alpha2}^2)^{-(a_{\alpha2}+1)}\exp\left(-\frac{1}{b_{\alpha2}\sigma_{\alpha2}^2}\right)\times\\
&\frac{1}{\Gamma(a_{\delta_1})b_{\delta_1}^{a_{\delta_1}}}(\delta_1)^{-(a_{\delta_1}+1)}\exp\left(-\frac{1}{b_{\delta_1}\delta_1}\right)\times\\
&\frac{1}{\Gamma(a_{\delta_2})b_{\delta_2}^{a_{\delta_2}}}(\delta_2)^{-(a_{\delta_2}+1)}\exp\left(-\frac{1}{b_{\delta_2}\delta_2}\right)
\end{aligned}
$$

Steps of the MCMC procedure are as follows:

1. The full conditional density for α_{1i} is normally distributed as

$\alpha_{1i} \mid \Delta \sim N\left[\overline{\alpha_{1i}}, \overline{H}_{\alpha_1}^{-1}\right]$ where

$$
\begin{aligned}
\overline{H}_{\alpha_1} &= T\times\delta_1^{-1}+\sigma_{\alpha_1}^{-2}\\
\overline{\alpha_{1i}} &= \overline{H}_{\alpha_1}^{-1}\left[\delta_1^{-1}\sum_{t=1}^{T}(y_{1it}-W_{1it}\theta_1-\delta_{12}\left[y_{2it}-W_{2it}\theta_2-\alpha_{2i}\right])\right].
\end{aligned}
$$

2. The conditional distribution of α_{2i} is normally distributed as

$\alpha_{2i} \mid \Delta \sim N\left[\overline{\alpha_{2i}}, \overline{H}_{\alpha_2}^{-1}\right]$ where

$$
\begin{aligned}
\overline{H}_{\alpha_2} &= T\times\delta_2^{-1}+T\times\delta_{12}^2\delta_1^{-1}+\sigma_{\alpha_2}^{-2}\\
\overline{\alpha_{2i}} &= \overline{H}_{\alpha_2}^{-1}\left[\delta_2^{-1}\sum_{t=1}^{T}(y_{2it}-W_{2it}\theta_2)-\delta_{12}\delta_1^{-1}\sum_{t=1}^{T}(y_{1it}-W_{1it}\theta_1-\alpha_{1i}-\delta_{12}\left[y_{2it}-W_{2it}\theta_2\right])\right].
\end{aligned}
$$

3. The full conditional of the parameter vector θ_1 is normally distributed as $N\left[\overline{\theta_1}, \overline{\mathbf{H}}_1^{-1}\right]$

$$\begin{aligned}
\overline{\mathbf{H}}_1 &= \underline{\mathbf{H}}_1 + \delta_1^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} W'_{1it} W_{1it} \\
\overline{\theta_1} &= \overline{\mathbf{H}}_1^{-1} \left[\underline{\mathbf{H}}_1 \underline{\theta_1} + \delta_1^{-1} \sum_{i=1}^{N} \sum_{t=1it}^{T} \mathbf{W}'_{it} (y_{1it} - \alpha_{1i} - \delta_{12} \left[y_{2it} - W_{2it}\theta_2 - \alpha_{2i} \right]) \right].
\end{aligned}$$

4. The full conditional of the parameter vector θ_2 is normally distributed as $N\left[\overline{\theta_2}, \overline{\mathbf{H}}_2^{-1}\right]$ where

$$\begin{aligned}
\overline{\mathbf{H}}_2 &= \underline{\mathbf{H}}_2 + \sum_{i=1}^{N} \sum_{t=1}^{T} W'_{2it} W_{2it} \left(\delta_2^{-1} + \delta_{12}^2 \delta_1^{-1} \right) \\
\overline{\theta_2} &= \overline{\mathbf{H}}_2^{-1} \left[\underline{\mathbf{H}}_2 \underline{\theta_2} + \sum_{i=1}^{N} \sum_{t=1}^{T} \delta_2^{-1} W'_{2it} (y_{2it} - \alpha_{2i}) - \sum_{i=1}^{N} \sum_{t=1}^{T} \delta_{12} \delta_1^{-1} W'_{2it} (y_{1it} - W_{1it}\theta_1 - \alpha_{1i} - \delta_{12} \left(y_{2it} - \alpha_{2i} \right)) \right]
\end{aligned}$$

