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Essays on bank capital, macroeconomic activity and financial deepening

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BOSTON UNIVERSITY
GRADUATE SCHOOL OF ARTS AND SCIENCES

Dissertation

**ESSAYS ON BANK CAPITAL, MACROECONOMIC ACTIVITY AND
FINANCIAL DEEPENING**

by

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(Order No.)

SUDIPTO KARMAKAR

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ABSTRACT

This dissertation consists of three essays on banking. The first two chapters analyze, theoretically and empirically, the relationship between bank capital and macroeconomic activity. The third chapter addresses a policy question about financial deepening in some emerging market economies.

The first chapter develops a dynamic stochastic general equilibrium model to examine the impact of macroprudential regulation on the bank's financial decisions and the implications for the real sector. It explicitly incorporates costs and benefits of capital requirements. We model an occasionally binding capital constraint and approximate it using an asymmetric nonlinear penalty function. It is seen that higher capital requirements can dampen business cycle fluctuations and stronger regulation can induce banks to hold buffers and hence mitigate an economic downturn. We also see that higher capital requirements can enhance the welfare of the economy as a whole. Lastly, we find that switching to a countercyclical capital requirement regime can help moderate business cycle fluctuations and raise welfare.

The second chapter empirically evaluates the impact of bank capital on lending patterns using an innovative instrumenting strategy. We construct an unbalanced quarterly panel of around nine thousand commercial banks over sixty quarters, from 1996 to 2010. Using different measures of capital, we find a moderate relationship between bank equity and lending. The relationship is also found to differ by size. The bigger banks have a greater responsiveness of lending to capital than smaller ones.

The third chapter evaluates financial deepening in the West African Economic and Monetary Union (WAEMU) and compares their performance with other top performers in Africa. First, we use an unbalanced panel of 16 countries and 158 banks and document some key areas that need immediate policy attention. Next, we use the financial possibility frontier methodology to benchmark the performance of some important economies in our sample, with respect to each other and their estimated potential. We find that the WAEMU countries perform poorly compared to the control group and their own estimated potential. We make policy recommendations to solve this problem and increase financial depth.

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List of Abbreviations

BCBP	Basel Core Banking Principles
CPP	Capital Purchase Program
CRS	Constant Returns to Scale
ECB	European Central Bank
FDIC	Federal Deposit Insurance Corporation
FSAP	Financial Stability Assessment Program
GDP	Gross Domestic Product
IFRS	International Financial Reporting System
PDD	Public Data Distribution
RWA	Risk Weighted Assets
TARP	Troubled Assets Relief Program
WAEMU	Western African Economic and Monetary Union

Chapter 1

Macroprudential Regulation and Macroeconomic Activity

“The reason I raise the capital issue so often, is that, in a sense, it solves every problem.” - Alan Greenspan to the Financial Crisis Inquiry Commission

1.1 Introduction

The banking sector is one of the most regulated ones in the world today. There are different forms of regulation but capital regulation is of paramount importance because bank capital is an extremely good indicator of the financial soundness of the bank and also its risk taking abilities.¹ Bank equity is of utmost importance but has not really been given its due by traditional monetary macroeconomics albeit the trend seems to be changing recently. As has been documented in Van den Heuvel (2009), in most bank related work, the focus is on reserve/liquidity requirements and how they affect the decision to accept demand deposits. In these studies, the bank capital regulation is mostly discussed as an afterthought. My work focuses on bank capital regulation, capital buffers and the implications for the economy.

¹Berger, Herring and Szego (1995) and Santos (2001) contain surveys on the motivations behind capital regulation

The commercial banks in the United States face capital requirements based on the the Basel Core Banking Principles. In December 2011, the Government of the United States announced that the Basel III guidelines will be fully implemented soon.

I develop a general equilibrium model with a representative household, a representative bank and a non financial firms sector divided into a capital goods producing sector and a final goods producing sector. The household earns labor income by working in the final goods producing firms. They also hold deposits and unit equity in the bank earning a risk free rate of return and dividends. The bank tries to maximize shareholder value given that it is owned by the household. Every period, the bank must decide on how many deposits to accept, the volume of loans and the amount of dividend payout. Following Aiyagari and Gertler (1999), I define dividends as the difference between net assets at the beginning of the period minus net assets in the end of the period. The bank will also have to satisfy a capital requirement constraint imposed by the regulatory authority. This constraint simply states that the bank must be able to finance a certain fraction of it's new assets with it's own equity. In other words, this constraint can also be interpreted as a cap on the amount of deposits to accept. Lastly, I also impose that the dividend payments have to be non negative. This point will be discussed at length at a later stage but for now, this assumption is important for the capital constraint to have force. This assumption makes sense because it can be prohibitively expensive to issue new equity especially when the economy is experiencing a downturn.

The non financial firms sector is divided into two parts, the capital goods producers and the final goods producers. The capital goods producers produce the investment goods and sell it to the final goods producers who in turn use this capital and labor, from households, to produce the final output. The capital goods producers maximize profits and are subjected

to adjustment costs. The final goods producing firms are in need of resources to buy capital goods and they approach the bank for loans. These firms make zero profits.

I will allow for two exogeneous shocks namely a TFP shock and a capital quality shock following Gertler and Kiyotaki (2010). As in Gertler and Kiyotaki, I will think about this as a shock to the quality of capital rather than a physical depreciation shock. The bank will not realize the value of this shock till the decisions on the loans and deposits are made. This is one of the most crucial assumptions and will be discussed in the model section. One can also think of this as the amount of risk in the bank's balance sheet. If unregulated, the bank always has a tendency to take on excessive risk and that is the rationale for capital requirements in this model. I show that higher capital requirements can reduce the volatility in the economy. I do find a net gain in welfare as well. I also address a policy question about how strict should the regulation be? I show that with stricter regulation, the cost of insolvency is high and so the banks hold greater buffers and that can provide structural stability to the financial system by reducing volatility. Lastly, I modify the model to study countercyclical capital requirements which is one of the main tenets of the recent macroprudential regulation proposed under Basel III. Switching from a flat capital requirement regime to a countercyclical regime also seems to reduce volatility and raise welfare.

This paper contributes to two strands of literature. The first one is the literature that tries to understand whether capital requirements are a boon or a bane for the economy. Giammarino (1993), Hellman et al. (2000) talk about the benefits of capital requirements owing to the moral hazard problem arising from deposit insurance. Admati et al. (2010) advocate for capital requirements much higher than what they currently are. They advocate for capital requirements as high as 20-25 percent, as in Britain. This is much higher than

the current FDIC regulations which is around 8 percent, for tier 1 and tier 2 capital taken together. The question that immediately comes to mind is are there no costs of these capital requirements and how do they affect a bank's financial decisions? If there are no costs, why not have 100 percent capital requirements and have all bank assets financed by equity. Van den Heuvel (2008) talks about the welfare implications of these requirements and shows that it can lead to a decline in welfare. The rationale there is as follows. The capital requirements introduce a financial friction into the system by limiting the banks ability to create assets by accepting deposit type liabilities. The household values deposits as given deposit insurance, it is like holding an asset with a safe return. So do the benefits outweigh the costs? Or is it the other way around? What is the net impact on welfare? There has been no consensus reached on this entire issue. I try to explore this question in greater detail by incorporating both the costs and benefits of capital requirements in the same framework.

The second strand of literature that my work relates to is the one that explores how credit constraints might have an impact on the macroeconomy. Kiyotaki and Moore (1997), Bernanke, Gertler and Gilchrist (1999) and Gertler and Kiyotaki (2010) are some of the major papers in this literature, by no means an exhaustive list though. Gertler and Kiyotaki (2010) studies financial intermediation and it's effect on the business cycle. However it assumes an always binding flow of funds constraint which is necessary to derive some intuitive analytical results. Additionally, there is no capital requirement constraint in that model. I will try to explore macroprudential policy in this paper keeping the set up similar to Aiyagari and Gertler (1999) and Gertler and Kiyotaki (2010). I pose the problem a bit differently. I not only allow for an explicit capital requirement constraint but also acknowledge that such a constraint is only occasionally binding. The difference between

bank equity and the minimum requirements are defined as the capital buffer in the model. The bank holds a buffer capital so that it remains compliant with the regulatory authority's requirements should there be an economic downturn. This modification will also allow me to investigate the role of countercyclical buffers to stabilize the economy, in a modified version of the model. There is one immediate benefit of this approach. De Wind (2008) and Den Haan Ocaktan (2009) document that it might well be that the constraint is binding in the steady state but not off steady state. Even in that case, the steady state results are greatly affected. I try to circumvent this problem by allowing for capital buffers. However, it must be acknowledged that solving such models with occasionally binding constraints can be computationally intense. Standard perturbation methods cannot be applied. Some people put forward a global solution but at the cost of losing tractability. I will be using the penalty function method, originally proposed by Judd (1998), to solve this model. Intuitively, this method allows anything to be feasible but penalizes the objective in case the constraint is violated. This method has gained quite a bit in popularity and has been widely used in a variety of settings by Den Haan and Ocaktan (2009) and Preston and Roca (2007) among others.

The rest of the paper is organized as follows. Section 2 gives some stylized facts about the equity asset ratio of commercial banks in the United States. Section 3 introduces the model. Section 4 discusses the analytical solution. Section 5 poses the numerical solution method and the outline for solving the model, section 6 puts forward the calibration while section 7 modifies the model to study countercyclical capital requirements. Section 8 presents the results while section 9 concludes with plan for future research. The tables and figures have been placed in the appendix.

1.2 Stylized Facts about the Equity Asset Ratio

At the very outset, let us look at some stylized facts about the equity-asset ratios of the commercial banks in the United States. Capital regulations along the lines of Basel Core Banking Principles require the equity-asset ratio to be above a certain threshold called the minimum capital requirement. To be precise, Basel I proposed a flat risk based capital requirement of about 8%, tier 1 and tier 2 capital taken together. Basel II introduced a risk based capital requirement which is that the banks have to hold a certain fraction of their risk weighted assets, as capital. The risk weights could be determined by the bank's own risk management models. The risk weights on business loans were the highest while the ones on Government bonds received a zero risk weight. In what follows, I will document the movement of the equity-asset ratio over time and then demonstrate the comovement of this ratio with some key real macroeconomic variables.

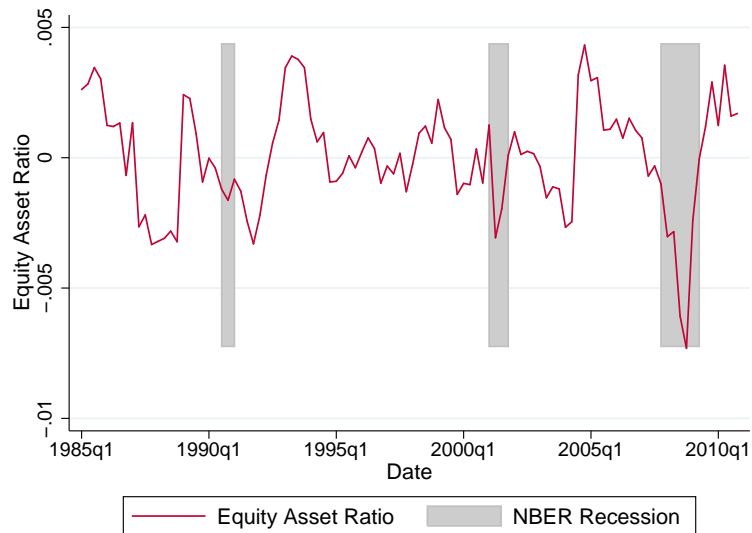


Figure 1-1: Time plot of the Equity-Asset Ratio

Figure 1-1 shows the time plot of the equity asset ratio since 1985.² The equity shown

²HP filtered with smoothing parameter equal to 1600

above is the banks common equity. The data covers a hundred and four quarters from 1985:Q1 to 2010:Q4. The data come from the Consolidated Report of Condition and Income, referred to as the Call Reports. The Federal Deposit Insurance Corporation requires all regulated financial institutions to file periodic information (financial and others). These data are maintained and published by the Federal Reserve Bank of Chicago.³ I plot the equity asset ratio superimposed on the NBER recession dates. As the figure shows, we have witnessed three recessions since 1985, the biggest one being the current one. The equity-asset ratio exhibits a procyclical pattern as one would expect. The reason for that is that during the recessions, the credit risk materialization is high and the amount of non performing assets (NPA) on a banks balance sheet rises which in turn causes the equity to shrink. If the banks are highly levered, then a small fraction of NPAs could bring about a substantial decline in equity and lead to insolvency. We will look into this issue later in the paper.

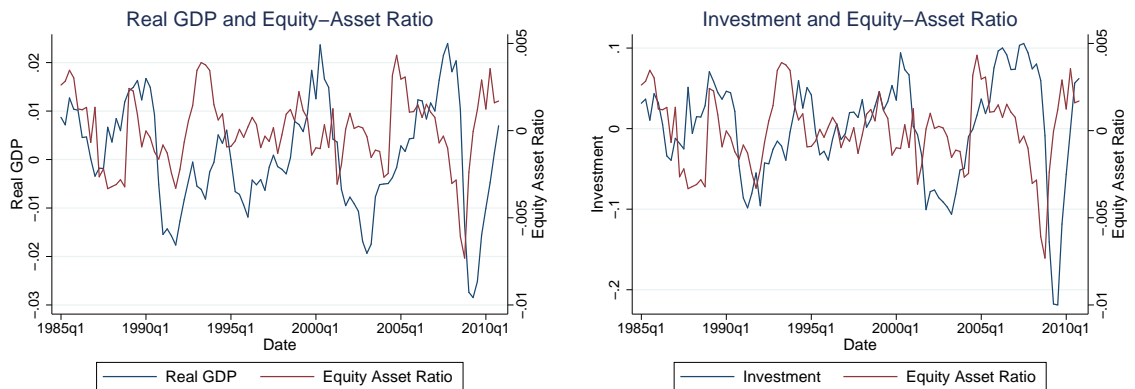


Figure 1-2: Equity-Asset Ratio, Real GDP and Investment

Figure 1-2 shows the comovement of the equity asset ratio with two main real variables namely the HP filtered GDP series and the gross private domestic investment in the

³This data is available at <http://www.chicagofed.org>

economy.⁴

The series co-moves or rather the equity-asset series seems to lead the series for output and investment. The data start at 1985 and it must be mentioned here that the Basel capital requirements were put into place for the first time in 1988-89. The potential cause for this comovement is the following. A decline in the equity-asset ratio triggered a shrinkage in the balance sheet of banks to remain compliant. The adjustment could not come from the numerator as it is difficult to raise capital, from the market, when the economic scenario is good. The liquidity crunch in turn meant a decline in investment and output. The data shows that this feedback takes roughly four quarters. Figure 3.2 below shows the correlation of the equity asset ratio with leads of investment and output gap. The correlation peaks at around 4 quarters and then tapers off.

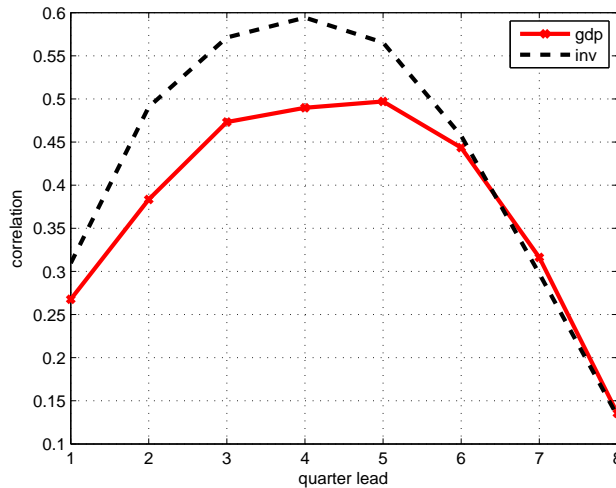


Figure 1-3: Equity Asset Ratio and lead GDP/Investment

Now that we have looked at the behavior of the equity-asset ratio it will be useful to define what we mean by capital buffers. The capital buffer is the excess of capital that a bank holds over and above the minimum level required by the regulator, the Federal Deposit

⁴The data are available in the FRED database of the Federal Reserve Bank of St. Louis

Insurance Corporation (FDIC) in the context of the United States. A pertinent question is why would the bank want to hold buffers? The bank will not want to hold buffers as it means forgone lending opportunities. On the other hand it might be prudent to hold buffers as that means the bank will not have to shrink its balance sheet, in an economic downturn, to meet the solvency requirements. What does the data say? It has been observed that the bigger banks in the United States, tend to hold zero or minimal buffers because they have implicit Government guarantees and better access to financial markets. The smaller banks on the other hand tend to hold larger capital buffers.

