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Basel II Capital Requirements and Bank Behaviour: Empirical Evidence from Brazilian Banks

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Abstract

This paper provides an empirical investigation on the relationship between Basel II capital requirement and the risk-taking behaviour of banks in Brazil. Building on previous studies, two econometric models were employed: the simultaneous equations model of Shrieves and Dahl (1992), and the model for bank portfolio behaviour developed by Berger and Udell (1994). In our sample of Brazilian banks, we found sufficient evidence that Basel II induced banks to increase their capital adequacy ratio. Meanwhile, banks capital and risk-taken levels appeared to be negatively related, indicating that an increase in capital adequacy ratio did lead to a reduction in level of risk banks undertake. Besides, there was no empirical evidence of moral hazard in the way Brazilian banks behaved. Nonetheless, the study also pointed out that the implementation of Basel II had contributed to a reduction in domestic credit in Brazil, and thus, it might have an adverse effect on the country's economy.

JEL classification numbers: C33, G21, G28
Keywords: Basel II, Capital Adequacy Ratio, Risk-taken level

1 Introduction

Numerous studies (see for example: Shrieves and Dahl, 1992; Berger and Udell, 1994; Ediz et al 1998; Gottschalk, 2010; and Griffith-Jones et al, 2012) have concentrated on the growth-enhancing role of banking regulations. However, the question of "has regulation effectively done its job of strengthening the banking and financial system to ensure a macro-economic stability?'' is still remaining unsolved.

The rapid evolution of market and financial risk induced regulators to further amend and improve existing regulations. Subsequently, Basel II was introduced in 2004 as a significant

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enhancement of the previous Accord. It was thus expected to overcome any existing problems under the first rules and continue to minimise crisis in banking industries. Nevertheless, there was no coincidence that the global banking system in 2007/2008 had failed to withstand the pressures of a deteriorating market. A number of bankruptcies and systematic failures have been witnessed during and after the crisis. Hence, one may argue that Basel II would protect no one: not the banks, not the public, and obviously not the borrowers and tax-payers (Armour and Tracy, 2014). As such, it is important to gauge the effectiveness of Basel rules.

To date, very few empirical studies have been conducted about the impacts of Basel II capital requirements on risk-taking behaviour of banks in developing economies. It's perhaps because both Basel I and Basel II were primarily designed for large and internationally active banks in developed countries, while smaller domestic banks in developing nations are often kept outside the jurisdiction of such regulations (Gottschalk, 2010). Therefore, developing countries often face great difficulties when attempting to understand and adopt the new Basel rules. For those reasons, this paper will concentrate on the influences of Basel II capital requirements on bank risk-taking behaviour in developing countries.

Brazil is chosen as the country of studying because with a high poverty rate and a large proportion of SMEs, Brazil can be a relatively good representative of developing nations. Besides, Brazil is among the first developing countries to implement Basel rule[2], and the information on prudential norms in Brazil is also available to collect.

The paper is now organised as follows. Section 2 reviews the theories related to the choice of banks' capital and risk-taking levels. Section 3 describes the data, models and methodologies employed. Section 4 presents and discusses the empirical results. Finally, conclusions will be drawn in Section 5.

2 Bank Behaviour towards Basel Regulation

2.1 Overview

According to Roy (2005), there are three possible courses of action that banks, who aim to raise their CAR either to obey the minimum regulatory requirements or for any other non-regulatory purposes, would follow: (i) raise capital (increase K); (ii) reduce higher-risk assets; or (iii) shrink total asset (lower A) (a proof of equation 2.1 is discussed in the Appendix).

$$\text{Where: } CAR = \frac{K}{RWA} = \widehat{CAR} = \widehat{K} - \widehat{RISK} - \hat{A} \tag{2.1}$$

Capital adequacy ratio; K = Regulatory capital set aside by bank; A = Total asset; RISK = RWA/A = Bank risk level; and RWA = Total Risk-weighted-asset.

It is also notable from equation 2.1 that a compelled increase in the capital adequacy ratio (CAR) could not prevent banks from simultaneously increasing their regulatory capital (K) and risk levels (RWA/A), given the fact that the growth rate of capital is higher than that of

[2]See more in Gottschalk and Sodre (2007), International Monetary Fund (2012).

the risk ratio, *ceteris paribus*. For that reason, regulatory capital requirements may well encourage banks to engage in more and riskier projects and induce them to behave in a moral hazard manner.

2.2 Regulatory Capital Requirements and Bank Capital Level

Keeley (1988) is among the first researchers focusing on the influences of Basel rule on banks' CAR levels. However, it is difficult to interpret his findings, since Keeley did not condition on obvious non-regulatory effects on the capital ratio levels. Shrieves and Dahl (1992), by using the simultaneous equations approach, found out that undercapitalised banks had increased their capital ratios (on average) by 140 basis-points more than well-capitalised banks.

Subsequently, Ediz et al. (1998) and Rime (2001) extended the work of Shrieves and Dahl (1992) and went into more detail when using dummy variable to measure the effect of regulatory pressures on bank behaviour. The univariate variable equals 1 for well-capitalised banks and 0 for those that did not meet the minimum capital levels. Although the two papers separately concentrated on two different countries, they shared a somewhat similar conclusion that the regulatory pressure variables were all positive and statistically significant. Hence, it is consistent with what found by Shrieves and Dahl (1992) that the regulatory pressures brought about by Basel rules did cause banks to increase their capital ratios.