5. The conditional distribution of the covariance parameter δ_{12} is normally distributed as $\delta_{12}|\Delta\tilde{\ } N\left[\overline{\delta}_{12}, \overline{H}_{\delta_{12}}^{-1}\right]$ where

$$\overline{H}_{\delta_{12}} = \underline{H}_{\delta_{12}} + \sum_{i=1}^{N} \sum_{t=1}^{T} \delta_1^{-1} (y_{2it} - W_{2it}\theta_2 - \alpha_{2i})' (y_{2it} - W_{2it}\theta_2 - \alpha_{2i})$$

$$\overline{\delta}_{12} = \overline{H}_{\delta_{12}}^{-1} \left[\underline{H}_{\delta_{12}} \underline{\delta}_{12} + \delta_1^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} (y_{2it} - W_{2it}\theta_2 - \alpha_{2i})' \left(y_{it} - \mathbf{W}_{it} \mathbf{\Omega} - a_i \right) \right]$$

6. The posterior distribution of the variance parameter $\sigma^2_{\alpha_1}$ is inverse gamma, i.e.

$$\sigma^2_{\alpha_1} \mid \Delta\tilde{\ } IG\left[\frac{N}{2} + a_{\alpha_1}, \left(b^{-1}_{\alpha_1} + \frac{1}{2}\sum_{i=1}^{N}\alpha'_{1i}\alpha_{1i}\right)^{-1}\right]$$

7. The posterior distribution of the variance parameter $\sigma^2_{\alpha_2}$ is inverse gamma, i.e.

$$\sigma^2_{\alpha_2} \mid \Delta\tilde{\ } IG\left[\frac{N}{2} + a_{\alpha_2}, \left(b^{-1}_{\alpha_2} + \frac{1}{2}\sum_{i=1}^{N}\alpha'_{2i}\alpha_{2i}\right)^{-1}\right]$$

8. The posterior distribution of the variance parameter δ_1 is inverse gamma, i.e.

$$\delta_1|\Delta\tilde{\ } IG\left[\frac{NT}{2} + a_{\delta_1}, \left(b^{-1}_{\delta_1} + \frac{1}{2}\sum_{i=1}^{N}\sum_{t=1}^{T}(y_{1it} - W_{1it}\theta_1 - \alpha_{1i} - \delta_{12}\left[y_{2it} - W_{2it}\theta_2 - \alpha_{2i}\right])^2\right)^{-1}\right]$$

9. The posterior distribution of the variance parameter δ_2 is inverse gamma, i.e.

$$\delta_2 \mid \Delta \sim IG\left[\frac{NT}{2} + a_{\delta_2}, \left(b^{-1}_{\delta_2} + \frac{1}{2}\sum_{i=1}^{N}\sum_{t=1}^{T}(y_{2it} - W_{2it}\theta_2 - \alpha_{2i})^2\right)^{-1}\right].$$

This completes the MCMC algorithm.

Appendix 2: Numerical Example and Monte Carlo Simulation

This section shows that the proposed MCMC algorithm produces reliable estimates. This can be tested by generating data according to the known parameters of the data generating process. We design a Monte Carlo simulation example for the studied random effects treatment model using 50 individuals, which are observed over 10 time periods. A new data set is generated at each step of the Monte Carlo experiment and the posterior mean and standard deviations are estimated. The covariates include two exogenous explanatory variables ($k = 2$), one endogenous regressor, and one instrument ($h = 1$), each of which were generated from the random normal distribution, so that $X_{it1} = (1, x_{it1}, x_{it2}, y_{it2})$ and $X_{it2} = (1, x_{it1}, x_{it2}, z_{it2})$ in the model

$$
\begin{aligned}
y_{it1} &= \alpha_{i1} + \beta_{10} + \beta_{11}x_{it1} + \beta_{12}x_{it2} + \rho_1 y_{it2} + \varepsilon_{it1} \\
y_{it2} &= \alpha_{i2} + \beta_{20} + \beta_{21}x_{it1} + \beta_{22}x_{it2} + \gamma_2 z_{it} + \varepsilon_{it2}.
\end{aligned}
$$