Since many of the bigger banks were highly levered during the period preceeding the financial crisis, a sharp decline in asset quality led to a substantial decline in the net worth forcing many financial institutions go below the minimum capital ratio. The Government had to intervene and bail out some financial institutions that were systemically important, by means of recapitalization. Given that the banking sector in the United States is pretty concentrated, it might be useful to look at the equity-asset ratio of the top four banks by assets namely J.P Morgan, Citibank, Bank of America and Wells Fargo. Figure (3) below shows how the capital asset ratio has evolved for these top four banks in the United States, in the years preceeding the financial crisis. These banks roughly account for two thirds of the market share in terms of assets and are hence a good proxy for the overall economy. Prior to the financial crisis, these banks remained very close to the statutory minimum requirements and even going below it sometimes.

A well capitalized bank need not engage in aggressive adjustment of asset portfolios in an economic downturn, to maintain the minimum capital requirements. Countercyclical

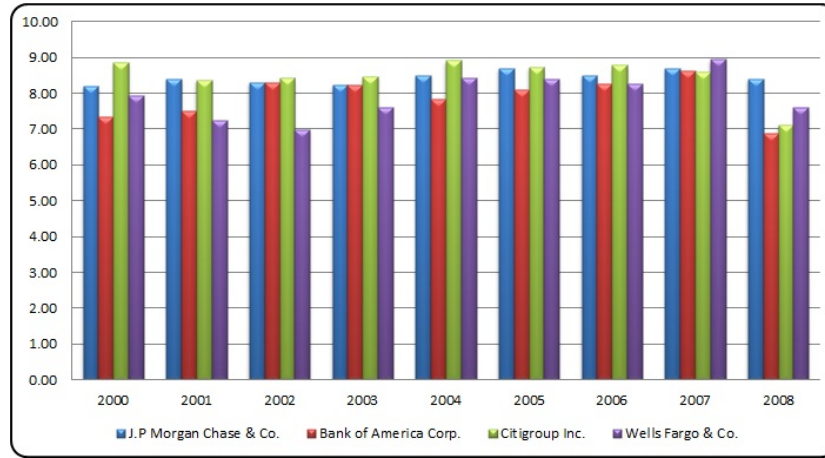


Figure 1-4: Capital/Asset Ratio of the top 4 BHCs

buffers⁵ will help the banks absorb losses. This will, thus, not result in a credit squeeze leading to a drop in overall economic activity. In the model I develop in the next section, I allow for endogenous buffers and try to explore this issue a bit more.

1.3 The Model

The model builds on the model by Aiyagari and Gertler (1999) and also incorporates some features of Gertler and Kiyotaki (2010). The main point of difference is that I allow for an occasionally binding capital constraint (countercyclical buffers) and try to approximate the solution by a penalty function method. I depart from the Modigliani-Miller framework by introducing a capital requirement constraint. These two features can be easily incorporated without significant costs in that the framework still remains tractable and yields some

⁵A simple way to compute the capital buffer is the following:

$$CB = \frac{Tier1 + Tier2}{RWA} - 0.08$$

where CB stands for capital buffer and RWA stands for risk weighted assets. In other words, it is the excess of tier 1 and tier 2 capital held by the bank over and above the regulatory 8% requirement. Tier 1 capital is the core measure of a bank's financial strength from a regulator's point of view. It primarily consists of common stock and retained earnings. It may also include non-redeemable non-cumulative preferred stock. Tier 2 capital represents supplementary capital such as undisclosed reserves, general loan-loss reserves and subordinated debt.

interesting results.

1.3.1 The Physical Environment

There are a continuum of non financial firms of mass unity. The non financial firms produce the final output of the economy by employing labor and capital as inputs. The production function takes the standard Cobb Douglas form which is:

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha}, \quad (1.1)$$

where A_t is the total factor productivity (TFP henceforth) and is governed by a Markov process and $0 < \alpha < 1$.

These firms producing the final output will hire labor from the households and buy capital goods from the capital goods producing firms. To buy these investment goods, the firm will have to approach the bank for loans. The price at which these loans are obtained and the price of capital goods is same and that means these firms earn zero profits. Denoting I_t as the aggregate investment and δ as the constant rate of depreciation, the law of motion for aggregate capital stock is given as:

$$K_{t+1} = [I_t + (1 - \delta)K_t]\theta_t, \quad (1.2)$$

where the interpretation of θ is as follows. Following Gertler and Kiyotaki (2010), I define θ as a capital quality shock. This is different from physical depreciation, which is captured by δ . The reference of the capital quality shock can be found in Merton (1973) and is a simple way of introducing an exogeneous source of variation in the value of equity. The aggregate output of the economy is divided into household consumption, C_t , and investment,

I_t . The resource constraint in this model is written as:

$$Y_t = c_t + c\left(\frac{I_t}{K_t}\right)I_t, \quad (1.3)$$

where the adjustment cost function exhibits constant returns to scale and will be discussed in detail in the section on calibration. I now introduce the other agents of the model namely the household that consumes, holds deposits and supplies labor, the representative bank that intermediates funds between the households and the manufacturing goods firms and also the non financial firms sector comprising the capital goods producers and the final goods producers.

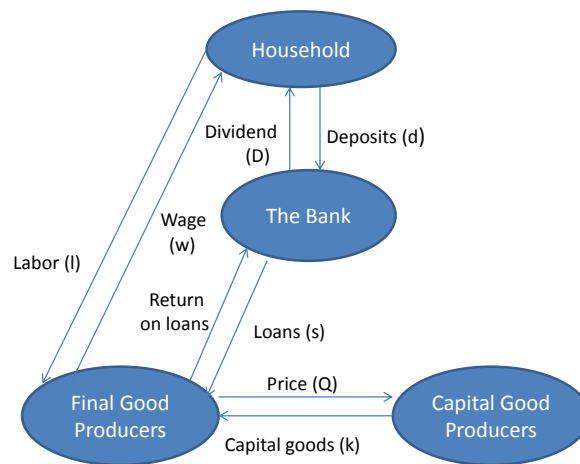


Figure 1.5: Flowchart of agents

Figure 1.5 above shows the flow of resources across the economy as has been explained in the preceding paragraphs.

1.3.2 The Household

In this model, I have a representative household that lends to non financial firms via the bank. The household does not hold capital directly but they put their deposits in the bank. They however own labor in exchange for which they earn wage income. They also own equity in the bank for which the bank pays dividends. The objective of the household will be to maximize its utility. The deposits that the household puts in the bank earn a one period risk free rate of return. The household preferences are given by:

$$U(c_t, d_t, l_t) = \frac{\left[ac_t^{1-b} + (1-a)d_t^{1-b} \right]^{\frac{1-\phi}{1-b}}}{1-\phi} - \chi \frac{l_t^{1-\varphi}}{1-\varphi} \quad (1.4)$$

where $(0 < a < 1)$, is the share parameter, $b, \varphi, \phi, \chi > 0$ and $b, \varphi, \phi \neq 1$, χ is the parameter measuring the disutility from supplying labor, φ is the Frisch elasticity of labor supply and $1/b$ is the constant elasticity of substitution between consumption and deposits. As b approaches zero, consumption and deposits become perfect substitutes. I abstract from many of the frictions in conventional DSGE modelling like habit formation of consumption, variable capital utilization and nominal wage and price rigidities. I however deviate from the Modigliani-Miller setup by having bank capital requirements, to be discussed shortly.

Let W_t denote the wage rate, d_t denote the deposits made this period, R_t the gross return on riskfree deposits and D_t the dividends received from the bank. This is justified given that the household owns the bank. The household budget constraint is then written as:

$$c_t + d_t = W_t l_t + D_t + R_t d_{t-1} \quad (1.5)$$

The left hand side shows the household expenditures every period. It consumes and sells deposits to the bank. The right hand side shows the total receipts that the household

earns. It consists of labor income, dividends and earnings from one period riskless deposits. The household maximizes the expected discounted utility subject to the budget constraint to yield the the optimality conditions as follows:

$$\frac{u'_l(c_t, d_t, l_t)}{u'_c(c_t, d_t, l_t)} = W_t \quad (1.6)$$

$$u'_d(c_t, d_t, l_t) + \beta u'_c(c_{t+1}, d_{t+1}, l_{t+1})R_{t+1} = u'_c(c_t, d_t, l_t) \quad (1.7)$$

where,

$$u'_c(c_t, d_t, l_t) = \left[ac_t^{1-b} + (1-a)d_t^{1-b} \right]^{\frac{b-\phi}{1-b}} ac_t^{-b},$$

$$u'_l(c_t, d_t, l_t) = \chi l_t^{-\varphi}$$

$$u'_d(c_t, d_t, l_t) = \left[ac_t^{1-b} + (1-a)d_t^{1-b} \right]^{\frac{b-\phi}{1-b}} (1-a)d_t^{-b}$$

Equation (7) differs from the standard Euler equation in that we now have our households derive utility from holding deposits. The right hand side shows the loss in utility by putting one unit more in deposits while the left hand shows the gain in utility from holding a unit deposit this period and the next periods gain in utility from consumption. Equation (6) is the standard equation governing the labor-leisure choice.

1.3.3 The Bank

The primary role of the bank in this model is to intermediate funds between the household and the non financial firms. This may be justified on the grounds that it minimizes transaction costs. The only way the firms can finance their investment is by taking loans from the bank. To finance these loans, the bank has to raise deposits from households and pay them a deposit interest rate. However, the bank has an additional capital requirement constraint to satisfy which stated in simple terms just says that the bank has to finance a certain

fraction of its risky assets (loans in this model) by the bank equity. Stated differently, this imposes a cap on the amount of deposits that can be raised. This hinders the bank from engaging in excessive risk taking and aggressive lending.

In this model, the bank will try to maximize the present discounted value of current and all future dividends while satisfying the flow of funds constraint, the capital requirement constraint and the non negative dividend constraint, to be introduced shortly. At the beginning of every period, the aggregate state is realized but not the financial shock. The bank has to decide on its volume of loans, deposits and dividend payout before this shock is realized and this assumption is of paramount importance as will become clear shortly. This risk of non compliance with the authority's requirements motivates prudential regulation in the model. The financial friction in this model is the equity regulatory constraint. And because of the timing issue briefly mentioned above, the bank will have an incentive to hold buffers and not remain close to the minimum stipulated level. If the bank maintains a capital that is close to the minimum requirements, then in the event of an economic downturn when credit risk materialization is high and loan recovery rates are low, the capital declines and there is a high probability that the bank might find itself non compliant with the regulations. Further, it is extremely difficult to raise fresh equity from the market during downturns. If the decline in this equity-asset ratio is sharp enough, it could also result in the loss of the entire charter value. To prevent that, the bank will have to cut back on lending in an effort to boost the equity-asset ratio. And this credit squeeze can further exacerbate the problem, something that we saw during the recent financial crisis.

In the context of the United States, the Federal Deposit Insurance Corporation requires all regulated financial institutions to provide some details (financial and others) every year. It monitors whether the financial institutions are sound enough and one of the main indica-

tors of financial soundness is the capital position of the bank. In FDIC parlance banks with more than 10 percent equity as a fraction of risk weighted assets are called well capitalized, those having 8-10 percent are called adequately capitalized, below 8 percent are undercapitalized, below 6 percent are significantly undercapitalized and those below 2 percent are critically undercapitalized.

If a bank falls below the 8 percent level, the FDIC first declares it as undercapitalized, if it is below 6 percent, then it can bring about a change in management and if the distress persists and the bank capital falls below 2 percent, the bank can be declared as insolvent and taken over. However, the bank will try to avoid being declared as undercapitalized because of loss in franchise value and losing its customer base. In my solution methodology, I adopt a penalty function approach where the amount of penalty imposed is proportional to the shortfall in capital and that is motivated by the FDIC penalty structure just described. I do not claim to replicate the realistic penalty imposed but my approximation certainly has elements of the idea. In what follows, I present the bank's optimization problem and try to provide an intuitive analytical explanation of the occasionally binding capital constraint before presenting the simulation results.

The bank maximizes the present discounted value of current and future dividends:

$$V_t = E_t \sum_{i=0}^{\infty} \Lambda_{t+i} D_{t+i} \quad (1.8)$$

The dividends are defined as the difference between net assets at the beginning of the period and the end of the period. It is written as follows:

$$D_t = [(Z_t + (1 - \delta)Q_t)\theta_t s_{t-1} - R_t d_{t-1}] - (Q_t s_t - d_t) \quad (1.9)$$

The first parenthesis shows the net assets (total receipts less payments due) at the beginning of the period while the second parenthesis shows the net assets at the end of the period. Z_t is the gross return on capital and can also be thought of as the dividend payment at t on the loans the bank had made in $t - 1$. Q_t is the price of capital (loans in this case) and s_{t-1} is the amount of loans made last period. As has been mentioned earlier, R_t is the riskless deposit rate. It must also be noted that the gross payoff from the asset depends on the capital quality shock, θ_t . The last equation can also be thought of as balance sheet constraint. Rearranging the terms we get:

$$Q_t s_t - d_t = [(Z_t + (1 - \delta)Q_t)\theta_t s_{t-1} - R_t d_{t-1}] - D_t$$

This equation simply states that the assets minus liabilities have to equal the bank capital (net worth) net of dividends. Unlike Gertler and Kiyotaki, I abstract from interbank market in this framework. In addition to the flow of funds constraint above, the bank also has to satisfy a capital requirement constraint or a margin constraint which can be written as follows:

$$[(Z_t + (1 - \delta)Q_t)\theta_t s_{t-1} - R_t d_{t-1}] - D_t - \kappa Q_t s_t \geq 0 \quad (1.10)$$

The most simple interpretation of this constraint is that the bank must finance a certain fraction (κ) of assets with its own resources. In other words, after the bank receives the payoff from assets net of deposit costs and pays out dividends, it must be left with sufficient funds to finance a fraction, κ , of the new loans it makes in that period.

It may be helpful to look at equations (9) and (10) together. Substituting out dividends in (10) yields:

$$(1 - \kappa)Q_t s_t \geq d_t$$

This is just setting a bound on the amount of deposits that the bank can accept. More precisely, the bank can, at most, finance $(1 - \kappa)$ fraction of its new loans with deposits. The remaining will have to be financed by the bank's own resources.

Lastly, we need one more condition for the capital constraint to have force. If it were easy to issue fresh equity instantaneously and costlessly, then the bank would have no incentive to manage its capital in a prudent manner because the market will always stand ready to bail it out. This assumption of not being able to raise fresh equity is intuitive. When the economic scenario looks grim, it is not possible to raise resources from the market. I will not make any attempt to model other institutional or commitment factors that might lead banks to use leverage rather than new equity issuance. In terms of the model, the following constraint is tantamount to saying that the bank cannot issue new equity. The only way to raise capital is by retained earnings.

$$D_t \geq 0 \tag{1.11}$$

We refer to the last constraint as the dividend constraint. I claim that if the capital requirement constraint is binding, the dividend constraint has to bind. To see that this is intuitive, let us consider the counterfactual. What would have happened if the capital constraint was binding but not the dividend constraint? In such a scenario, the bank could easily reduce the dividend payments and once again satisfy the capital constraint. So it is imperative that when the equity constraint is binding, dividend payments have been reduced to zero.

An important question to ask is why would the bank want to hold this excess equity in the first place? In other words, what is the role of capital in the model? This question is nested in a bigger question which asks what is the role of capital in general? To answer

this question we have to understand the bank's problem a little more. The key timing issue is that when the bank makes choices of loans, deposits and dividends, the capital quality shock is not realized yet. In terms of the real world, when a bank takes a decision on its loan portfolio, it does not know how many of those loans are going to default in the next period. If a lot of assets go bad, the bank equity can get wiped out quickly leading to insolvency. The bank will want to hold a buffer capital to prevent this from happening. In terms of the model, at the end of every period when the shock is realized, the total return from loans is known. Given the banks choice of dividends, it should also have enough resources to satisfy the regulatory constraint. If this is not the case, then the bank will have to face some unfavorable consequences. The bank will want to avoid such unfavorable consequences.