More recently, Hussain and Hassan (2005), who focused on the effects of Basel Capital Accords on eleven developing countries over a five-year period since the day Basel was first introduced in each nation, indicated that Basel rules did have a direct impact on the banks' capital ratios. It thus provided a similar conclusion with all the previous studies mentioned above.

Although there has been some empirical evidence (Shrieves and Dahl, 1992; Ediz et al., 1998; Rime, 2001; Hussain and Hassan, 2005) supporting the belief that higher capital requirements induced banks to increase their capital adequacy ratios, one may step further to ask: how was that raise achieved? (E.g. did banks increase the regulatory capital requirements, reduce risk-taking levels, shrink total assets or simultaneously increase their regulatory capital and risk levels?). And does it really mean that stricter capital requirements would help increase financial stability? Those questions will be addressed in later parts of this paper.

2.3 Relationship between Bank Capital and Risk-taking Decisions

This section aims to shed some light into the theoretical frameworks of the relationship between capital adequacy ratio and the level of risk bank undertake.

2.3.1 Rationale for a positive association

By using a utility-maximising framework, Koehn and Santomero (1980) and Kim and Santomero (1988) pointed out that the introduction of higher capital ratios had induced banks to shift their portfolios towards riskier assets due to inefficiently priced deposit insurance. This happened because flat requirements restricted the bank's risk-return frontier, thus leading them to compensate losses in utility from the upper-limit on leverage with, perhaps, the optimal option of increasing the riskiness of the portfolio (Roy, 2005). In particular, although Basel rules with different risk-weight categories might induce banks to shift away from high risk-weighted assets towards lower ones (Gottschalk, 2010), for any asset category which is subject to similar proportional capital charge, banks might have an incentive to move towards the riskier assets within that category since higher risks were expected to provide greater future returns. As a result, a positive correlation between capital ratio and risk-taking would be observed.

Subsequently, Rochet (1992) employed the portfolio approach developed by Hart and Jaffee (1974) and found out that when the ultimate intention of banks was to maximise the market value of their future revenues, risk-based capital ratios could not stop the banks from selecting highly specialised and risky portfolios.

Although using a different method from those of Kim and Santomero (1988) and Rochet (1992), Blum (1999), with a dynamic model, had drawn a somewhat similar conclusion that higher capital regulations may in fact increase a bank's risk level due to the inter-temporal effect. According to Blum (1999), if banks find it prohibitively expensive (or even completely unable) to raise additional equity capital to comply with new capital requirements tomorrow, they may wish to increase the risk today.

2.2.2 Rationale for an adverse association

The evidence for the first strand seems strong. However, their findings (Koehn and Santomero, 1980; Rochet, 1992) have been criticised on several grounds. First of all, according to Keeley and Furlong (1990), capital requirements could indeed induce banks to reduce their risk-taking if they possessed well-diversified portfolios. Besides, undercapitalised banks could meet the risk-based requirement by increasing capital and/or reducing portfolio risks, while well-capitalised banks may choose to reduce capital or to increase risk levels. And finally, those findings might only be consistent under Basel I rule, in which only five risk-weighted categories were adopted and banks were required to calculate their minimum capital reserve based on a single risk-weight for each type of assets. Under Basel II, numerous risk-weights were employed depending upon not only the type of assets but also the credit worthiness of particular assets within that asset class (i.e. AAA commercial loans are now treated in a different way from BBB commercial loans – unlike in Basel I Accord). Thus, riskier assets (even in the same asset type, i.e. corporate bond) are now more costly for banks. As a consequence, banks might have less motivation to shift towards riskier assets.

More recently, Hussain and Hassan (2005) employed the three-stage least square (3SLS) model to carry the simultaneous equations approach developed by Shrieves and Dahl (1992) and found strong empirical evidence that bank capital and risk-taking levels were inversely related in the selected eleven developing nations. Thus, their finding was consistent with what suggested by Keely and Furlong (1990) about a negative relationship.

Indeed, there are various theoretical and experimental explanations for the possible relationship between banks' capital and risk levels. Therefore, whether stricter capital requirements induce banks to increase or reduce their risk-taking levels is still a question with no simple answer. As summarised by Shrieves and Dahl (1992), a positive correlation between bank capital and risk-taken levels may be resulted from regulatory costs, unintended impacts of minimum capital requirements, bankruptcy-cost avoidance, or managers' risk aversion. Meanwhile, a negative correlation may be caused by the mispricing of deposit insurance.

2.4 Basel II and the Patterns of Bank Asset Portfolios

There have been continual debates on whether risk-based capital requirements proposed in Basel II can have an effect on the real economy through the reduction in banks' lending when banks' capital is constrained. Gottschalk (2010) claimed that Basel rules led to a shift in bank asset portfolios towards government securities and against private sector, which in turn, might encourage banking concentration and contribute to a 10-year deduction in domestic credit production in Brazil. Figure 2 describes the growths in government securities and commercial and industrial loans in Brazil, following the adoption of Basel II.