We follow the prior specifications outlined in Section 3, and the random effects were generated as

$$
\alpha_{ij} \sim N(0, \sigma^2_{\alpha_j}) \qquad j = 1, 2,
$$

where $\sigma^2_{\alpha 1}$ and $\sigma^2_{\alpha 2}$ were set to one to allow the random effects to follow i.i.d. standard normal distributions. The model parameters were set to $\beta_1 = (1, 1, 1)$, $\rho_1 = 0.5$, $\beta_2 = (1, 1, 1)$, and $\gamma = 0.5$, and the idiosyncratic error terms ε_{it1} and ε_{it2} were generated using the bivariate normal distribution with mean zero and variance-covariance matrix defined with the variance parameters set to $\sigma^2_{\varepsilon_1} = 1$, $\sigma_{\varepsilon_1\varepsilon_2} = 1$, and $\sigma^2_{\varepsilon_2} = 2$, which implies very strong evidence of endogeneity in y_2.[8]

The Monte Carlo experiment was comprised of 500 Gibbs sampler simulations, meaning that 500 data sets were generated and 500 Markov chains were estimated. Each simulation consisted of 5,000 iterations, following an initial 1,000 replication burn-in phase. Based on the Markov chains the posterior means and standard deviations were calculated and collected. Table A.1 presents means of the posterior means and standard deviations for the model parameters based on 500 observations. The results show that the distribution of the posterior means for all model parameters are centered very close to their true values with relatively small margins of error. In order to confirm that the MCMC results were not influenced by the initial conditions, multiple simulations using alternative starting values were also run (similar conclusions were drawn and therefore these results were not reported). Overall the MCMC algorithm produces reliable results.

[8] $\rho = \frac{\sigma_{\varepsilon_1\varepsilon_2}}{\sqrt{\sigma^2_{\varepsilon_1}\sigma^2_{\varepsilon_2}}} \approx 0.7$

Table A.1: Numerical example: Monte Carlo simulations

Variable	True Value	Mean	SD
ρ_1	0.50	0.578	0.032
β_{10}	1.00	0.899	0.146
β_{11}	1.00	0.918	0.054
β_{12}	1.00	0.918	0.049
β_{20}	1.00	0.987	0.156
β_{21}	1.00	0.996	0.067
β_{22}	1.00	0.993	0.066
γ	1.00	1.069	0.057
Variance Parameters			
σ_{α_1}	1.00	0.963	0.203
σ_{α_2}	1.00	0.937	0.215
σ_1^2	1.00	0.872	0.073
σ_2^2	2.00	1.983	0.133
σ_{12}	1.00	0.778	0.082

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Table 1. Basel II and Basel III capital requirements, percent of risk-weighted assets

	Basel II	Basel III
A. Quantity of Capital		
Minimum Total Capital	8.0	8.0
Capital Conservation Buffer	n.a.	2.5
Minimum Total Capital Plus Conservation Buffer	n.a.	10.5
Countercyclical Buffer	n.a.	0-2.5
Global Systemically Import Banks (G-SIB) Surcharge	n.a.	1-2.5
Minimum Total Capital Plus Conservation Buffer, Countercyclical Buffer, & G-SIB Charge	8.0	11.5-15.5
Leverage Ratio	n.a.	3.0
B. Quality of Capital		
Minimum Common Equity Capital	n.a.	4.5
Minimum Capital Instruments with Incentive to Redeem	4.0	6.0

Source: Dagher et al. (2016)