1.3.4 Capital Goods Producers

These firms produce the investment good by using the final output and are subjected to adjustment costs.⁶ They sell these goods to the final goods producing firms who need this capital and labor to produce their output. They choose investment by maximizing the following objective function:

$$\max E_t \sum_{\tau=0}^{\infty} \Lambda_{t,\tau} [Q_{\tau} I_{\tau} - c(I_{\tau}/K_{\tau}) I_{\tau}] \quad (1.12)$$

where,

$$c(I_t/K_t) = \left(\frac{b_1}{1-a_1} \left(\frac{I_t}{K_t} \right)^{1-a_1} + c_1 \right)$$

⁶The adjustment cost is a concave and increasing function that satisfies $c(\delta)=\delta$ and $c'(\delta)=1$ The only parameter that is of importance here is the curvature of this function or how sensitive is the investment-capital ratio to the price of capital (a_1). The value of this parameter is taken from the extensive literature on Q theory. Christiano and Fischer (1998), Jermann (1998), Boldrin et. al (2001) and Uhlig (2004) use a value of 0.23 for this parameter. The other two parameters are chosen to make the steady state independent of a_1 .

Profit maximization yields the following optimality condition.

$$Q_t = c_1 + \frac{a_1 b_1}{1 - a_1} \left(\frac{I_t}{K_t} \right)^{1-a_1} \quad (1.13)$$

1.3.5 Final Goods Producers

As mentioned earlier, these firms play a crucial role in the model because they are the ones who demand loans from the bank to purchase investment goods. Put differently, these firms issue securities to the bank and this security price will respond sharply to changes in the bank's net worth position thereby affecting investment a great deal. These firms operate a CRS technology and use labor and capital goods as the inputs for their production process. The production function is standard Cobb Douglas. The wage rate and the gross return are given as follows:

$$W_t = (1 - \alpha) \frac{Y_t}{L_t} \quad (1.14)$$

$$Z_t = \frac{Y_t - W_t L_t}{K_t} = \alpha A_t \left(\frac{L_t}{K_t} \right)^{1-\alpha} \quad (1.15)$$

α is the share of output going to capital. These goods producers earn zero profits. Exploiting perfect competition, the price of loans and price of investment goods are identical in this set up.

1.3.6 Market Clearing

We now close the model by listing the various market clearing conditions. There are four markets in the model described namely, the goods market, the labor market, the securities market and the deposit market.

The final output is used for consumption and investment and so the goods market

clearing condition or the resource constraint once again is:

$$Y_t = C_t + c\left(\frac{I_t}{K_t}\right)I_t \quad (1.16)$$

The security market clearing comes in next. Following Gertler and Kiyotaki, the total amount of securities issued/supplied must be equal to the aggregate capital accumulated and hence the condition is:

$$s_t = (I_t + (1 - \delta)K_t) \quad (1.17)$$

The labor market clearing condition requires that:

$$\frac{\chi L_t^\varphi}{C_t^{-\sigma}} = \frac{(1 - \alpha)Y_t}{L_t} \quad (1.18)$$

The deposit market clears by Walras law.

1.3.7 Timing

At the beginning of the period, the aggregate state of the economy i.e the TFP shock is realized. The bank shock or the capital quality shock is realized at the end of the current period. In other words, when the bank is making lending decisions it knows A_t but not θ_t . Next the capital quality shock is known and so is the bank's net income which is receipts from assets less deposit costs. If this is positive, the bank pays dividends and proceeds to the next period. If this is not the case, the regulator will set dividends equal to zero and prevent the bank from engaging in valuable lending. Note that if the net income is negative, the capital constraint is violated as well and this is precisely the role of capital in this model. If the bank does not hold a capital buffer, then it will be prevented from indulging in profit making opportunities in the event of a large unfavorable shock.

1.4 Analytical Results

In this section I present some analytical results and provide an intuitive explanation of the occasionally binding equity constraint. I present different cases when the constraint is binding or is likely to bind at some point in the future and explain the implications for the real sector. The bank will choose loans, deposits and dividends to maximize the present discounted value of dividends subject to the flow of funds, equity and dividend constraints. The first order conditions for the problem as given below.

$$E_t[\Lambda_{t,t+1}\gamma_{t+1}R_{t+1}^e] + (1 - \kappa)\mu_t = \gamma_t \quad (1.19)$$

$$E_t[\Lambda_{t,t+1}\gamma_{t+1}R_{t+1}] = \gamma_t - \mu_t \quad (1.20)$$

$$\Omega_t + \mu_t = \gamma_t, \gamma_t \geq 1, \quad (1.21)$$

In the last equation, $\gamma = 1$ if $D_t > 0$. Also the return on loans is given as:

$$R_{t+1}^e = \theta_{t+1} \frac{(1 - \delta)Q_{t+1} + Z_{t+1}}{Q_t}$$

Ω and μ are the multipliers on the flow of funds and margin constraints respectively. The following cases are possible:

Case 1: $\mu_t = 0$: This is the case when the equity constraint is not binding in the current period. The Euler equation assumes the standard form and the risk free rate is the inverse of the expectation of the stochastic discount factor. As mentioned earlier, if the margin constraint binds at time, t , or at any $t + i$, the dividend constraint must bind at time t . The intuition is straightforward. If the bank is very close to the minimum requirements and there is a possibility of violating the constraint, then the bank must reduce dividends

to zero and accumulate the retained earnings. If $D_t \geq 0$, then the Bank can easily reduce D and remain compliant with the regulations! The point is that in this case, we are in the standard asset pricing world. The bank accepts deposits and makes loans while remaining compliant with the regulations. The financial friction is not relevant in this case. However, as we will see in the following cases, this is not always the case. Let us explore a bit further.

Case 2: $\mu_t > 0$: The dividend on loans can be written as:

$$E_t R_{t+1}^e = \frac{\gamma_t - (1-\kappa)\mu_t - \text{cov}(\Lambda_{t,t+1}\gamma_{t+1}, R_{t+1}^e)}{E(\Lambda_{t,t+1}\gamma_{t+1})}$$

And, given the equation for risk free rate, I derive the expression for excess returns as:

$$E_t R_{t+1}^e - R_{t+1} = \frac{\kappa\mu_t - \text{cov}(\Lambda_{t,t+1}\gamma_{t+1}, R_{t+1}^e)}{E(\Lambda_{t,t+1}\gamma_{t+1})} \quad (1.22)$$

In this case, the equity constraint is binding in the current period. The asset pricing formulae will differ from the frictionless case. The risk premia is above the fundamental level which corresponds to the last case. When the capital constraint binds and the bank is not able to issue fresh equity instantaneously, it will have to reduce its holding of risk weighted assets to meet the requirement. In terms of the model, the bank is holding these securities issued by the final goods producers. When the bank is forced to unload some of its assets at a discount, it drives down asset prices and leads to a decline in investment and economic activity. This amplifies the economic downturn. An alternative and a different way of looking at the similar situation would be as follows. When the constraint binds, the bank will have to cut back on the amount of loans it finances and hence the final goods producers will not be able to purchase enough of investment goods and hence output and consumption would decline. Let us now turn to the final case.

Case 3: $\mu_{t+i} > 0$ for some $i \geq 1$: A similar mechanism will operate here. The covariance

between γ_{t+1} and R_{t+1}^e is negative and so if there is some chance that the constraint will bind in the future, then that could lead to a higher risk premium on assets currently. This in turn will lead to the complications discussed in the last case and bring about a slump in economic activity. We thus find that this theory is indeed very powerful. It does not really matter whether the bank is insolvent today or is likely to be insolvent in the near future. The implications for the real sector can be equally severe under both circumstances. The reason for the covariance being negative is the following. If γ_{t+1} is positive, that means the equity constraint is binding at $t + 1$. As discussed earlier, that will force the asset price at $t + 1$ to be below its fundamental level and hence the return on loans will be lower in $t + 1$.

1.5 Numerical Solution: The Penalty Function Method

In models with occasionally binding constraints, the standard perturbation methods cannot be employed as the policy function is non differentiable in the vicinity of the steady state. Some people may put forward a global solution by value function iteration methods but due to the curse of dimensionality, this may not be feasible if the state space is rich. I use the penalty function approach, originally proposed by Luenberger (1973) and Judd (1998). This approach has also been used by Preston and Roca (2007), Kim, Kollman and Kim (2009), Den Haan and Oaktan (2009) and more recently by Abo Zaid (2012).⁷

The idea is simple. We allow anything to be feasible but let the objective function have some unfavorable consequences if the constraint is violated. More precisely, the penalty

⁷More examples are Christiano and Fischer (2000), Mendoza (2010) and Brunnermeier and Sannikov (2011). Preston and Roca (2007) use an interior function to ensure satisfaction of intertemporal budget constraints and hence in their framework, this interior function (penalty) approaches infinity as the capital holdings of agents approaches the borrowing limit. Kim, Kollman and Kim (2009) use a similar method to solve a heterogeneous agent model with aggregate uncertainty. They show that the model does pretty well to minimize Euler equation errors provided the capital at the beginning of the period is large enough. Den Haan and Oaktan also use this methodology to solve a heterogeneous agent model. Abo Zaid (2010) applies this method to solve a model with the zero lower bound.

imposed is zero when the constraint is not violated and goes to infinity as the constraint binds tightly. Thus this model nests the original model. By doing this, we convert the original model with inequality constraints into one that has only equality constraints. Now we can apply standard perturbation methods to solve this model. There are a few penalty functions in the literature but I use the one presented in De Wind (2008). The primary reason for choosing this penalty function is that the function is asymmetric and generates a skewed response to shocks as we observe in the data. The table 1.1 below shows the skewness of some of the most important macroeconomic variables and the performance of the model with this asymmetric penalty function.

Table 1.1: Skewness (Model Vs Data)

	Investment	Output	Cap. Buffer
Data	-0.8462	-0.0054	-0.4782
Model	-0.7448	-0.0029	-0.5011

Always binding constraints and symmetric penalty functions do not generate such a model behavior. Further, penalty parameter in this specification can be altered easily to change the curvature and without affecting the model properties. The form of the penalty function is as follows:

$$P = \psi^{-2} \exp[\psi(\kappa Q_t s_t + D_t - (Z_t + (1 - \delta)Q_t)\theta_t s_{t-1} + R_t d_{t-1})]$$

The term within the parenthesis is the capital buffer. If this term is negative, it means that the bank is compliant with the regulatory requirements and there is no penalty. However, once this term becomes negative, there are some unfavorable consequences. The objective function of the bank is modified as follows:

$$V_t = E_t \sum_{i=0}^{\infty} \Lambda_{t+i} [D_{t+i} - \frac{d_{t+i-1}}{\psi^2} \exp[\frac{\psi}{d_{t+i-1}} (\kappa Q_{t+i} s_{t+i} + D_{t+i} - (Z_{t+i} + (1 - \delta)Q_{t+i})\theta_{t+i} s_{t+i-1} + R_{t+i} d_{t+i-1})]]$$

where the penalty function is normalized by the state variable to preserve the constant returns structure.

Once we incorporate the penalty function in the objective function, there is no need to write the capital requirement constraint separately while solving the problem. The parameter ψ governs the curvature of the penalty function and will be a key parameter in the analysis below.

On solving the above modified objective function subject to the budget constraint for the bank, we get expressions similar to the ones we obtained earlier and they are as follows:

$$E_t[\Lambda_{t,t+1}(\lambda_{t+1} + \Omega_{t+1})R_{t+1}^e] + (1 - \kappa)\lambda_t = \lambda_t + \Omega_t$$

$$E_t[\Lambda_{t,t+1}(\lambda_{t+1} + \Omega_{t+1})R_{t+1}] = \Omega_t$$

$$R_{t+1}^e = \theta_{t+1} \frac{Z_{t+1} + (1-\delta)Q_{t+1}}{Q_t}$$

$$\lambda_t + \Omega_t = 1$$

$$\text{and, } \lambda_t = \frac{1}{\psi} \exp\left[\frac{\psi}{d_{t-1}}(\kappa Q_t s_t + D_t - (Z_t + (1-\delta)Q_t)\theta_t s_{t-1} + (R_t d_{t-1}))\right]$$

λ is the punishment term in terms of the model terminology. In other words, it is the shadow valuation of violating the constraint. It is also the derivative of the penalty function with respect to the capital buffer.

Some important issues need to be discussed regarding the incorporation of a non linear punishment function. De Wind (2008) and Den Haan and Oaktan (2009) have extensive discussion on these issues. The main point is as follows. The penalty function is highly non linear and so we might be tempted to put in a lot of curvature by choosing a high value of ψ . However, typically we are restricted to lower order perturbations and so putting in a lot of curvature might not be the best idea. In this paper, the model is solved using a third

order approximation and so the problem is tackled here. The penalty function is highly non linear and I perturb at a sufficiently higher order. The choice of the order of approximation was also straightforward. A first order approximation is immediately ruled out given the non linearity of the penalty function. The third order is chosen to capture the asymmetric nature of the problem. In other words, the bank is not penalized for holding excess capital but only when it falls short of the minimum requirements. The standard deviation of the shocks are expected to affect all the terms in the policy function and not just the constant.⁸

Figure 1.6 demonstrates the class of penalty functions as the amount of curvature is changed. On the horizontal axis, I plot the level of buffers from negative five percent (equivalent to bank holding three percent capital) to positive two percent (equivalent to bank holding ten percent capital). On the vertical axis, I plot the penalty imposed for different levels of curvature, as a function of buffers. For $\psi = 130$, we get the most severe penalty while the reverse is true for $\psi = 50$. An important issue here is as follows. We can see that the greater the curvature the closer is penalty model to the original model. In my simulations, I work with a reasonably penalty i.e $\psi = 130$, which is permissible as the order of approximation is high in this particular case.

Ideally we want the constraint to be non binding in the vicinity of the steady state and so we want the penalty function to be flat in this region (slope should be small near the steady state). However, a flat penalty function means that the steady state is farther away from the steep part of the function and in that case, given the magnitude of the shocks, we might not get the desired asymmetry. I chose the value of ψ keeping these issues in mind

⁸Recently user friendly softwares like Dynare and Dynare++ have made it possible to perturb at any order. I do not adopt higher orders as in those cases, the impulse response functions tend to be noisy owing to the presence of high degree polynomials. That problem can be taken care of by the method of pruning but the results have been unsatisfactory thus far. However, these issues will not be discussed in any more detail, in this paper. In the following figure, I plot the penalty functions for varying levels of curvature.

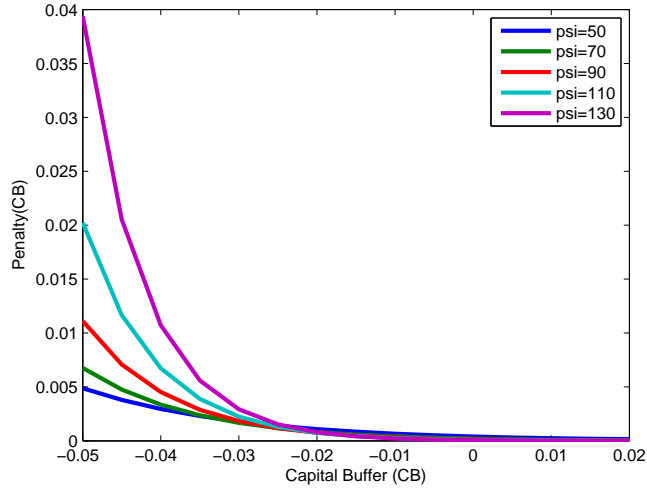


Figure 1-6: The Penalty Function for different levels of curvature

and also to match the skewness of some key macroeconomic variables in the data as has been documented earlier.

1.6 Calibration

I now discuss how the model was calibrated and in the next section I present some results of the numerical solution. Table 1.2 in the appendix lists the values of the parameters. Most of the parameters are standard. The discount factor, β , was chosen to get an annualized risk free return of four percent. The value of κ is set at eight percent which is in line with the Basel I requirements that the banks should hold eight percent of tier 1 and tier 2 capital as a fraction of it's risk weighted assets. Depreciation is set to be ten percent annually. The disutility of labor was calibrated to get a steady state labor supply of 0.3. Labor supply elasticity is set at two.

The two shocks in the model are the total factor productivity shock and the capital quality shock. They follow independent Markov processes as follows:

$$\ln A_t = (1 - \rho_A)\ln A + \rho_A \ln A_{t-1} + u_t$$

$$\ln\theta_t = (1 - \rho_\theta)\ln\theta + \rho_\theta\ln\theta_{t-1} + v_t$$

The TFP shock has more persistence and less volatility than the financial shock. The AR(1) coefficient and the standard deviation of this shock is in line with the standard business cycle literature being 0.9 and 0.01 respectively. Estimates of Solow residuals yield a highly persistent AR(1) process in levels. The standard deviation replicates US postwar quarterly output growth volatility. The calibration of the financial shock follows Gertler and Karadi (2011). I think of this shock as a rare event but conditional on occurrence, it follows an AR(1) process. The persistence of this shock is 0.75 and it has a standard deviation of 5 percent. The target is to get a ten percent decline in effective capital stock over eight quarters, investment remaining roughly same. Next we turn to the parameters of the utility function. Following standard business cycle literature, the inverse of the intertemporal elasticity of substitution, ϕ , is set equal to 2. The values of the share parameter, a , and the elasticity of substitution between consumption and deposits, b , are chosen to yield a deposit to consumption ratio of 0.7, a number that is consistent with the US data⁹.