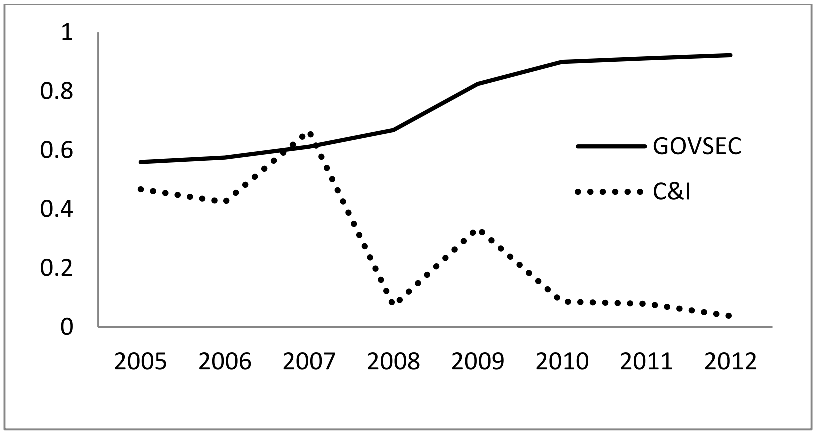

Figure 2: Growths in Government Securities and C&I Loans (Brazil: 2005 – 2012)
(Source: Bankscope, 2005 - 2012)

According to Figure 2, there have been inverse trends between the growth rates of government securities and loans to commercial and industrial sectors in Brazil. While the average growth rate of government securities invested by Brazilian banks showed an obvious upward trend, the figure for C&I loans substantially decelerated during the period. This suggests that Basel II led to a shift in bank portfolios from risky assets to relatively safer ones. This also indicates that domestic credit production was somewhat deducted in Brazil, following the implementation of Basel II in 2005.

Nevertheless, there may not be sufficient evidence to judge whether Basel II led to that re-allocation of bank portfolios. As stated by Haubrich and Wachtel (1993), the shift in bank portfolios might simply be caused by high levels of interest rates so that government securities would become more profitable for banks.

In short, if the re-allocation of bank portfolios was indeed a subsequent result of Basel II implementation, there would be a serious problem. Since Basel II might also contribute to an increase in the pro-cyclicality of credit provision, the deduction in banks' lending would be further accelerated[3]. Thus, if banks' lending is constrained by the increasingly tighten-up Basel rules, while equity capital is prohibitively expensive (or even completely unable) to be raised during recession, significant inverse impacts on the macro-economy and banking stability would be inevitable.

[3]See for example: Griffith-Jones and Spratt (2001).

3 Data and Model Specification

The ultimate objective of this paper is to investigate the underlying banks' behaviour towards the regulatory capital requirements and its resulting effects on the economy. Therefore, it employs two following econometric models: the simultaneous equations model of Shrieves and Dahl (1992), and the model for bank portfolio behaviour established in Berger and Udell (1994).

3.1 Model 1 - Data and Sample Description

Following Shrieve and Dahl (1992), we employ the simultaneous equation approach to investigate the possible impacts of Basel II on Brazilian banks' capital and risk-taken levels. Since Basel II was adopted in Brazil in December 2004, the time period in our sample for the most up-to-date available data is 2005-2012. Data is collected from *Bankscope* and the *World Bank.*

3.1.1 The Model

From the literatures, banks' capital and risk decisions seem to be simultaneously determined and interrelated. Furthermore, as illustrated by Shrieves and Dahl (1992), changes in capital and risk levels are the results of exogenous shocks (i.e. regulatory pressure) and discretionary behaviour. Therefore, the observed changes in banks' capital and risk levels will be modelled as having two components: discretionary variable and exogenous factors:

$$\Delta \mathbf{CAR}_{j,t} = \Delta_d \mathbf{CAR}_{j,t} + \boldsymbol{E}_{j,t} \quad (3.1)$$
$$\Delta \mathbf{RISK}_{i,t} = \Delta_d \mathbf{RISK}_{j,t} + \boldsymbol{U}_{i,t} \quad (3.2)$$

Where

- $\Delta \mathbf{CAR}_{j,t}$ and $\Delta \mathbf{RISK}_{i,t}$ are the observed changes in capital and risk, respectively for bank j in period t
- $\Delta_d \mathbf{CAR}_{j,t}$ and $\Delta_d \mathbf{RISK}_{j,t}$ are both *discretionary adjustments*, and
- $\boldsymbol{E}_{j,t}$ and $\boldsymbol{U}_{i,t}$ are both *exogenous factors*

Following Shrieves and Dahl (1992), the discretionary changes (or the endogenously determined adjustments) in capital and risk equations can be modelled using the *partial adjustment model* as below:

$$\Delta_d \mathbf{CAR}_{j,t} = \alpha(\mathbf{CAR}^*_{j,t} - \mathbf{CAR}_{j,t-1}) \quad (3.3)$$
$$\Delta_d \mathbf{RISK}_{j,t} = \beta(\mathbf{RISK}^*_{j,t} - \mathbf{RISK}_{j,t-1}) \quad (3.4)$$