Table 2: Mean and standard deviations (in parenthesis) of variables

Variable	2008	2009	2010	2011	2012	2013	Full Sample
Rwa (million US$)	487.46	591.15	741.54	810.51	927.15	966.93	754.13
	(734.65)	(767.00)	(1,131.65)	(1,202.74)	(1,299.18)	(1,369.94)	(1,096.95)
Ta (million US$)	9.46	10.19	11.79	13.10	15.31	16.59	12.74
	(13.46)	(13.84)	(15.28)	(16.96)	(19.18)	(20.64)	(16.65)
RwaTa	71.27	89.84	62.71	60.59	60.78	58.53	67.29
	(30.53)	(126.18)	(23.13)	(21.57)	(19.30)	(17.47)	(55.59)
ln(RwaTa)	4.12	4.15	4.04	4.02	4.03	3.99	4.06
	(0.67)	(0.74)	(0.53)	(0.48)	(0.46)	(0.50)	(0.56)
Tc (million US$)	0.83	0.98	1.34	1.43	1.59	1.71	1.32
	(1.24)	(1.23)	(2.04)	(2.16)	(2.38)	(2.59)	(2.00)
TcTa	0.13	0.16	0.13	0.12	0.11	0.10	0.13
	(0.09)	(0.159)	(0.06)	(0.06)	(0.05)	(0.04)	(0.08)
Te (million US$)	1.30	1.34	1.48	1.52	1.71	1.96	1.55
	(2.11)	(2.09)	(2.17)	(2.23)	(2.43)	(2.75)	(2.28)
TeTa	0.14	0.13	0.13	0.12	0.11	0.11	0.12
	(0.09)	(0.08)	(0.06)	(0.06)	(0.05)	(0.04)	(0.07)
Loan (million US$)	5.66	6.02	6.86	7.61	9.09	9.74	7.49
	(8.23)	(8.43)	(9.12)	(10.00)	(11.60)	(12.30)	(10.00)
LoanTa	0.56	0.53	0.52	0.51	0.54	0.55	0.54
	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.18)	(0.17)
Non_{t-1} (million US$)	0.16	0.23	0.28	0.34	0.40	0.39	0.30
	(0.25)	(0.39)	(0.45)	(0.58)	(0.61)	(0.55)	(0.48)
$(\text{NonTa})_{t-1}$	0.017	0.028	0.021	0.023	0.029	0.024	0.022
	(0.015)	(0.013)	(0.010)	(0.013)	(0.025)	(0.017)	(0.019)
Roaa	0.009	0.003	0.007	0.005	0.012	0.012	0.008
	(0.011)	(0.017)	(0.014)	(0.020)	(0.013)	(0.017)	(0.015)

Rwa (risk-weighted assets); Ta (total bank assets); RwaTa (ratio of risk-weighted assets to total assets); Tc (total capital); TcTa (ratio of total capital to total assets); Te (total equity); TeTa (ratio of total equity to total assets); Loan (total bank loans); LoanTa (ratio of bank loans equity to total assets); Non_{t-1} (lagged nonperforming loans); NonTa_{t-1} (lagged ratio of nonperforming loans to total asset); Roaa (average return on assets).

Table 3. Posterior means and standard deviations of parameters

Variable	Mean	SD	$\Pr(\beta_k > 0)$
Dependent Variable: RwaTa			
Intercept	0.326	0.100	0.988
2009	0.077	0.068	0.864
2010	-0.016	0.066	0.387
2011	0.040	0.063	0.709
2012	0.057	0.062	0.801
2013	0.020	0.062	0.608
TeTa	0.036	0.100	0.636
LoanTa	0.205	0.093	0.972
$(\text{NonTa})_{t-1}$	0.007	0.101	0.516
RwaTa_{t-1}	0.844	0.067	0.998
TcTa	0.165	0.093	0.955
Dependent Variable: TcTa			
Intercept	0.032	0.237	0.674
2009	0.026	0.027	0.849
2010	0.002	0.022	0.563
2011	-0.004	0.020	0.446
2012	-0.015	0.019	0.211
2013	-0.020	0.018	0.135
TeTa	0.174	0.102	0.953
LoanTa	0.046	0.101	0.727
Roaa	0.014	0.099	0.554
TcTa_{t-1}	0.037	0.052	0.776
Variance Parameters			
σ_{α_1}	0.06506	0.07416	1
σ_{α_2}	0.06310	0.04284	1
σ_1^2	0.11027	0.03528	1
σ_2^2	0.00487	0.00276	1
σ_{12}	0.00064	0.00096	0.827

Figure 1. Posterior distribution of the effect of TcTa on Risk parameter