1.7 The Countercyclical Capital Requirement Regime

Capital regulations provide structural stability to the financial system which in turn makes the economy more resilient to adverse shocks. However, the question that arises is what form of prudential regulation is the best one? The Basel Committee on Banking Supervision has laid out a set of core principles popularly referred to as Basel I, II & III. Without going into the minute details, Basel I required that banks hold a certain fraction of their risk weighted assets as capital. Basel II was basically a shift to a risk based capital regime where banks had to hold a certain fraction of their risk weighted assets as capital and the risk weights

⁹Van Den Heuvel (2008) and Chari, Kehoe and McGrattan have a discussion on this issue

were calculated by banks, based on their internal risk management systems. The debate that immediately cropped up is whether this transition generates extra procyclicality. This issue has been explored by many researchers and the evidence is mixed. But having said that, in the aftermath of the financial crisis, a consensus has emerged that there is need to amend the Basel II guidelines. This has paved the way for the discussion on macroprudential regulation. In this section, I will modify the model to study the implications of such a policy.

Without proceeding further to explore the other forms of prudential regulation in the context of the model, a discussion of the procyclicality issue is required. As has been mentioned earlier, some researchers have found evidence of capital requirements being procyclical. This is all the more true if the requirements are too low. In the event of an economic downturn, the credit risk materialization is high and loan recovery rates are low. In such a situation, the bank capital declines, sometimes to the extent that the bank finds it difficult to remain solvent. The adjustment in the capital asset ratio could come from the numerator or the denominator. But, since in times of financial distress, it is difficult to raise capital from the market, banks will fire sell assets to boost the capital asset ratio. This brings about a credit crunch and exacerbates the already existing problem. In other words, the capital requirement reinforces the business cycle. Transitioning to the Basel II regime has certain implications for procyclicality as well. The reason for that is risk in itself is cyclical in quantity and value. In economic downturns, the risk is higher (Borio et al. 2001). Also the price of risk is low in booms and high in busts (Lowe 2002). I now consider how the model can be used to analyze countercyclical capital requirements as it is known to control the procyclicality problem.

In this section, the problem is modified so that the capital requirement is time varying and countercyclical in nature. Essentially, we allow κ to vary with time and this is governed

by the following equations. The capital requirement constraint can be written as:

$$[(Z_t + (1 - \delta)Q_t)\theta_t s_{t-1} - R_t d_{t-1}] - D_t - \kappa_t Q_t s_t > 0$$

where κ evolves as follows,

$$\kappa_t = (1 - \rho_\kappa)\bar{\kappa} + (1 - \rho_\kappa)\Lambda_\kappa(\log Y_t - \log Y_{t-1}) + \rho_\kappa \kappa_{t-1} \quad (1.23)$$

If Λ_κ is positive, this means that the capital requirements are countercyclical. In good times, the banks will have to hold more capital and these requirements decrease in downturns. This should help us mitigate the procyclicality problem. The reason is that during a financial crisis, the capital requirements get lowered and so the bank does not have to embark on aggressive selling of assets and this spares the economy of the credit squeeze that we have observed.

More precisely, I perform two thought experiments and try to simulate the path of the economy in response to an adverse shock. The benchmark is the model with flat capital requirements with $\kappa = 0.08$. I consider a mildly countercyclical policy and an aggressive countercyclical policy. The first regime corresponds to a decline in capital requirements from 8 percent to 7.5 percent over six quarters after the financial shock. The second regime corresponds to the more aggressive countercyclical capital requirement regime with κ declining from 8 percent to 6 percent over six quarters. $\Lambda_\kappa = 10.5$ corresponds to the first case while $\Lambda_\kappa = 41.8$ corresponds to the latter.

1.8 Results

In this section, I discuss the results of the numerical solution. The tables are in appendix 1 while the figures can be found in appendix 2.

1.8.1 Exploring the Asymmetry in the Model

As mentioned previously, the penalty structure in the model is asymmetric and non linear. It might be helpful to look at the differential behaviour of the model in response to an equal magnitude positive and negative unit financial shock. The results are presented in figure

1.8.2 Changing the Capital Requirement

Figure 1-8 plots the impulse response¹⁰, of the key variables in the model, to a financial shock. The model was solved for three different levels of capital requirements i.e. eight, ten and fourteen percent. We observe a dampening in the amplification produced when the economy is hit by this adverse shock. Higher capital requirements means that banks have more resources to absorb shocks. The banks with lower capital are the ones that are highly levered and the impact of an economic downturn, on these banks, is much greater than their well capitalized counterparts. This is of paramount importance and this point needs to be stressed. In the period preceding the financial crisis, many financial institutions had leverage ratios between twenty and thirty. That meant that only a three and a half percent loss in assets would be enough to wipe out the entire bank equity. It is for this reason that higher capital requirements should be implemented. On the lines of Basel Core Banking Principles, there are other pillars to improve the financial health like quality of capital and liquidity requirements but that is beyond the scope of this paper. Here we focus only on capital requirements. Coming back to figure 1-8, as capital requirements increase, the bank does not have to adjust as much, to the shock, and so the economy witnesses a much subdued response. The benchmark case here is the one with eight percent capital

¹⁰The paper presents impulse responses that are non linear. As in the case of non-linear IRFs, the starting point matters. For this analysis, I start from the steady state for all the plots.

requirements. The steady state excess returns is about a hundred and thirty basis points.¹¹ The financial shock leads to a fall in the bank net worth and a sharp rise in the excess returns. The bank has to adjust by reducing its asset holdings. This leads to a decline in asset prices and investment. The output and consumption also decline accordingly. The fall in asset prices has a second round effect on the bank capital as well. This is the key mechanism that operates in the model. It must be noted however, that when the bank is well capitalized, this mechanism is weakened because the impact of a shock on the balance sheet is proportional to how levered the bank is.

1.8.3 Altering the Penalty Parameter

An interesting question to ask is how do the impulse response of the key variables in the model look as we alter the amount of punishment imposed in case the capital requirement constraint is violated. The value of the punishment parameter, ψ , controls the curvature of the penalty function and the penalty term λ . More precisely, it shows how severely the bank is punished once it violates the capital requirement constraint. In figure 1-9, I construct the impulse responses for two levels of the penalty term (λ) - a high and a low one. This is done by altering the value of ψ . If we look at the impulse response for the key variables, namely consumption, investment, capital and output, we find the shock is amplified a great deal with a higher value of ψ . The red line corresponds to the value of $\psi = 160$. The blue line represents a higher penalty corresponding to a value of $\psi = 130$. Note that the higher value of ψ though ad hoc, is not of much importance. We are trying to gain some intuition on a bigger policy question here. What this figure really shows that it might be a good

¹¹The average spread between mortgage rates versus government bond rates, BAA corporate bond rates versus government bonds and commercial paper rates vs T-Bill rates, in the pre 2007 period, was around a hundred basis points, Gertler and Kiyotaki (2010).

idea to impose a more stringent penalty if the bank fails to meet the capital requirements. If that is the case, the bank will try to maintain a capital buffer so that it does not have to shrink its balance sheet in a downturn to remain compliant with the regulations. The current FDIC penalties are such that the bank is declared critically undercapitalized only when the capital is 2 percent of risk weighted assets. That might be a bit too low and there is need to reformulate that structure, as it seems.

1.8.4 Time Varying Capital Requirements

Figure 1-10 plots the evolution of some key macro variables under three different capital requirement regimes. The red line is the model with flat capital requirements, the blue line is the model with mildly countercyclical capital requirements while the black solid line is the model with strongly countercyclical capital requirements.¹² Clearly the models with time varying requirements generate less volatility than the benchmark model with flat requirements. The intuition is straightforward. If the banks do not have to meet higher capital standards during a downturn, they will not have to adjust rapidly. This can help mitigate the credit squeeze problem. The banking sector will continue lending and financing investment. After the financial crisis, a consensus has emerged that there is need to shift to such macroprudential policies. My model makes a similar policy recommendation. The last row of table 1.4 shows that by introducing time varying capital requirements, the correlation between the bank capital and output is also reduced to a great extent suggesting a solution for the procyclicality problem.

¹²Please refer the section on Countercyclical Capital Requirements for a discussion of each of these regimes.

1.8.5 Welfare Implications

Lastly, let us address the question about welfare implications of capital requirements in the model. It has been mentioned in the literature that introduction of capital requirements might lead to a loss in welfare because it constrains the ability of banks to make loans by creating deposit type liabilities. This is true but there is no conclusive evidence on how severe this decline is. There might also be net gains from imposing such requirements as they provide stability to the financial system and forward looking individuals will incorporate this gain in their decision making. I compute the welfare under different levels of capital requirement and also under the countercyclical capital requirement regime. The objective is the households utility function which can be written recursively as follows:

$$W_t = U(c_t, d_t, l_t) + \beta E_t W_{t+1} \quad (1.24)$$

I report the welfare results in tables 3 and 5 in the appendix. Table 3 shows some steady state numbers of consumption and welfare under the flat capital requirement regime. The thought experiment here is as follows. I simulated the model for three different levels of capital requirement, namely eight, ten and fourteen percent. I ask the question, what is the welfare gain/loss from operating at 8% instead of say, 14%? Can we do better by shifting to a regime with higher κ ? To report the welfare in consumption terms, I compute what amount of adjustment in consumption (ΔC) would generate the same steady state welfare as the hypothetical benchmark case which is the case with $\kappa = 0.14$. It is observed that there is a decline in consumption and welfare. In other words, there can be net gains from implementing higher capital requirements. Higher capital requirements reduce use of retail funding but also prevent insolvency which casts a negative externality on the household

sector by choking off dividends. The benefits here are outweighing the costs.

How do the welfare figures look like if we transition to a world with countercyclical capital requirements? The results are presented in table 5. We can see that the welfare is higher under the countercyclical scheme than under the fixed capital requirements. In fact the strongly countercyclical regime generates a gain which is equivalent to about 1.11% of consumption. The intuition for these results is the following. During the downturn, the capital requirements are reduced and so the bank does not have to adjust as much to remain solvent. This prevents the credit squeeze and the overall decline in economic activity. The households being forward looking will anticipate this benefit. This is basically the justification for implementing macroprudential policies and the model supports this line of reasoning.

1.9 Conclusion

This paper builds a framework where the benefits and costs of capital requirements can be analyzed. It presents a set up to analyze macroprudential policy in a world of occasionally binding capital constraints. I show that higher capital requirements can actually help banks absorb shocks better. It is also shown that if the banks hold buffers, they will not need to sell assets, at a discount, in a downturn to remain compliant with the regulations but just reduce their buffers to absorb shocks. Moreover, stringent regulations might be necessary for banks to hold excess capital as holding capital can be costly. The model has some nice welfare results as well. Effect on welfare is a strong point of criticism against higher capital requirements. Based on my analysis, I propose that we might be operating in a suboptimal world with very low regulatory requirements. I show that this is indeed the case in my model. The model can also be easily modified to analyze countercyclical capital

requirements. Countercyclical buffers do make the economy resilient to downturns and in terms of welfare, the society is much better off under such regulations than the current set of policies.

In future work, the question I want to explore, is about the quality of capital. We can have capital requirements as high as twenty percent but is that number enough? What if the capital is not of sufficiently high quality? The other question that I am interested in exploring concerns the optimal timing issue in countercyclical capital requirement regime. If capital requirements are raised too quickly in booms, we might hamper growth while if they reduced too rapidly in downturns, bank defaults become more likely. So what should be ideal window while implementing such prudential regulations? I believe more work on these lines is required especially at this time when macroprudential regulations are being gradually put in place.

1.10 Appendix: Tables

Table 1.2: Calibration

Parameter	Symbol	Value
Discount Rate	β	0.99
Capital Requirement	κ	0.08
TFP shock persistence	ρ_A	0.90
Volatility of TFP shock	σ_u	0.01
Depreciation	δ	0.025
Penalty parameter	ψ	130
Share of Capital	α	0.33
Risk Aversion	σ	1.5
Mean of TFP	\bar{A}	1.00
Disutility of labor	χ	10.36
Inverse of Frisch Elasticity of labor supply	φ	0.5
Utility fn. share parameter	a	0.95
Intratemporal el. of Substitution	$1/b$	0.39
Persistence of Financial shock	ρ_θ	0.75
Volatility of Financial shock	σ_θ	0.05
Adjustment Cost Parameter	a_1	0.23

Table 1.3: Steady State Results

Variable	$\kappa = 0.14$	$\kappa = 0.10$	$\kappa = 0.08$
Consumption	0.4603	0.4600	0.4559
Welfare	20.29	19.98	19.32
Welfare Decline (in cons. terms)	–	0.35 %	0.43 %

Table 1.4: Business Cycle Statistics

	Output	Consumption	Cap-buffer	Investment
Standard Deviations				
Data	0.0115	0.0056	0.0093	0.0419
Model	0.0188	0.0058	0.0099	0.0320
Model (cc κ)	0.01001	0.00529	0.00954	0.02801
First Order Autocorrelations				
Data	0.88	0.83	0.93	0.87
Model	0.96	0.89	0.99	0.92
Correlations with Output				
Data	1.00	0.88	0.96	0.91
Model	1.00	0.92	0.91	0.96
Model (cc κ)	1.00	0.79	0.64	0.94

Table 1.5: Welfare Results

Variable	Flat κ	cc κ	Strongly cc κ
Welfare	19.32	20.07	21.78
Welfare Gain (in cons. terms)	--	0.76%	1.11%