Where: $\mathbf{CAR}^*_{j,t}$ and $\mathbf{RISK}^*_{j,t}$ are the target capital and risk levels, respectively, of banks j at time t.
Therefore, the discretionary changes in bank j's capital and risk levels are proportional to the difference between the bank's *target levels* at time t and its one period *lagged value.*
When we substitute equations (3.3) and (3.4) to equations (3.1) and (3.2), respectively, the following equations are expected:

$$\Delta \mathbf{CAR}_{j,t} = \alpha(\mathbf{CAR}^*_{j,t} - \mathbf{CAR}_{j,t-1}) + E_{j,t} \qquad (3.5)$$
$$\Delta \mathbf{RISK}_{i,t} = \beta(\mathbf{RISK}^*_{j,t} - \mathbf{RISK}_{j,t-1}) + U_{i,t} \qquad (3.6)$$

Therefore, the observed change in capital at time t is a function of the difference between the bank's target capital and its one-period-lagged value, and any exogenous shocks. Similarly, the same argument is applied for the RISK equation.

3.1.2 Definition of Capital and Risk

There are two definitions of the required bank capital: the capital-to-total-assets ratio (K/A) and the capital-to-risk-weighted-assets ratio (K/RWA). Although the first definition (K/A) was employed by Shrieves and Dahl (1992), K/RWA ratio has become a more popular method of measuring a bank's required capital level since the introduction of the risk-weighted approach in Basel rules. Therefore, the second definition of bank capital will be used in this paper: CAR = K/RWA.

Additionally, there are two different measurements of the "capital" component (K) in K/RWA ratio. One may use Tier 1 regulatory capital to calculate the capital requirement for credit risk. The other may employ total regulatory capital to calculate the total capital requirement for the entire risks at the bank. Since the objective of this research is to examine the issues related to the bank's entire risk exposure and its associated capital requirement, the second measurement of "capital" component will be used.

Regarding the risk ratio (RISK), it is defined as the ratio of total risk-weighted-asset to total assets (RWA/A). RISK will be used as a proxy to measure the entire risk exposure at a bank. There are two major reasons for using RWA/A. Firstly, the data for other methods of measuring risk (like Value-at-Risk or the volatility of banks' asset prices) were not available for the sample observations. Secondly and most importantly, using RWA/A ratio does not require us to capture and measure the exact risk levels of the bank. Instead, the purpose of this paper is to measure the "regulatory risk" that banks and regulators might have used in order to investigate and monitor bank "riskiness" (Roy, 2005).

Unfortunately, the levels of target capital (CAR*) and risk (RISK*) are not directly observable since they may vary cross-sectionally (Shrieves & Dahl, 1992). Nevertheless, according to Hussain and Hassan (2005), there are some sets of observable factors describing the banks' specific conditions and the state of the economy, which may have an impact on the banks' target capital and risk levels.

3.1.3 Bank-specific variables

Bank size (SIZE)

Consistent with the previous studies (Shreves and Dahl, 1992; Jacques and Nigro, 1997; and Rime 2000), the natural log of assets will be used as a measurement of bank size (SIZE). The SIZE variable is included in both capital and risk equations because it may have an impact on banks' target capital and risk levels, due to its relationship with the diversification strategies, the nature of investment opportunities and the capability of banks to access equity capital.

Loan loss provisions (LLOSS)

The ratio of loan loss provision to total asset (LLOSS) is also included in both equations as a measure of funds that banks set aside to cover bad loans. Loan loss provision is included in CAR equation because a raise in LLOSS may put banks' capital under pressure if banks do not buildup an appropriate equity buffet to handle credit loss. Alternatively, a bank's current loan loss provisions may also affect the RISK ratio since they may lead to a deduction in the nominal amount of risk-weighted-assets.

Bank profitability (ROA)
Although bank profitability (as measured using ROA) was not included in the original model of Shreves and Dahl (1992), it has been widely employed as an important indicator in later studies, including Aggarwal and Jacques (1997), Rime (2000), and Roy (2005). ROA may have a positive effect on a bank's capital if the bank prefers to increase its capital through retained earnings rather than through equity issues in the presence of asymmetric information in the marketplace.

3.1.4 Country-specific variables

Macroeconomic variable (GDP)
GDP growth is also included in the model to investigate the possible influences of economic conditions on banks' capital and risk decisions. It is particularly important to study because macroeconomic conditions in emerging and developing nations are believed to have higher volatility compared to other developed nations (Pugel, 2007).

Regulatory Pressure (REG)
Since regulatory pressure is the cornerstone factor influencing banks' behaviour, a dummy variable (REG) reflecting the degree of regulatory pressure brought about by Basel II will be included as a determinant factor of banks' target capital and risk levels. For well-capitalised banks which hold equal and above the minimum standards set by the state regulators, REG will take the value of one. Otherwise, zero value will be attached.