1.11 Appendix: Figures

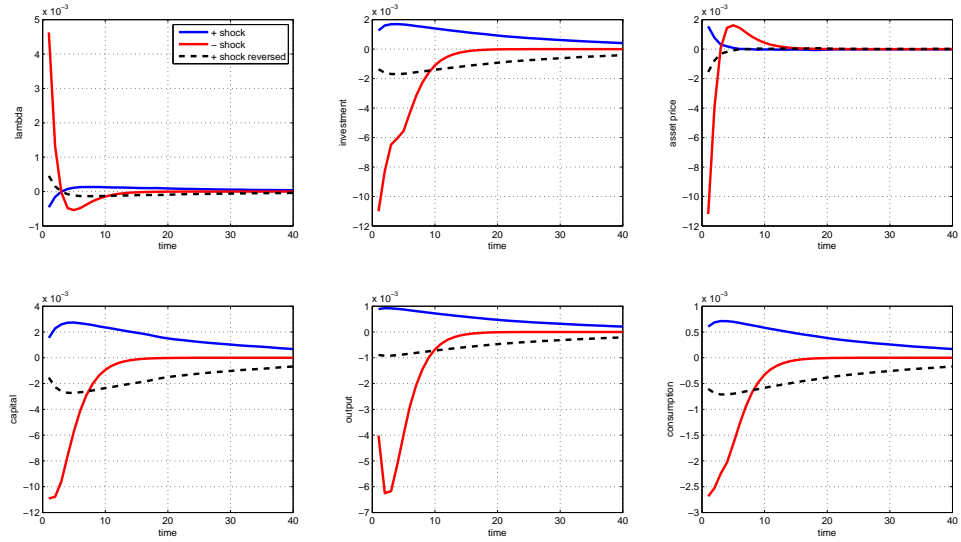


Figure 1-7: Asymmetric Response to a unit Financial Shock

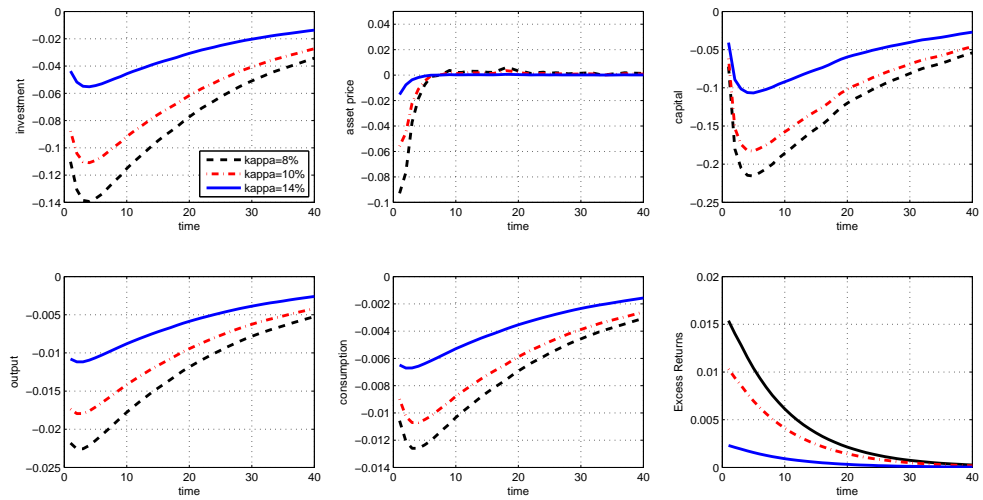


Figure 1-8: Altering the Capital Requirement

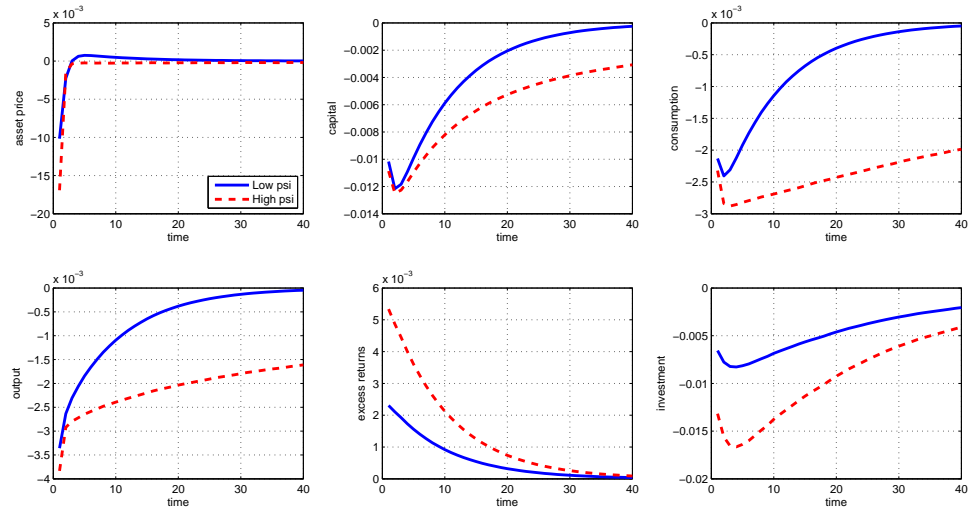


Figure 1-9: Altering the Penalty Parameter

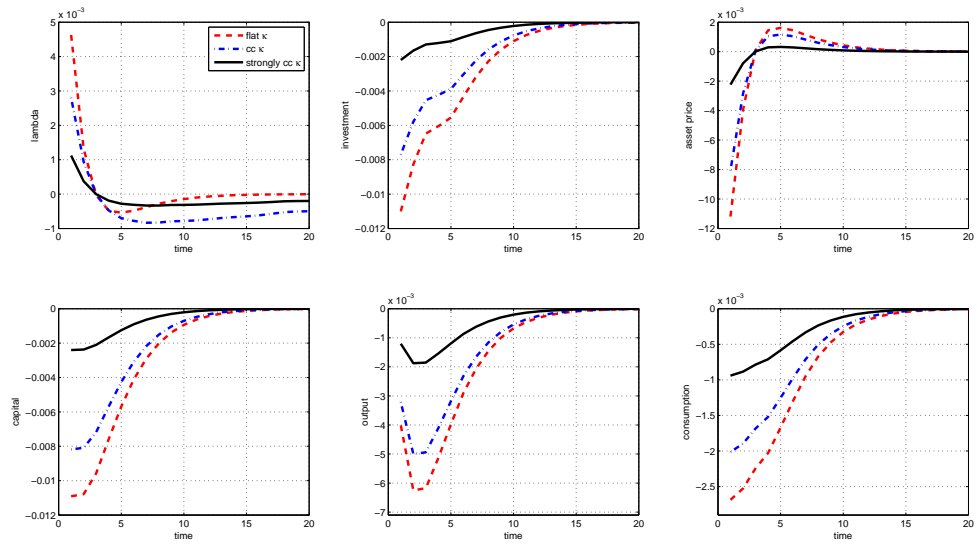


Figure 1-10: Flat vs countercyclical capital requirements

Chapter 2

Bank Capital and Lending: An Analysis of Commercial Banks in the United States

2.1 Introduction

The banking sector is one of the most regulated ones today and bank capital regulation is of utmost importance. The commercial banks in the United States face capital requirements based on the the Basel Core Banking Principles. In December last year, the government announced that the Basel III guidelines will be fully implemented soon. The banks in the United States have to hold about eight percent capital (Tier 1 and Tier 2)¹ as a fraction of it's risk weighted assets. They do not default at eight percent but are declared undercapitalized. The regulatory authority, which is the Federal Deposit Insurance Corporation in the context of the USA, takes over the bank only if the bank capital is less than two percent of the risk weighted assets in which case the bank is said to be critically undercapitalized. The cost of defaulting or even being undercapitalized could be substantial. It could lead to the

¹Tier 1 capital is the core measure of a bank's financial strength from a regulator's point of view. It primarily consists of common stock and retained earnings. It may also include non-redeemable non-cumulative preferred stock. Tier 2 capital represents supplementary capital such as undisclosed reserves, general loan-loss reserves and subordinated debt.

bank's franchise being revoked in the worst case scenario. Obviously, the bank would take steps to ensure such a state never occurs. Hence they take decisions on how much capital to hold and this choice is indeed a difficult one for reasons that will be discussed later in the paper. Banks do not have complete control over their regulatory capital asset ratios simply because the returns on the risk weighted assets are stochastic. In an unfavourable state, the bank may well find itself below the minimum capital requirements even though it maintained the eight percent level. Thus the banks hold buffers to absorb such negative shocks. In a bad state of nature, this buffer will act as a cushion and prevent the capital ratio going below the minimum stipulated ratio.

In the aftermath of the financial crisis, there has been some work that tries to explore the linkages between financial and real sectors. The effect of changes in bank capital on lending decisions is the primary determinant of the linkage between financial conditions and real activity. This paper takes a step towards quantifying this important relationship. During the financial crisis, when the likelihood of a credit crunch was still under debate, the relation between bank capital and bank lending was a key policy concern. Likewise, when the Troubled Asset Relief Program (TARP) moved to inject capital into banks through the Capital Purchase Program (CPP), the impact of the program on real activity largely focused on the effect of these injections on bank lending. More recently, this question has re-emerged in light of proposals announced by the Basel Committee on Banking Supervision to raise banks' capital requirements and limit leverage ratios².

There are not many recent estimates for the U.S of the impact of changes in bank capital on lending. In the aftermath of the 1990-91 recession, many observers debated whether the newly introduced capital regulations along the Basel guidelines were hindering

²See Berrospide and Edge (2010)

lending. Although this debate did not yield a consensus, it did result in the development of empirical models that sought to quantify the effect of bank capital on bank lending. For example, Hancock and Wilcox (1993, 1994) estimated models relating changes in individual banks' loan growth to measures of loan demand and bank capital. Similarly, Berger and Udell (1994) specified an equation relating the growth rate of various bank assets to different measures of bank capital ratios. Finally, Bernanke and Lown (1991) developed state-level equations linking bank loan growth to bank capital ratios and employment, for a single state (New Jersey).

In this study, we mainly ask one question. We ask how the bank capital affects the lending decisions of banks. Our sample only includes commercial banks. The data comes from the Call Reports database, maintained by the Federal Reserve Bank of Chicago. We conduct the analysis only for the lower three quantiles by total assets and this point will be made clearer when we explain the endogeneity issues and identification strategy. Our results appear more in line with the results obtained by Berrospide and Edge and the estimates we obtain are substantially smaller than suggested in statements by US treasury officials post the financial crisis. The reasoning that Berrospide and Edge have in their paper, reconciling the two sets of results, applies to our case as well and so for the benefit of the reader, we put forward the justification here.

The statements from the US Treasury suggest that a \$1 increase in bank capital leads to a \$8 - \$10 increase in lending capacity. These magnitudes are reasonable once we make the assumption that banks actively manage their assets to maintain a constant leverage. This view is based on a scatterplot from Adrian and Shin (2007). We reproduce this figure below. The sample period used in figure 2.1 is 1963 to 2006, the same as that employed by Adrian and Shin. The constant leverage ratio is apparent from the scatterplot. This suggests a

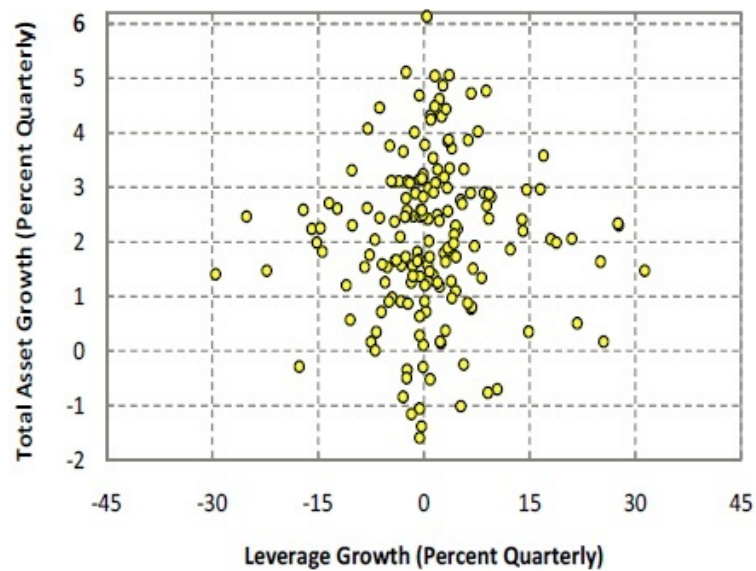


Figure 2-1: Asset and Leverage Growth (1963-2006)

very active management of assets by commercial banks. This implies that a change in bank capital has a magnified effect with the scaling factor equal to the leverage ratio.

Now, how do we compare our regression results with the Adrian-Shin scatterplots? We must acknowledge the major structural change that took place in the banking sector following the introduction of the Basel Banking Accord, in 1989. Our sample starts from 1996 while Adrian and Shin sample start from 1963.³ To find out what effect this choice of sample period has on the analysis, consider the figure 2-2 below, from Berrospide and Edge (2010).

The left panel shows relation between asset and leverage growth prior to Basel (1963:Q1-1989:Q4) and this is consistent with the Adrian and Shin assumption. The interesting part is the right panel which plots data post Basel i.e 1990:Q1-2008:Q3. As can be seen from comparing these plots, the feature of the data that has led to the view that commercial banks actively manage their assets to maintain constant leverage is much more of an artifact

³Berrospide and Edge start from early 90s as well, i.e after the introduction of the Basel Accord.

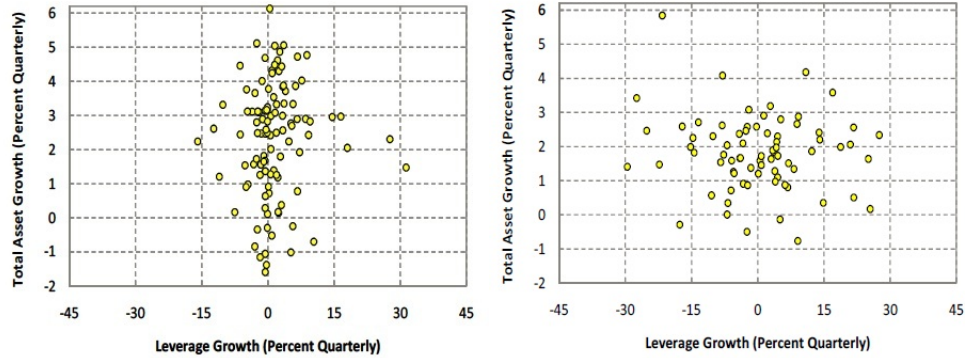


Figure 2.2: Asset and Leverage Growth (Pre & Post Basel)

of the early part of the sample and is considerably less evident in the latter part. Indeed, in the latter part of the sample, there is no obvious correlation between asset and leverage growth.

The rest of the paper is organized as follows. Section 2 surveys the literature, section 3 describes the dataset we use, section 4 explains the empirical model, variables and methodology, section 5 presents the estimation results and section 6 concludes. The graphs and tables are placed in the appendix.

2.2 Related Literature

The impact of bank capital on lending is one of the key questions that arises when we want to explore macro-financial linkages. It is hence surprising that there are not many recent estimates for the United States of the impact of changes in bank capital on lending. In the aftermath of the 1990-91 recession, Hancock and Wilcox (1993, 1994) estimated models relating changes in individual banks' loan growth to measures of loan demand and bank capital. The methodology developed in Hancock and Wilcox (1993) could be problematic and a bit difficult to interpret for the following reason. They measure response of lending to excess/shortfall of capital from a target ratio. The issue here is that this equation

could be misspecified. If the target is poorly specified, then the excess/shortfall is also poorly specified. Berger and Udell (1994) specified an equation relating the growth rate of various bank assets to different measures of bank capital ratios. Finally, Bernanke and Lown (1991) developed state-level equations linking bank loan growth to bank capital ratios and employment, for a single state (New Jersey).

If we look beyond the United States, there are some studies that seek to quantify this relationship between bank equity and credit extension. Peek and Rosengren (1997), Puri, Rocholl and Steffen (2010) use loan applications from German Landesbanks to examine the effect of shocks to capital on the supply of credit by comparing the performance of affected and unaffected banks. Gianetti and Simonov (2010) use Japanese data to perform a similar exercise concerning bank bailouts. These papers do find a relevant role for capital in determining loan volumes, although they do not explicitly compare the magnitudes of the effects they find with those implied by the constant leverage view. Another group of papers use firm and bank loan-level data; these include Jimenez, Ongena, and Peydro (2010), who use Spanish data, and Albertazzi and Marchetti (2010), who use data on Italy. These papers find sizeable effects of low bank capitalization and scarce liquidity on credit supply.

The papers using Spanish and Italian data find a larger value for the impact of capital on loans. Santos and Winton (2010), using US loan level data (syndicated loans), obtain relatively small effects of bank capital on lending. Also, Elliot (2010) uses simulation based techniques to find small effects of capital ratios on loan pricing and loan volumes for U.S. banks. De Nicolo and Lucchetta (2010) use aggregate data for the G-7 countries and conclude that credit demand shocks are the main drivers of bank lending cycles. Our magnitudes of this effect are modest and appear consistent with other papers that employ U.S. data.

2.3 Data and Stylized Facts

For this analysis we prepared an unbalanced panel of commercial banks balance sheet data. Our data covers sixty quarters from 1996:Q1 to 2010:Q4. The data is obtained from the Consolidated Report of Condition and Income, referred to as the Call Reports. The Federal Deposit Insurance Corporation requires all regulated financial institutions to file periodic information. These data are maintained and published by the Federal Reserve Bank of Chicago.⁴

The appendix provides a detailed documentation of the data. Regulatory capital requirements have undergone a few changes ever since their inception in the late 1980s. In 1985-1986, banks had to hold a primary capital exceeding 5.5% of assets. By the end of the decade, this rose to 7%. Effective December 31, 1990, the banks were required to hold a total capital of 7.25% as a fraction of risk weighted assets with the Tier 1 capital being at least 3.25%. These ratios further got hiked to 8% and 4% following the implementation of Basel I in the end of 1992. Then on, these ratios have remained fairly stable. In our sample, we do not encounter such sudden changes.

Table 2.1 in the appendix gives the summary statistics of the data. We have 343,752 observations covering around nine thousand commercial banks in the United States. We ignore the top and bottom deciles. To elaborate, we rank the banks by average size (measured by log of total assets) over the sample period and then drop the top decile and bottom deciles. The rationale for this stems from our instrumenting strategy. Our main instrument for the capital ratio is the interaction between land price changes and the real estate lending of a particular bank. We think that it is only the relatively smaller/medium sized banks

⁴Historic data from 1976 to 2010 is available at the Chicago Federal Reserve website. Beginning with the March 31, 2011, call reports are only available from the FFIEC Central Data Repository's Public Data Distribution site (PDD)

that are more sensitive to local land price movements. The bigger banks are much more diversified across states and hence we leave them out for the sake of this analysis. The bottom decile is dropped as these are extremely small in terms of total assets and have limited or no access to capital markets. These banks are the ones that report extremely high capital asset ratios and hence we treat them as outliers for our analysis. We only include banks that have a capital adequacy ratio less than or equal to 25%. We also drop the banks if we find that the loan growth rate exceeds 50% in a particular quarter. This is indicative of a merger and hence we do not include these banks in this study.