Substituting the linear functions of the variable selected to explain the banks' target and risk levels, the model defined by equation (3.5) and (3.6) is written as follows:

$$\mathbf{\Delta CAR_{j,t} = \lambda_0 + \lambda_1 SIZE_{j,t} + \lambda_2 ROA_{j,t} + \lambda_3 LLOSS_{j,t} + \lambda_4 REG_{j,t} + \lambda_5 GDP_{j,t} + \lambda_6 \Delta RISK_{j,t} + \lambda_7 CAR_{j,t-1} + \mathit{E}_{j,t}} \qquad (3.7)$$

$$\mathbf{\Delta RISK_{j,t} = \theta_0 + \theta_1 SIZE_{j,t} + \theta_2 LLOSS_{j,t} + \theta_3 REG_{j,t} + \theta_4 GDP_{j,t} + \theta_5 \Delta CAR_{i,t} + \theta_6 RISK_{j,t-1} + \mathit{U}_{j,t}} \qquad (3.8)$$

Since the right-hand sides of both equations include endogenous variables ΔRISK and ΔCAR to examine the possible simultaneous relationship between changes in capital and risk levels, following Shreves and Dahl (1992), simultaneous estimation of equation (3.7) and (3.8) will be carried out by employing two-stage least square model (2SLS)[4].

[4]Since the simultaneous-equation system is carried by the 2SLS model, the test of endogeneity is necessary to conduct to see if the 2SLS model is appropriate to perform. According to Hausman (1978), if there is no endogenous problem, then the OLS estimators provides consistent and efficient estimators, and thus, the 2SLS model is unnecessary to perform. This paper employs the Hausman Specification Test to test for the endogenous problem under the null hypothesis of no endogeneity. And since the p-value reported is very small, the null hypothesis is rejected. Hence, the instrumental variables are needed and the simultaneous-equation approach carried by the 2SLS model is valid.

3.2 Model 2

By looking at the factors influence both capital and risk levels, the first model only gives us an overview of the overall reactions of banks. However, it cannot tell us the underlying motivations and how those changes could be achieved. Therefore, the second model will step further to investigate the behaviour of different types of assets in bank portfolios. By doing so, it will give us a reliable sense of what banks thought about the new regulatory capital requirements (e.g. did they find such regulations necessary and try their best to comply with Basel rules?; *OR*, did they believe that regulations were not necessary, thus attempting to get away from it by operating in moral hazard manners?). Hence, by looking at the root of the problems, there will be a better chance for us to discover the actual impacts of Basel II on banks' behaviour as well as on the economy.

3.2.1 Sample Description

In this model, the empirical study is proceeded by examining the differences in banks' asset portfolios between the pre and post-Basel-ii implementation periods in Brazil. Thus, the data was collected throughout the period from 2000 until 2012. In particular, 2000 was chosen as it is the first year that data was collected in *Bankscope*, while 2012 was chosen since the data for 2013 and 2014 have not yet been fully updated.

For the convenience purpose, the period of 2000-2004 will be referred to as the "Control Period", and it's used to measure the banks behaviour in pre-Basel II adoption period. On the other hand, the period from 2005 to 2012 will be referred to as the "Basel II Period" as it will describe the banks behaviour and performances during the period of Basel II implementation.

It's important to examine both control period and Basel-ii period because a control period of "normal time" is necessary to compare and analysis the "true" impacts of Basel II capital requirements on banks behaviour and performance.

3.2.2 Main Model Specification

Building on previous work by Berger and Udell (1994), this section primarily concentrates on examining the behaviour of two main asset categories: government securities (GOVSEC) and commercial and industrial loans (C&I). These two types of asset were chosen because broader and/or other asset categories within the risk-based capital approach are relatively heterogeneous (Haubrich and Wachtel, 1993).

Indeed, GOVSEC and C&I may well represent the different risk-weighted categories recommended under Basel-ii. Government securities are generally treated as relatively low-risk assets with relatively low expected returns. Although government securities may be categorised as low as 0% for OECD countries, they can also be weighted as high as 100% for unrated nations. On the other hand, loans to commercial and industrial sectors, by its nature, are considered to have the highest risk (and therefore high-weighted). However, it also provides much higher expected returns.

Following Haubrich and Wachtel (1993), all dependent variables will be measured in form of their annual growth rate, denoted as:

$$\mathbf{ASSET_{i,t} = \ln(ASSET_{i,t}) - \ln(ASSET_{i,t-1})}$$

Where: $Asset_{it}$ represent bank i's asset at time t.

To examine how and why the growth rates of bank assets differ between the pre and post-Basel II implementation periods, according to Berger and Udell (1994), the following regression will be used:

$$\mathbf{ASSET_{ijt} = \varphi_0 + \varphi_1 BASEL_{(t-1)} + \varphi_2 CAR_{i(t-1)} + \varphi_3 INC_{i(t-1)} + \varphi_4 GDP_{(t-1)} + \varphi_5 INFL_{(t-1)} + \mu}$$

Where:

- $ASSET_{ji\,t}$= Asset j, at bank i during time t
- BASEL = Dummy variable that equals 1 for each year of Basel II period, 0 otherwise
- CAR_i = Total regulatory capital at bank i
- INC = Net Income
- GDP = annual GDP growth
- INFL = annual inflation rate
- μ = exogenous determining random shock

Similar to the previous model, CAR is employed to measure the total amount of capital required for the entire risks at the bank. The INC variable measures the bank's net income. It is included in the model because the previous year performance may have an influence on the bank's following year strategies. Additionally, two macro-economic variables GDP and INFL are also taken into account to measure the possible external impacts of the economy on bank' behaviour and performance.

Another notable feature is that all independent variables are measured in one-period lagged forms. There are two major ideas behind that. Firstly, lagged variables allow for the minimization of any unintentional feedback from the endogenous variables (Berger and Udel, 1994). Secondly, the one-year lagged period also helps obtain reasonable explanations for the adjustments of both banks' and regulators' behaviour, which is resulted from what actually happened in the previous year

4 Empirical Results

4.1 Model 1 – Overall Behaviour of Brazilian Banks

4.1.1 Factors affecting target capital and risk levels

Table 1 provides the regression results of model 1. As can be seen from this table, bank size (SIZE) appears to have a direct relationship with changes in banks' capital and risk levels. The relationship was negative and statistically significant under both CAR and RISK equations, indicating that an increase in bank size will lead to a reduction in both capital and risk levels, and *vice versa*.

In fact, an inverse relationship between the size of the bank and its capital level is expected. Since larger banks might have better ability to access capital markets and raise capital if wished, they can operate with lower amounts of capital (Roy, 2005). Thus, this empirical result does not support what suggested by Gottschalk (2010) that larger banks increase their capital adequacy ratios more than smaller banks.

Regarding the risk level, according to Gottschalk and Sen (2006), the relationship between SIZE and RISK is expected to be positive, which may indicate that larger banks are expected to face greater risks.

Table 1: Model 1 – Overall Behaviour of Bank

Panel A: Dependent Variable = **ΔCAR**

ΔCAR	Coefficient	Std. Error	t-value	Pr (>|t|)	
C	47.81628194	6.43336169	7.43255	1.0702e-11	***
ΔRISK	-0.08055335	0.02417171	-3.33255	0.0011086	**
SIZE	-2.16144357	0.41106113	-5.25820	5.5051e-07	***
ROA	-0.16004986	0.20032391	-0.79896	0.4257094	
LLOSS	-0.70272379	0.26035542	-2.69909	0.0078352	**
GDP	-0.22929638	0.24042084	-0.95373	0.3419128	
REG	9.13765287	1.19623906	7.63865	3.5127e-12	***
LCAR	-0.92443190	0.02363576	-3.91115	< 2.22e-16	***
R^2	0.41689				
No. Obs.	144				

*Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Panel B: Dependent Variable = **ΔRISK**

ΔRISK	Coefficient	Std. Error	t-value	Pr (>|t|)	
C	60.09180132	17.90187831	3.35673	0.0010210	**
ΔCAR	-0.16042493	0.06621550	-2.42277	0.0167090	*
SIZE	-1.94497489	1.07803561	-1.80418	0.0733993	.
LLOSS	2.12918071	0.74706510	2.85006	0.0050469	**
GDP	0.32405887	0.67352360	0.48114	0.6311848	
REG	-0.03992638	3.28853262	-0.01214	0.9903307	
LRISK	-0.49408891	0.05645521	-8.75187	6.8834e-15	***
R^2	0.37583				
No. Obs.	144				

*Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

The rationale for this positive relationship is that, while smaller banks might be constrained from doing large (and yet riskier) development projects (due to the lack of expertise, sophisticated financial instruments and certain markets), *ceteris paribus*, the larger the size of the bank is, the higher capability they have to take part in large (and yet, riskier but also higher expected return) projects. Therefore, larger banks may expose to higher risks, and *vice versa*. However, this is not the case in this study, where bank size was found to be significantly and negatively related to risk-taking decisions. This may be due to the diversification benefits, thus larger banks should have lower risk (and *vice versa*). Nevertheless, the evidence of a negative relationship is not quite strong since the estimated coefficient is just marginally significant (at 10%).

Turing to ROA, although ROA is considered a good proxy for bank profitability, the relationship between ROA and ΔCAR is not statistically significant. With regard to loan loss provision (LLOSS), it appears to be negative and statistically significant in CAR equation, but then turns to be positive and statistically significant in RISK equation. In terms of GDP growth (GDP), Table 1 shows that there is a negative association between GDP and changes in banks' capital adequacy ratios. However, the result is not statistically significant. Similarly, there is no statistical evidence suggesting that GDP has an impact on banks' risk levels.

4.1.2 The impact of Basel II Capital Accord on banks' capital and risk

According to the empirical evidence provided in Table 1, in Brazil, regulatory pressure had a positive and significant impact on banks' capital levels. Thus, there is statistical evidence that in Brazil, along with well-capitalised banks, banks hold below the minimum capital requirements did effectively improve their capital adequacy ratios in order to avoid the penalties implied by the regulators. This is in line with what suggested by Roy (2005) that in 10 OECD nations, regulators had successfully forced undercapitalised banks to increase their capital ratios. Nevertheless, this is contrary to what found in Hassan and Hussain (2005) about a negative relationship between regulatory pressure and bank capital in 11 developing countries.

With respect to risk, the coefficient was found to be negative. However, because the estimated parameter is not statistically significant, the evidence of an adverse relationship is not observable and one may argue that, at least for the scale and scope of this study, regulatory pressure brought about by Basel II had no direct effect on banks' risk-taking decisions.