As the table shows, we collected data on three different measures of capital, namely the capital adequacy ratio (CAR), the tier 1 capital ratio (Tier 1 Capital) and the common equity to asset ratio (ETA) but in this chapter, the results reported will only be for the first two as these two are the regulatory ratios which is what we are interested in. The medium sized banks in the United States appear to be well capitalized by all measures. They are well above the Basel 8% minimum capital requirements and that is a positive point to note from the table.

We work with a host of loan to asset ratios in this paper as our data is not merger adjusted and so if we had looked at loan growth rates per se, that would not be a satisfactory analysis. The loan data we gather comprises loans made to the real estate sector, commercial and industrial loans, agricultural loans and loans to households. LTANR shows the loan to assets ratio where we leave out real estate loans and include the other three categories. LTAR is the loans made to the real estate sector normalized by total assets. The mean real estate lending as a fraction of total assets is about 47% which is quite substantial. This justifies our instrument all the more. The banks are sufficiently exposed to the real estate sector and hence their bank capital will be a lot more sensitive to real estate price

movements.

The other variables we have are the growth in the house price index ($g-HPI$). It shows that on average the real estate prices have risen by about 7.4%, in the sample period. This data was collected from the FRED database.

We now look at some stylized facts in the data. It is useful to look at some of the key variables, in our analysis, for the US at four different points in time, within our sample. Figure 3 shows the distribution of the loan to asset ratios of banks in our sample. Figures 4-6 show how the distribution of bank capital has changed over time. It clearly shows that towards the end of the sample there are many more banks who operate at low levels of capital. The fourth panel represents this all the more being after the financial crisis during which the balance sheets of most banks shrunk leading to a loss in equity. The mass to the left of the 10% capital level has increased irrespective of the measure of capital we use. Figures 7 and 8 show the time series of these variables. The grey bands show the NBER recession dates. This helps us understand the behavior of these variables over time. It is clear how the house prices and the bank capital fell dramatically during the recent financial crisis. We show all three measures of bank capital as discussed earlier.

2.4 The Empirical Framework

The empirical model we wish to estimate is the following:

$$\text{Log}(LTANR_{i,t}^s) = \alpha_i + \nu_s + \beta K_{i,t} + \gamma_1 BSC_{i,t-1} + \gamma_2 Macro_{t-1} + u_{i,t} \quad (2.1)$$

Where,

- $\text{Log}(LTANR_{i,t}^s)$ is the logarithm of the loan to asset ratio of bank i at time t , with

headquarters located in state s . Here the loans are all the loans made by the bank except the real estate loans. To elaborate on this point a little more, the loans included in this variable are the industrial/commercial loans, loans to individuals and the loans to agriculture. The only other major lending sector is the real estate sector which is not included in LTA, the reason for which will be outlined below. It is evident that the change in the dependent variable is the growth rate of the loan to asset ratio.

- K is a measure of bank capital. We will be working with two different measures of capital. First, we use the capital adequacy ratio which is the Tier 1+ Tier 2 capital as a fraction of risk weighted assets. Second, we use the Tier 1 ratio as a robustness check.
- BSC consists of lagged bank specific controls which include loan chargeoffs as a measure of risk in the balance sheet and total securities normalized by total assets as a measure of liquidity in the banks balance sheet.
- Macro controls for the state of the overall macroeconomy i.e. aggregate shocks. We use the growth rate of real GDP as the control.
- α_i and ν_s are the bank and state fixed effects respectively.

2.4.1 Endogeneity Issues and IV Estimation

We are aware that the equation above suffers from a potential endogeneity problem. In practice, the banks decide on it's lending strategy and retained earning decision simultaneously. In other words, the equation above assumes that the bank sequentially decides on how much capital to hold and then how many loans to make. In practice, however, this might not be a reasonable assumption. We think that such decisions are not sequential but

simultaneous. Hence we find a suitable instrument for bank capital. Our instrument is the banks exposure to the real estate sector. Our first stage regression is the following:

$$K_{i,t} = \alpha + \theta \overline{LTAR}_{i,t-1}^s * \% \Delta LP_t + controls_{i,t-1} + v_{i,t} \quad (2.2)$$

Here,

- \overline{LTAR} is the average loans made to the real estate sector over total assets in the last three quarters. It measures the exposure of a bank to this particular sector. The greater the exposure, the greater will the bank capital be sensitive to real estate price movements.
- LP is the real estate price index at the state level
- $controls_{i,t-1}$ includes bank specific and macro controls as discussed earlier.

Here we instrument bank capital by the interaction between the change in real estate prices and real estate exposure of the bank. If the real estate prices in a particular state increase, then the impact on bank capital depends on the banks exposure to the real estate sector. If a bank has sufficient exposure to the real estate market, a rise in land price means that the value of its assets have risen and that in turn means that the bank now has greater equity. On the other hand, if the bank has limited exposure to the real estate sector, this rise in land prices will have a much subdued impact on its capital. We report the regression results later to prove the validity of the instrument but it is clear that our instrument is correlated with the bank capital and uncorrelated with the error because our dependent variable is the loans made to all sectors except the real estate sector. This is not correlated with land price movements or loans made to real estate in the last three quarters.

2.5 Regression Analysis

Table 2 shows the first results for the impact of bank capital on lending. This is the baseline specification and we add controls sequentially here. Columns (1)-(4) use the capital adequacy ratio as the measure of capital while columns (5)-(8) use the tier 1 capital ratio. Columns (1) and (5) include no additional controls in the regression. The magnitude of β is significant at the 1% level. We see that on introducing controls, the coefficient remains significant at the 1% level.⁵ The baseline results show a subdued impact of bank capital on lending. A 1% point increase in the CAR leads to an increase in the growth rate of banks loan to asset ratio in the range of 54bps and 96bps. We now look into other specifications of the model and also study different measures of capital to assess the robustness of our estimates.

Table 2.3 shows the results of our main IV estimation. The dependent variable is still the growth rate of loan to asset ratio where the loans exclude those made to real estate sector. The first two columns show results from our entire sample which is all commercial banks except the top and bottom decile. The next two columns show results from banks above the median and the last two columns show results for banks which are below the median. We also use the two measures of capital for each of the three samples. We include state fixed effects in the regression to capture within state changes. We also include lagged macroeconomic and bank specific controls. However, before we discuss the results listed in this table, perhaps we should briefly comment on the first stage regression which is the direct estimation of equation (2). The results are shown in table 2.4. We use the percentage change in real estate prices times the three quarter average of real estate loan to asset ratio

⁵We use lagged liquidity and chargeoffs as bank specific controls and lagged GDP growth as the macro control variable.

as the instrument. The first and second columns predict the CAR and the tier 1 capital respectively. The next two columns are for the bigger banks while the last two are the smaller banks. The sign on the instrument is positive which means that with a rise in asset values, the bank capital increases, assuming that liabilities are roughly constant.

Now let us look at table 2.3 in detail. The coefficient on the capital ratio remains positive and significant at the 1% confidence level across all specifications. We find a moderate response of lending to bank capital. As discussed earlier, the magnitudes are much smaller when compared to Adrian and Shin (2007) but are in agreement with other papers that use US data and where the sample period starts after the introduction of the Basel Banking Accord in 1989. The other thing to note is that the effect of capital on lending is bigger for the relatively bigger banks as shown by columns (4)-(6). The reason could be as follows. The bigger a bank gets and the more capital it has, it can give out more loans than a smaller bank. Bigger banks tend to enjoy greater access to financial markets and government guarantees than smaller banks. Hence their LTA growth rate responds more to capital than their smaller counterparts. For the whole sample, we find that a 1% increase in capital leads to an increase in the growth rate of LTA which ranges between 0.54% and 0.96% depending on what measure of capital we use. For the sample above the median this effect ranges between 1.00% to 2.8% while for the smaller banks, the range is between 0.30% and 0.46%. Berrospide and Edge do not consider separate studies for the different groups of banks as we do but using bank holding company data, their estimates are quite close to ours.

2.6 Conclusion

This paper seeks to quantify the impact of bank capital on lending as this is one of the key policy questions while analyzing financial-real sector linkages. Using a subset of the commercial banks in the United States and an innovative instrumenting strategy, we find a modest impact of bank equity on lending behavior. Our estimates are consistent with other recent studies in the literature that have worked on US data. Some earlier papers do report much higher estimates but they do not account for the structural change in the banking sector following the introduction of the Basel Core Banking Principles. We find that a 1% increase in capital leads to an increase in the growth rate of LTA which ranges between 0.54% and 0.96% depending on what measure of capital we use. For the bigger banks this effect ranges between 1.00% to 2.8% while for the smaller banks, the range is between 0.30% and 0.46%.