4.1.3 The relationship between capital adequacy ratios and risk decisions

With regard to the relationship between a bank capital adequacy ratio and its risk-taken decision, the regression results at the top of Panel A and B of Table 1 suggest that changes in capital and risk are inversely related over the 2005-2012 period. The coefficients are both statistically significant and equal to -0.08 and -0.16 in CAR and RISK equations, respectively. It implies that 1 percent point increase in capital will reduce the risk taken by 0.16 percent point, while a similar increase in risk will have 0.08 percent point negative impact on capital. The results are in line with what found by Hussain and Hassan (2005), who provide strong empirical evidence based on the sample of 11 developing countries where changes in capital and risk levels are negatively related. Thus, in Brazil, there is statistical evidence that higher capital adequacy ratios do not lead to higher risk.

This result is not surprising, and also consistent with what proposed by Jacques and Nigro (1997), and Hussain and Hassan (2005). The possible explanation is that undercapitalised banks can meet the risk-based-capital requirements by increasing capital and/or reducing portfolio risk, while well-capitalised banks may choose to reduce capital or increase risk levels. The findings, therefore, do not support Shrieves and Dahl (1992)'s conclusion of a positive relationship as explained by "buffer capital theory", "managerial risk aversion theory", and "bankruptcy cost avoidance theories".

4.1.4 Discussion of findings

It can be seen that Brazilian regulators had succeeded in forcing banks to hold more capital reserve. However, regulatory pressure brought about by Basel II and the regulators had no influence on the banks' chosen levels of risk. Meanwhile, the model also suggests that an increase in capital ratios will lead to a decrease in banks' risk-taking levels, and *vice versa*. Thus, the actual impacts of Basel II requirements on banks' behaviour are still somewhat ambiguous here in this study. As a result, the second model, by examining the behaviour of different types of assets in banks' portfolios, would allow us to obtain an inside-out view of banks' behaviour towards Basel II requirements.

4.2 Model 2 – Behaviour of Bank Portfolios

4.2.1 Descriptive Statistics

The definition and sample means of all dependents and independents variables were described in Table 2 of the Appendix. It can be seen that, on average, the growth rates of government securities (GOVSEC) invested by Brazilian banks had raised double: from 9 percent in 2000-2004 period to 17 percent after the implementation of Basel II in 2005. As a result, this figure shows the evidence that Brazilian banks had, in fact, increased the holding of the relatively low-risk assets in their portfolio since the implementation of Basel II in the country. Turning to loans, contrary to the patterns observed for government securities and cash, the average growth rate of loans to commercial and industrial (C&I) had declined considerably from 41% to 12% between the control and Basel II periods - a more than 3-times decrease.

Thus, the descriptive statistic in Table 2 provide evidence that there were somewhat a shift in banks asset portfolios from high-risk assets to the less-risky ones between the pre- and Basel II periods. However, it's not clear if the shrinkage of risky asset was a resulting impact of Basel II. Therefore, the second regression model presented in section 3.2 will be carried to investigate the "true" impacts.

Table 2: Variable Definitions and Sample Means

Symbol	**Definition**	Control Period **Sample Mean**	Basel II Period **Sample Mean**
	A. Asset Growth Rates		
GOVSEC	Annual growth rate of government securities	0.09	0.17
C&I	Annual growth rate of commercial & industrial loans	0.41	0.12
	B. Basel II Implementation Period		
BASEL	Dummy variable equals 1 for 2005–2012, 0 otherwise	0	1
	C. Bank Capital Variable		
CAR	Capital Adequacy Ratio	19.9	19.3
	D. Bank Specific and Macroeconomics Variables		
INC	Net Income ($)	235,153.02	57,124.46
GDP	Annual growth rate of GDP (annual %)	5.009	2.675
INFL	Inflation rate (annual %)	5.845	7.572

4.2.2 Main Empirical Results

The regression was performed using Panel Pooled Ordinary-Least-Square (POLS). POLS was chosen because the number of observations is relatively small, thus regression results provided by Random- and Fixed-effect approaches may not be appropriate.

Government Securities

Panel A of Table 3 provides the regression results for government securities (GOVSEC). The estimated coefficients on BASEL are positive and statistically significant. Thus, this supports the first model's findings and strengthens the evidence proposed in the previous section that Basel II does have a direct and positive impact on the amount of government securities invested at Brazilian banks. In other words, Basel II encouraged banks to invest more in government securities.

In terms of the relationship between GOVSEC and regulatory capital requirements (CAR), the coefficient estimated appears to be positive and statistically significant. Therefore, this indicates that a raise in capital requirements led to an increase in the growth rate of government securities invested by banks.
Meanwhile, regarding other explanatory variables, such as GDP growth (GDP), and inflation (INFL), it can be seen that both variables have a negative but insignificant impact on GOVSEC. Similarly, income (INC) appears to be not statistically significant. In fact, the relatively small number of observation may contribute for the insignificant results.

Commercial and Industrial loans
Finally, the regression results of the C&I equation is provided in Panel B of Table3. It is interesting to note that the overall patterns are somewhat contrasting with what have been found in GOVSEC equation.
With regards to the overall relationship between the level of commercial and industrial loans (C&I) and Basel II capital requirements, the estimated coefficient on Basel is negative and statistically significant.

Table 3: Behaviour of Bank Assets Portfolio
Panel A: Dependent Variable = **GOVSEC**

GOVSEC	Coefficient	Std. Error	t-value	Pr (>|t|)	
C	9.3655e-01	4.2077e-02	22.2579	< 2.2e-16	***
BASEL	8.0022e-02	2.7514e-02	2.9084	0.003991	**
CAR	1.4670e-03	6.7217e-04	2.1825	0.030096	*
INC	2.0723e-09	5.4170e-08	0.0383	0.969518	
GDP	-6.8183e-03	5.0236e-03	-1.3572	0.176045	
INFL	-7.5988e-04	4.5543e-03	-0.1668	0.867638	
R^2	0.08291				
No. Obs.	234				

*Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Panel B: Dependent Variable = **C&I**

C&I	Coefficient	Std. Error	t-value	Pr (>|t|)	
C	6.3895e-01	1.4890e-01	4.2912	2.628e-05	***
BASEL	-3.2812e-01	9.7363e-02	-3.3701	0.0008824	***
CAR	6.9357e-03	2.3786e-03	2.9159	0.0039011	**
INC	-8.8859e-08	1.9169e-07	-0.4636	0.6434105	
GDP	-3.4070e-03	1.7777e-02	-0.1917	0.8481845	
INFL	-2.7948e-02	1.6116e-02	-1.7341	0.0842532	.
R^2	0.073175				
No. Obs.	234				

*Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

This thus suggests strong evidence that there was a direct and inverse relationship between Basel II and the amount of loans Brazilian banks lent to commercial and industrial sectors. In other words, banks tended to lend less to commercial and industrial sectors in Basel II implementation period, and vice versa. Hence, this is contrary to the trends found in GOVSEC equation that the levels of relatively low-risk assets like Treasury securities were increased during the Basel II period.

4.2.3 Discussion of findings

The first finding from this model is that a rise in regulatory capital requirements led to an increase in the growth rate of government securities. This is in line with the literature (Berger and Udell, 1994) about a positive relationship. The positive and statistically significant relationship between the BASEL and GOVSEC further the evidence of the positive influence of Basel II on banks' holding of government securities. Therefore, the model for bank portfolio performance strongly indicates that the new regulatory framework induced banks to invest more in less risky assets.

On the other hand, the relationship between banks' loans to commercial and industrial sectors and Basel II is found to be negative and statistically significant. Thus, it contrasts to what have been found for government securities and indicates that Basel II did induce banks to reduce their lending.

To sum up, an important conclusion drawn from this section's empirical findings is that there is statistically significant evidence that Brazilian banks had reallocated their asset portfolios from high-risk assets to lower-risk securities in response to the new regulatory capital requirements during the period 2005-2012.

5 Conclusion

This paper found the empirical evidence of regulatory pressure brought about by Basel II had effectively induced Brazilian banks to raise their capital ratios. Furthermore, banks' capital adequacy ratios and risk-taking decisions were found to be simultaneously determined and interacted. During the period from 2005 to 2012, changes in capital and risk were inversely related implying that an increase in capital will lead to a reduction in risk-taken levels by bank. As a result, Brazilian banks did not appear to increase their capital and risk simultaneously, and the empirical evidence provided here in this study strongly indicates that Brazilian regulators has succeeded in requiring banks to comply with the new regulatory accord. Thus, there is no statistical evidence of moral hazard in the way Brazilian banks behaved.

Additionally, our work found empirical evidence in support of literature that Basel II contributed to the reduction of domestic credit in Brazil. This is because, in response to the Basel II requirements, Brazilian banks had shifted their asset portfolios from riskier assets (i.e. loans to commercial and industrial sector) to relatively safer ones (i.e. government securities). Subsequently, this may, under the 'credit view', have macro-economic effects on the economy.

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Appendix

Proof of equation 2.1

The decomposed form of regulatory capital will be analysed to investigate how banks respond to the new capital requirements:

$$Regulatory\ Capital\ = \frac{Regulatory\ Capital}{RWA} * \frac{RWA}{A} * \frac{A}{1}$$

Or in other words:

$$K = \frac{K}{RWA} * \frac{RWA}{A} * \frac{A}{1}$$

Where

- K = regulatory capital set aside by the bank
- RWA = risk-weighted-asset
- A = total asset
- K/RWA = CAR = capital adequacy ratio
- RWA/A = RISK = bank risk level

According to Roy (2005), taking log and differentiating (w.r.t time) of both sides, the above equation will then become:

$$\frac{\partial log(K)}{\partial t} = \frac{\partial log(CAR)}{\partial t} + \frac{\partial log(RISK)}{\partial t} + \frac{\partial log(A)}{\partial t}$$

It is therefore:

$$\frac{\Delta K}{K} = \frac{\Delta CAR}{CAR} + \frac{\Delta RISK}{RISK} + \frac{\Delta A}{A}$$

Similar to Haubrich and Wachtel (1993), by using the standard circumflex notation for proportional change ($\widehat{K} = \frac{\widehat{K}}{K}$), we get:

$$\widehat{K} = \widehat{CAR} + \widehat{RISK} + \hat{A}$$

Or

$$\widehat{CAR} = \widehat{K} - \widehat{RISK} - \hat{A} \qquad (2.1)$$