2.7 Appendix

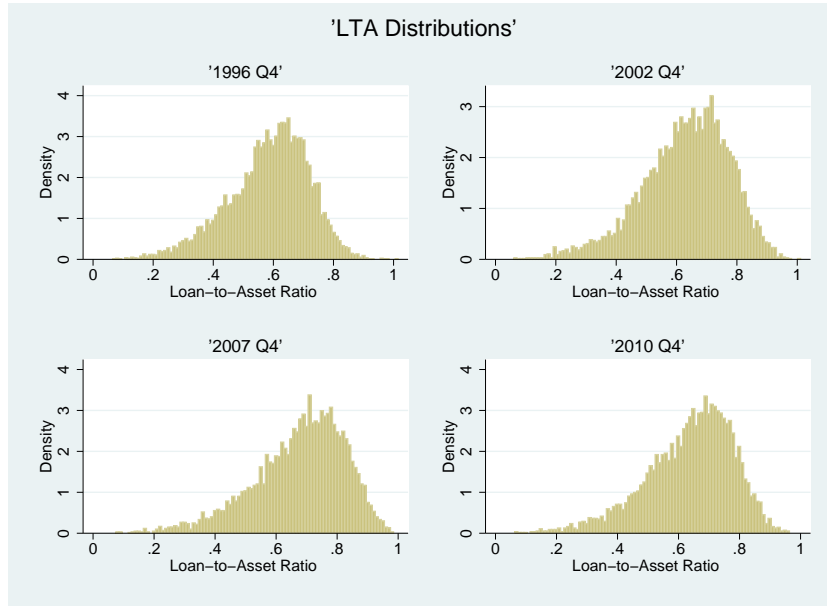


Figure 2.3: Distributions of the Loan to Asset Ratio

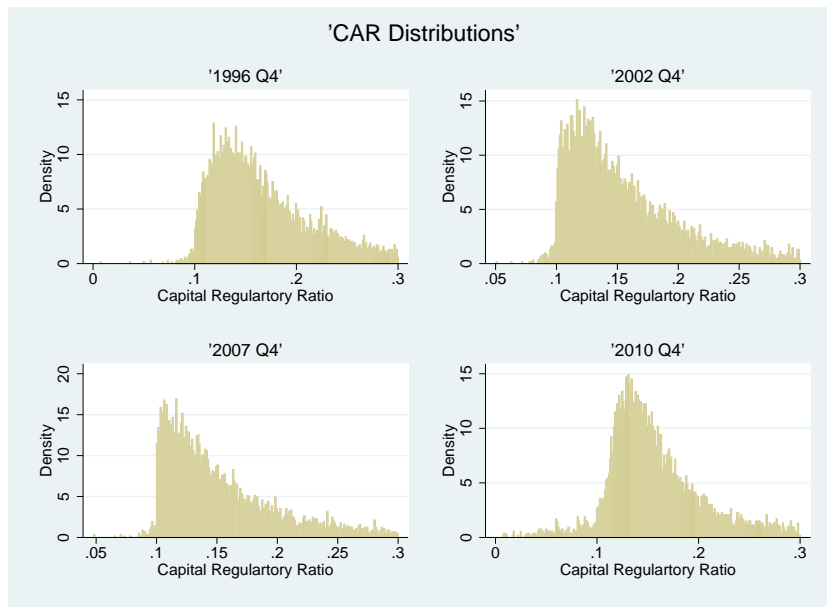


Figure 2.4: Distributions of the Capital Adequacy Ratio

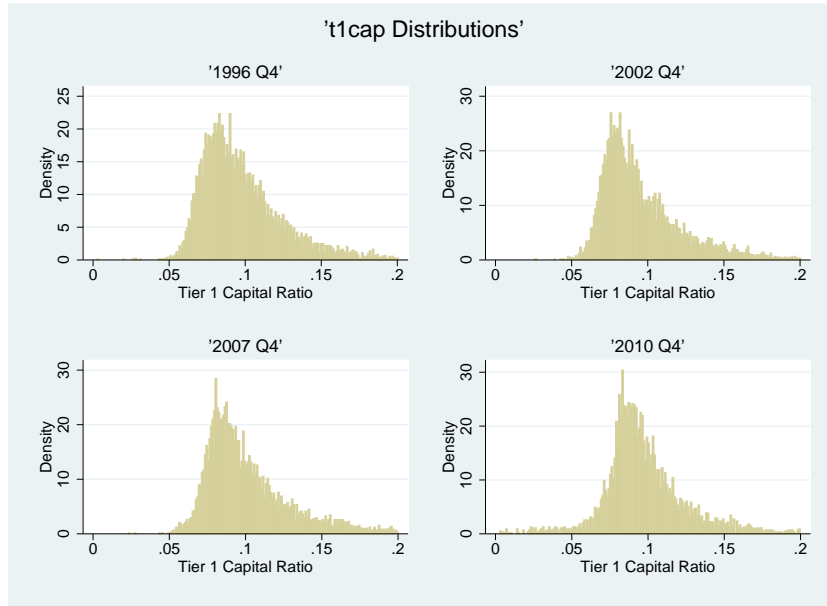


Figure 2-5: Distributions of the Tier 1 Capital Ratio

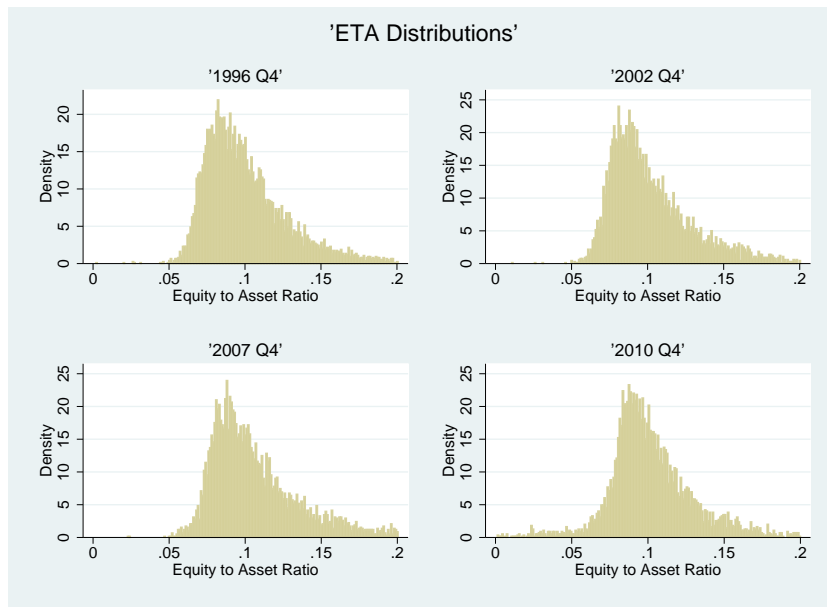


Figure 2-6: Distribution of the Equity to Asset Ratio

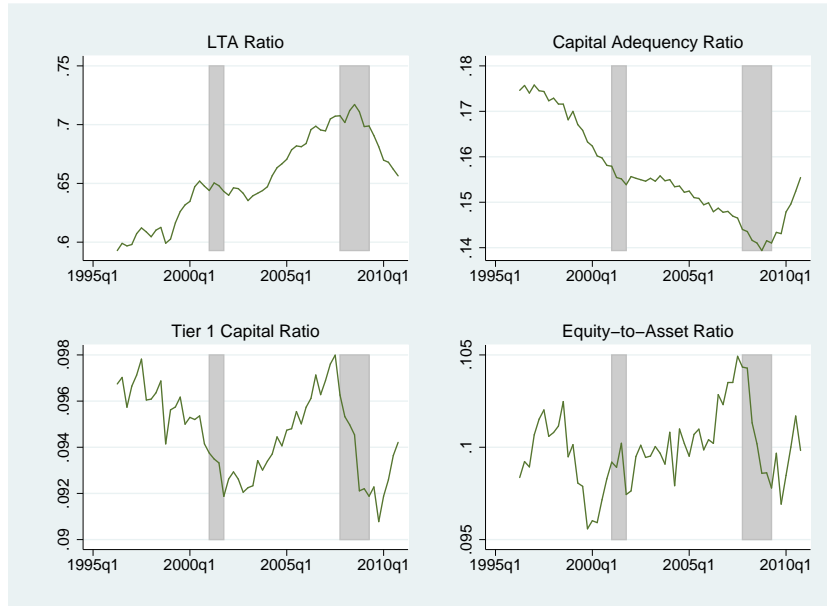


Figure 2-7: Time series of key variables

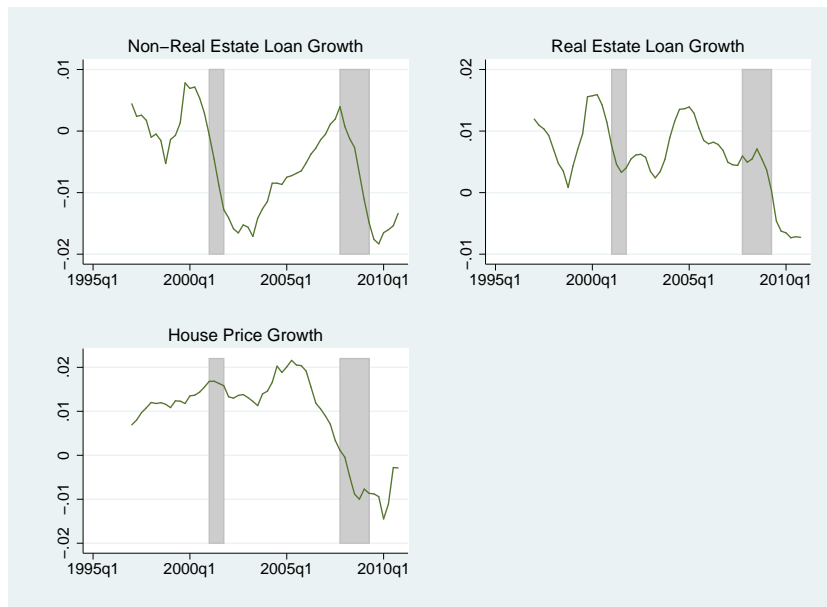


Figure 2-8: Time Series of key variables

Table 2.1: Summary Statistics

variable	P1090 Mean	P1090 Median	P1090 Std. Dev	P1050 Mean	P1050 Median	P1050 Std. Dev	P5090 Mean	P5090 Median	P5090 Std. Dev
CAR	.1540137	.1357274	.0628767	.1494959	.132637	.0587232	.1703565	.1491529	.073754
LTA	.6618504	.6804286	.1422631	.6691721	.6877862	.1389038	.6353646	.6513489	.1508657
Tier 1 Cap	.0944965	.087746	.0284753	.0925495	.0864958	.0268008	.10154	.0933873	.0328989
ETA	.1000612	.0930245	.03069	.0984914	.0918667	.0295065	.1057397	.0979309	.034036
LTAR	.4728172	.4787601	.1690381	.4905286	.4978052	.1640772	.4087473	.4013956	.1712086
LTANR	.1890332	.1691712	.1196852	.1786435	.1588451	.1165974	.2266173	.2100842	.1231296
LTAR Growth	.0051585	.0034024	.0601283	.0046708	.003375	.0567165	.0069228	.0035328	.0710885
LTANR Growth	-.0062324	-.007669	.0930919	.0046708	.003375	.0567165	-.0045057	-.0061382	.0984303
HPI Growth	.0073549	.0091837	.0169058	.0074148	.0091973	.0174381	.0071381	.0090787	.0148196
Liquidity	.2102305	.1830245	.1447389	.2175472	.1902032	.1528398	.2028939	.1772485	.1357383
Chargeoffs	4.115694	4.189655	1.85726	3.533396	3.610918	1.713573	4.647981	4.736198	1.823503
GDP Growth	.006325	.0067952	.0070901						

Table 2.2: IV Regression (Adding Controls Sequentially)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	LTANR	LTANR	LTANR	LTANR	LTANR	LTANR	LTANR	LTANR
	CAR	CAR	CAR	CAR	T1 Cap	T1 Cap	T1 Cap	T1 Cap
Capital	0.269*** (0.012)	0.251*** (0.016)	0.424*** (0.046)	0.540*** (0.079)	1.632*** (0.258)	0.355*** (0.022)	0.832*** (0.122)	0.964*** (0.173)
L.liquidity		-3.770*** (0.202)	-5.770*** (0.560)	-7.026*** (0.922)		-1.069*** (0.047)	-1.341*** (0.126)	-1.366*** (0.149)
L.chargeoffs			0.007* (0.004)	0.012** (0.005)			0.084*** (0.015)	0.099*** (0.021)
L.growth				-6.770*** (1.272)				-3.908*** (1.063)
State Effects	Y	Y	Y	Y	Y	Y	Y	Y
Observations	343,266	143,394	126,336	126,336	343,266	143,394	126,336	126,336
Number of id	9,015	6,870	6,729	6,729	9,015	6,870	6,729	6,729

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.3: Main IV Regression

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	LTANR	LTANR	LTANR	LTANR	LTANR	LTANR
	CAR	T1 Cap	CAR	T1 Cap	CAR	T1 Cap
	All	All	Big	Big	Small	Small
CAR	0.540*** (0.079)		1.004*** (0.350)		0.298*** (0.038)	
T1 Cap		0.964*** (0.173)		2.77*** (1.819)		0.459*** (0.059)
L.liquidity		-7.026*** (0.922)	-12.034*** (3.927)	-1.444** (0.577)	-4.301*** (0.473)	-1.187*** (0.094)
L.chargeoffs		0.012** (0.005)	0.099*** (0.021)	0.007 (0.198)	0.011*** (0.004)	0.048*** (0.009)
L.growth		-6.770*** (1.272)	-3.908*** (1.063)	-16.059*** (6.133)	-14.798 (10.957)	-2.301*** (0.630)
State Effects	Y	Y	Y	Y	Y	Y
Observations	126,336	126,336	66,191	66,191	60,145	60,145
Number of id	6,729	6,729	3,340	3,340	3,389	3,389

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.4: First Stage Regression

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CAR	TI Cap	CAR	TI Cap	CAR	TI Cap
	All	All	Big	Big	Small	Small
Instrument	5.740*** (1.487)	3.258*** (1.086)	2.625 (1.719)	1.023 (1.273)	13.521*** (2.794)	8.790*** (2.005)
L.liquidity	11.438*** (0.509)	0.537** (0.250)	11.094*** (0.611)	0.203 (0.324)	11.741*** (0.790)	0.839** (0.370)
L.chargeoffs	-0.059*** (0.008)	-0.123*** (0.006)	-0.029*** (0.010)	-0.109*** (0.008)	-0.096*** (0.012)	-0.143*** (0.009)
L.growth	14.924*** (1.077)	5.394*** (0.662)	17.031*** (1.305)	5.870*** (0.834)	12.945*** (1.737)	5.072*** (1.041)
Constant	14.775*** (0.127)	10.913*** (0.062)	13.662*** (0.140)	10.536*** (0.080)	14.583*** (0.175)	10.716*** (0.084)
State Effects	Y	Y	Y	Y	Y	Y
Observations	126,467	126,467	66,262	66,262	60,205	60,205
R-squared	0.079	0.030	0.092	0.030	0.073	0.031
Number of id	6,820	6,820	3,383	3,383	3,437	3,437

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Chapter 3

Financial Depth in the WAEMU: Benchmarking Against Frontier SSA Economies

3.1 Introduction

The importance of financial depth for broad-based economic growth is widely recognized. The empirical literature has demonstrated that countries with higher levels of financial sector depth tend to grow faster.¹ Financial depth, which measures access of private sector to credit, has been particularly challenging to improve in sub-Saharan Africa. Deeper financial systems with wider access to credit help promote and support entrepreneurship and social mobility and thus are vital for broad-based economic growth. Therefore, identifying factors that promote financial deepening, and explains differences in financial depth across countries on that dimension, warrants closer examination.

In Sub-Saharan Africa (SSA), financial depth has been uneven across regions and remains a critical policy challenge despite progress over the past two decades. The focus of

¹See Levine and Zervos (1998) and Khan and Senhadji (2000).

this paper is to examine where the West African Economic and Monetary Union²(WAEMU) stands relative to some selected economies in the SSA and which factors may help explain this performance. The benchmark group is comprised of some frontier SSA countries, the High Growth Non-Oil Exporters (HGNOEs).³ The novelty of this paper is that: i) it focuses on a group of African countries with shared monetary and financial policies, and compares it to a group of high performing countries in SSA, and; ii) it uses two complementary empirical approaches to compare the two groups of countries: first, a regression analysis to identify the factors that explain the difference in financial depth between the WAEMU and the control group, and second, a case study to benchmark the biggest and most financially advanced economy in the WAEMU (Cote d'Ivoire) against a comparable country in the control group (Mozambique). The case study is based on the financial benchmarking methodology developed by the World Bank (Beck et. al., 2010; Feyen and Kibuuka, 2012). Our analysis is based on a panel of 16 countries (eight countries from the WAEMU, and eight HGNOEs) over the period 1997-2009. Over that time period, FSAPs (the IMF's Financial System Assessment Program) were performed on both Cte d'Ivoire and Mozambique, which helps us account for the structural reforms underlying the difference in financial deepening between the two countries. Moreover, the period is sufficiently long to capture the lagged impact of policy reforms on improving the financial environment. The results are consistent with the literature: we show that stronger rule of law, infrastructure, and credit information collection and dissemination have a strong impact on financial sector depth.

²The WAEMU countries are Benin, Burkina Faso, Cte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo. The eight countries are all members of the CFAF currency zone.

³The High Growth Non-Oil Exporters (HGNOEs) are the countries with an average per capita growth rate of at least 3 percent during 1995-2009. Eight frontier SSA countries fall into this category: Botswana, Cape Verde, Ethiopia, Mauritius, Mozambique, Rwanda, Tanzania, and Uganda. (cf. IMF, African Regional Economic Outlook, October, 2010).

3.2 Stylized Facts and Empirical Literature Review

Basic indicators of financial depth show that the WAEMU is lagging relative to the control group. The figure below depicts the development of credit to the private sector and broad money in terms of GDP. In the WAEMU, the ratio of private sector credit to GDP increased marginally from 12 percent to 17 percent between 1997-2009, while it accelerated from 17 percent to 37 percent of GDP in the control group, as is seen in the left panel of figure 3-1. The ratio of broad money to GDP, a measure of the degree of monetization, followed a similar profile. Broad money relative to GDP grew from 31 percent to 52 percent in the benchmark countries, while rising from 20 percent to 29 percent in the WAEMU over the period, as shown in the right panel of figure 3-1, below.⁴

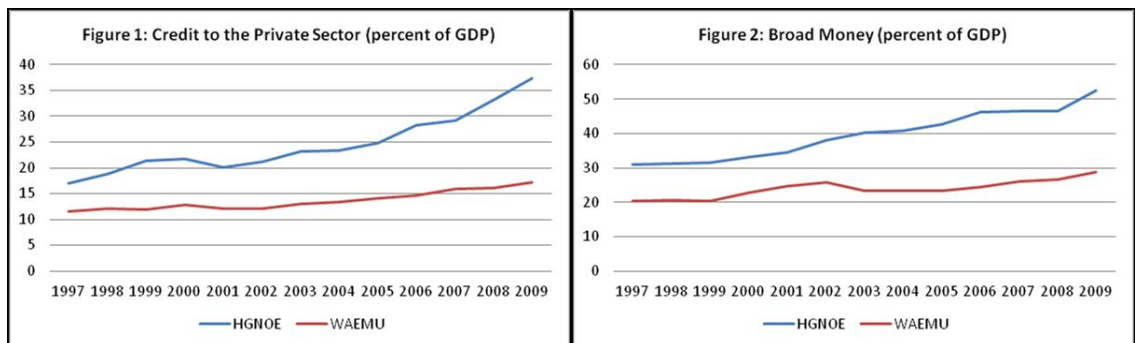


Figure 3-1: Private Sector Credit to GDP Ratio

The banking system in the WAEMU is not only shallower compared to the benchmark countries, but it is also less profitable. Return on assets, weighted by bank assets, remained constant around 1.3 percent in the WAEMU, half of the level in HGNOEs, as is evident from figure 3-2. The contrast is also striking for return on equity. In explaining the differences in financial depth across countries, the empirical literature distinguishes between

⁴Source: Bankscope

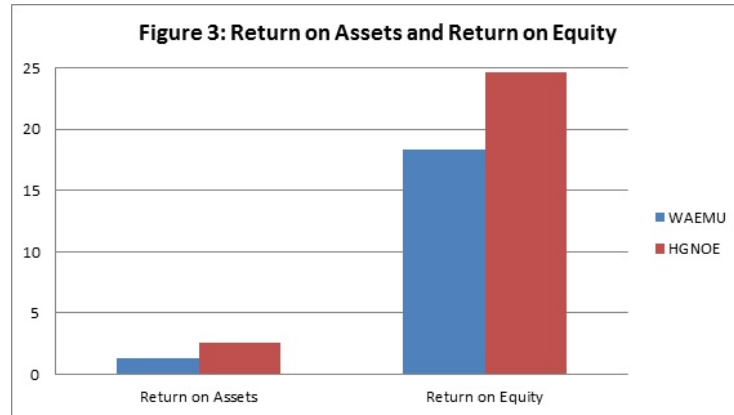


Figure 3.2: Return on Assets and Equity

structural factors and policy factors.⁵ Structural factors are country-specific characteristics that cannot be altered by policies in the short run. These include the overall level of economic development and other characteristics such as population size and density, age dependency. The overall level of development, measured by per capita income, can effect financial depth through elevating demand for financial services and higher supply of savings. Countries with larger populations and higher population density can have deeper financial penetration and lower cost of financial intermediation from economies of scale. The share of non-working young and old populations (age dependency) affects savings and lending patterns. Policy factors are those that may impact the banking environment including macroeconomic policies (such as inflation, fiscal balance, and debt), institutional policies (regulatory and supervisory framework, accounting and disclosures practices, credit information and contract enforcement), and other financial sector reforms that may liberalize credit markets or enhance market competition.

There is evidence in the literature that both structural factors and macroeconomic policies can have an impact on financial deepening. Levine (2003) and Claessens and Feijen

⁵Demirguc-Kunt (2006) provides a comprehensive survey of the explanatory variables used in the analysis.

(2006) show the importance of overall economic development, measured by per capita income. On macroeconomic policies, Detragiache et al. (2005) find a negative impact of inflation on financial depth, while Boyd and al. (2001) highlight the non-linear relationship between inflation and financial development.

Looking beyond macroeconomic performance, there is also evidence that contract enforcement, credit infrastructure, and market liberalization play an important role. Using bank-level cross sectional data, Demetriades and Fielding (2011) investigate the determinants of individual banks' loans in the WAEMU. Their results suggest that banks are reluctant to lend because the infrastructure to screen and monitor borrowers is not developed. Governance in all its aspects (government effectiveness, control of corruption, and rule of law) also plays a role. Detragiache, Gupta and Tressel (2005) find that contract enforcement and property rights matter in financial development. Sacerdoti (2005) explains the low ratio of credit to private sector to GDP by a deficiency in the supporting institutional framework. Ghura, Kpodar, and Singh (2009) explain low financial depth in the CFA franc zone countries through the weaker legal, contractual, and institutional environment in the region compared to SSA. Using the financial liberalization index constructed by McDonald and Schumacher (2007) that captures some aspects of financial reforms (credit controls, interest rate controls, informal financial sector), Ghura, Kpodar, and Singh (2009) find that this aggregate index is related to greater depth in financial development.

3.3 The Regression Analysis

In this section, we analyze the difference between financial depth in the WAEMU and in the comparator group, after controlling for other relevant factors. In our empirical analysis, the measure of financial sector development is credit to the private sector as a share of GDP. The analysis is based on a panel of 16 countries over the period 1997-2009 at annual frequency. The panel analysis allows us to track the WAEMU countries over a relatively long time horizon and compare them with other peer economies. We use macroeconomic data from the IMF International Financial Statistics, and indicators on institutions, political stability, and credit infrastructure from the World Bank. We estimate credit to the private sector as a share of GDP using the following model:

$$S_{c,t} = \alpha_1 + \sum_j \beta_j X_{c,t}^j + \sum_m \beta_m Y_{c,t}^m + d_t + \nu_{i,t} \quad (3.1)$$

Where the vector $X_{c,t}$ contains macroeconomic variables specific to country ‘c’ at time ‘t’. $Y_{c,t}$ contains country-specific institutional and policy variables. d_t is a vector of dummy variables that takes a value 1 if the country belongs to the WAEMU region and zero otherwise.

The macroeconomic indicators include the log of GDP per capita and the log of inflation. Per capita GDP measures the overall level of economic development and is expected to positively affect credit to the private sector. As income rises, demand for financial services increases and that might lead to better penetration. Also with higher income, there might be

greater savings, which means the banks will have more resources to lend from. Low inflation is considered as a sign of macroeconomic stability, which promotes financial intermediation. Thus the expected coefficient sign for inflation is negative.

Policy and institutional variables include indices on rule of law, political stability, credit coverage, internet coverage among adults, and the quality of contract enforcement. The rule of law represents a measure of the extent to which banks have faith in contract enforcement, police, and courts, and the likelihood of crime and violence. A strong rule of law is expected to create an environment conducive to bank lending. Property rights captures the dimension of rule of law related to the strength of collateral entitlements and enforcement, which helps banks extend collateralized credit. Political stability, measured here by the perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means (Worldwide Governance Indicators) is another factor that we consider in explaining financial penetration. When the political environment is stable, there is less uncertainty, and banks are more willing to lend. The quality of contract enforcement, measured by the number of days required to enforce a contract, is also an important determinant of bank lending. The greater the number of days needed to enforce a contract, the costlier is borrowers default for bank, and thus the smaller is the amount of credit they disburse. Credit coverage captures the quality of credit information. Credible credit bureaus encourage the expansion of credit as they enable on the one hand lenders to better screen borrowers, assess and manage risks, and on the other hand borrowers to gain access to finance. Internet coverage is used as a proxy for infrastructure development, which reduces the cost of bank penetration and helps improve bank geographical coverage. A good internet coverage indicates a solid telecommunication infrastructure, which is critical bank

transactions and transfers.

Tables 3.1 and 3.2, respectively, show some descriptive statistics and correlations. Credit to the private sector relative to GDP is most correlated with infrastructure, rule of law, and GDP per capita. Various measures of the quality of legal environment (rule of law, property rights and political stability) are highly correlated with each other, suggesting that they may be measuring similar attributes of the credit environment.

To further the analysis, we used a two-step Feasible Generalized Least Squares (FGLS) to estimate the model above.⁶ The estimation approach allows us not only to address issues of heteroscedasticity, but also to estimate the impact of time-invariant variables such as the WAEMU dummy, while controlling for country-specific effects. Several model specifications have been estimated and the results are presented in Table 3.4.

The WAEMU dummy is negative and significant even after controlling for macroeconomic variables (column 1), thereby providing evidence that financial deepening is indeed weaker in the WAEMU than in high growth non-oil exporting countries in Sub-Saharan Africa. The sign and significance of the WAEMU variable are, however, not stable when policy and institutional factors are accounted for.

As expected, macroeconomic variables are important determinants of credit to the private sector relative to GDP. The impact of inflation is negative and significant in most specification of the model. Per capita GDP is positively associated with the financial depth in all specifications.

Looking at institutional/policy variables, we find that political stability, availability of

⁶The first step estimates an OLS and collects the residuals; the second step estimates generalized least squares with a variance matrix build from the residuals collected in the first step.

information on borrowers, strength of legal framework, and quality of infrastructure are associated with deeper financial markets (columns 2-6). The introduction of some of these variables substantially weakens the control variable for WAEMU countries, suggesting that they may explain away most of the differences in financial depth between the WAEMU and HGNOEs.

Both rule of law and property rights capture the quality of the legal environment and are highly correlated (Table 3.2). They both are significantly associated with financial depth (columns 2 and 6). However, the introduction of rule of law in the regression weakens the WAEMU control variable, which becomes insignificant. In other words, once rule of law is accounted for, the difference between the WAEMU group and the HGNOEs becomes statistically insignificant.⁷ This result is in line with the literature that finds that a stronger legal framework promotes financial development as depositors can provide longer term savings and banks can extend more credit as they have a greater chance at recovering non-performing assets through courts.

The results also indicate that political stability matters for financial depth (column 3). In a politically stable environment, banks have more confidence to lend because there is less uncertainty and a greater chance of recovering their outlays. While political stability matters, it does not explain away the differences between the WAEMU and the HGNOEs, as the WAEMU control variable remain significant.

Quality of infrastructure, as measured by internet coverage, positively affects financial depth (column 4). It also explains away the difference in financial depth between the WAEMU and HGNOEs. Better infrastructure allows financial institutions to reach borrow-

⁷The introduction of property rights slightly weakens the WAEMU dummy, which remains significant.

ers at a lower cost, thereby encouraging more lending.

Information on borrowers as measured by credit coverage is another important factor that is positively associated with financial depth (column 5).⁸ The introduction of credit coverage in the regression also explains away the difference between the WAEMU and HGNOEs. If banks have more information on their customers, they will screen them better and will engage in greater lending as they will be less exposed to defaults. Small and medium-sized enterprises (SMEs) and other entrepreneurs with good quality projects and good track-record will have access to credit and be able to undertake profitable investment projects.

Overall, the results show that the difference in financial depth between the WAEMU and HGNOEs is explained by the quality of the legal environment, infrastructure, and information available on borrowers. When rule of law, property rights and political stability are simultaneously introduced in the model, only rule of law is significant (column 7), indicating that there is some overlap in the dimension of the institutional environment measured by these variables.

3.4 Case Study

After documenting that the WAEMU region fares poorly when pitted against some other peer countries of the SSA region and identifying some of the key variables contributing to the underdevelopment, we further deepen the empirical analysis by exploring where Cote

⁸The result of this regression should be interpreted with care, as the sample size drops substantially due to limited data on credit coverage. Also, for this reason, we do not further explore the impact of credit coverage on credit to the private sector in the presence of other explanatory variables.

d'Ivoire⁹ stands relative to its potential, and in relation to Mozambique—a country which appears to be the most structurally similar to Cote d'Ivoire.¹⁰ While Mozambique does not have the most developed financial sector in the control group, it shares many key structural similarities with Cote d'Ivoire such as population and dependency ratios. In that sense, financial sector differences between Cote d'Ivoire and Mozambique can be largely attributed to differences in policy. Table 5 compares Cote d'Ivoire and Mozambique with respect to several structural characteristics used in the financial benchmarking literature. To benchmark Cote d'Ivoire against Mozambique, we first use FinStat and then we document policy asymmetries that might explain the difference between the two countries.

3.4.1 Where Cote d'Ivoire Stands Relative to Mozambique and to its Potential?

Figure 3-3 shows that for much of this period, Cote d'Ivoire and Mozambique were almost on par in terms of financial depth with private sector credit to GDP at around 15 percent for each in 2007. But Mozambique started outperforming Cote d'Ivoire thereafter. Comparison with the expected 75th percentile provides additional insights as it shows that Cote d'Ivoire systematically underperformed relative to its potential over the period. The deviation of Cote d'Ivoire's private credit levels from its statistical benchmark and in relation with Mozambique suggests that there is possible policy and institutional gaps in the country.

The next section aims to identify factors explaining why Cote d'Ivoire is lagging relative to

⁹Financial infrastructure and activities were not much affected by the internal crisis of the last decade. In particular, the south of Cote d'Ivoire, the financial and economic center of the country accounting for the bulk of GDP was under the government's control during the socio-political crisis of 2002-2007. However, in the absence of crisis the financial sector might have developed faster.

¹⁰Based on GDP per capita and population, Feyen and Kibuuka (FinStats, 2012) find that Mozambique is the most structurally similar to Cte d'Ivoire among the control group of countries.

Mozambique and to its potential.¹¹

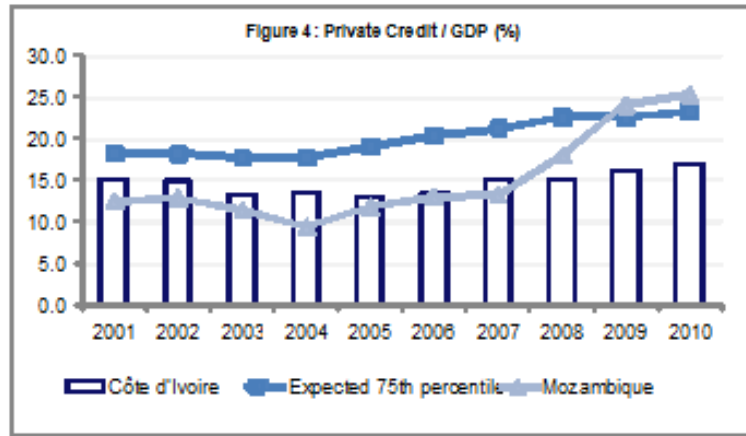


Figure 3-3: Financial Deepening in Cote d'Ivoire

3.5 Explaining the Financial Depth Gap

We referred to the Financial System and Stability Assessment Reports and the World Bank's Doing Business reports to explain the weak performance of Cote d'Ivoire relative to Mozambique and to its potential. We observe differences between Mozambique and Cote d'Ivoire during the covered period in terms of strength of contract enforcement and credit information, two essential factors in expanding credit availability.

Mozambique's government took forceful actions in strengthening contract enforcement, with the establishment of a specialized commercial court, the increase by 10 percent of the number of new judges, and the introduction of performance measure. As a result, the time taken to resolve a commercial dispute fell by 72 percent. Doing Business 2008

¹¹We also looked at where the other WAEMU countries stand relative their potential. We found that, except Senegal, all the other countries perform below their potential. The graphs are displayed in the appendix. These countries belong to the same monetary union, and they share the same monetary policy and a common regulator of the financial sector. As such, the financial sector development issues in these countries are similar to those we detail below for Cote d'Ivoire.

cited Mozambique as the top performer in contract enforcement in Africa. Second, a new legal framework for credit registries has been enacted in Mozambique, which resulted in expanding the scope and accessibility of credit information. According to World Bank's Doing Business 2009, the depth of the credit information index improved from 3 to 4, out of a possible 6.

Finally, several other reforms undertaken by Mozambique's authorities over this period helped increase the flow of credit (FSAP, 2009). These include: (i) transitioning from an overall-compliance supervisory regime to risk-based supervision, which improved Bank of Mozambique's adaptability to risks and its monitoring of a broader range of vulnerabilities, while forcing supervisors to closely inspect bank balance sheets; (ii) enhancing the financial infrastructure by significantly improving the national payments system, (iii) a new legislation on microfinance, and (iv) limiting the dollarization of loans by raising the provisioning requirement on foreign exchange loans to non-exporters. The increased financial depth in the case of Mozambique was just one of several positive outcomes of the broad reform agenda. Other gains include:

- A massive restructuring and clean up of bank balance sheets, which reduced non-performing loans (NPLs) from 17 percent of gross loans in 2003 to 2.8 percent in September 2008
- An increase in banks' outreach with a rise in the number of branches and ATM machines, particularly in rural and semi-urban areas. Credit however remained heavily concentrated with limited credit for small and medium-sized enterprises and non-salaried individuals

- A sharp rise in the number of microfinance institutions from 19 in 2003 to 87 in 2008

Meanwhile, contrary to Mozambique, Cote d'Ivoire has not made any significant inroads in addressing weaknesses in institutional environment that hinder financing deepening (Regional FSAP 2007-08 and FSAP 2009).¹² No major progress has been recorded in improving the legal and judicial framework, nor in the credit information infrastructure. As pointed out by the FSAP 2009, the legal and judicial framework was unpredictable and offered little security for credit activities; contract enforcement was costly and slow; and credit information infrastructure remained deficient-the country being rated 1 out of 6 in terms of the depth of credit information by Doing Business Report, 2010. In addition, the financial position of microfinance institutions was worrisome, with the largest networks virtually bankrupt. Table 1 compares Mozambique and Cote d'Ivoire along several facets of financial reforms over the period 2003-2010. These institutional weaknesses discourage lending activities and explain why Cote d'Ivoire's financial depth lied below its potential.

This comparison between Cote d'Ivoire and Mozambique sheds light on the role of institutional factors in financial deepening. However, despite the recent improvements, Mozambique continues to face many challenges in its institutional environment. While establishing the commercial court was a necessary step, enforcement of collateral remains costly and slow. Further progress is needed in addressing credit information infrastructure and national payment system shortcomings, as well as increasing competition. As a result, several key indicators in Mozambique remained stagnant. Particularly, excess liquidity

¹²Some steps have been taken by the Ivoirian authorities in 2011-12. This includes the creation of commercial courts in January 2012 and the adoption of a decree on the enforcement of arbitration court decisions (exequatur) in February 2012. Efforts to simplify business activities (starting a business, registering properties) are also underway. Financial sector policies are mostly defined at the regional level, limiting the ability of Cote d'Ivoire to promptly take needed measures in this area; however, there is a scope to national financial sector policies: the restructuring of public banks, the definition of the role of the state in the financial sector.

remained high, and lending to agriculture remained anemic at below 10 percent of total loans for most of the period. These indicators reflect the extent of the challenge of boosting rural financing given the weak infrastructure and property rights, as well as the lack of long-term financing resources due to the short-maturity of liabilities.

3.6 Conclusion

This paper compares the experience of countries with varying infrastructure and institutional quality and policy regimes within Sub-Saharan Africa on financial sector development, specifically credit to the private sector as a share of GDP. We find evidence that stronger rule of law, infrastructure, and credit information collection and dissemination lead to higher bank lending to the private sector. Particularly, the paper makes the argument that these factors played a key role behind the advancement of financial depth in high-growth non-oil exporting countries and may explain the relatively poor performance in the WAEMU region. These results are in line with other empirical studies that highlighted the role of institutions, particularly the effectiveness of the legal/judicial framework, in promoting financial intermediation and bank lending.

The paper goes further into details of the policies that may be behind the slower financial development in WAEMU by contrasting the experience of Cote d'Ivoire (the biggest economy in the WAEMU) with Mozambique (a comparable country in the control group). We find the key contrast to be stronger policies in Mozambique on banking supervision, commercial courts, and credit information collection and dissemination. Reforms in these areas may explain how from 2007-2010, private sector credit to GDP rose in Mozambique

from less than 15 percent to almost 25 percent—a 10 percentage point gain—while in Cote d'Ivoire the increase was less than one fourth of that.

3.7 Appendix: The Financial Possibility Frontier

The results presented in this section are based on the concept of financial benchmarking methodology presented in Beck et al. 2009. The benchmarks were estimated using FinStats, a tool developed by the World Bank that implements the methodology in Beck 2009 and estimates the financial benchmarks for the quasi-totality of countries in the world. The concept of financial benchmarking is based on the idea that there are structural factors that determine the level of financial development a country can attain. Some factors are conducive to financial sector development (e.g. income levels) and others inhibit it (e.g., low density of population, which makes infrastructure deployment costly relative to the population served and minimizes the benefit of economies of scale in banking). The benchmarking allows for cross-country comparisons to see how a specific country is doing relative to other countries with similar structural characteristics and at similar stage of development. The benchmarking approach in Beck, assumes that once appropriate controls are introduced, the process of financial development is broadly comparable across countries and stages of development. Financial sector development is affected three types of factors: economic development, other structural characteristics and the policy environment.

$$X_t = \alpha Y_t + \beta P_t + \gamma Z_t + \varepsilon_t \tag{3.2}$$

Here, X is an indicator of financial development, Y is an indicator of economic development and Z is a vector of structural characteristics.

Economic development is captured by income per capita. Demand for financial services increases as income grows. On the supply side, richer countries have better infrastructure and higher competition, which lower the price of financial services. Income per capita is endogenous, but financial sector development affects income per capita with a delay. The reason for this is that changes in the policy environment affect the financial sector first, and the financial sector in turn then affects economic growth. Therefore, we can write:

$$Y_t = \alpha' P_t + \beta' P_{t-1} + \gamma' Z_t + \varepsilon'_t \quad (3.3)$$

The policy environment does not change radically overnight. Good policies today are generally linked to the good policies of yesterday but also to today's innovations.

$$P_t = \alpha'' P_{t-1} + \nu_t \quad (3.4)$$

The structural variables included in the benchmarking analysis are a set of factors that are considered as external to policy, at least in the short run. These factors include: population, age dependency, a time factor, and special circumstances. Countries with larger population and higher population density can have deeper and low cost of providing financial services thanks to economies of scale. The share of non-working young and old populations (age dependency) affects saving and lending patterns. Over time, all financial systems tend to

improve, albeit at different speed, because of global factors that "lift all boats". To account for this, a time trend is included in the regression. Many special factors affect financial sector development: in oil exporting countries, income per capita can be out of proportion with the financial and overall economic development of the country. In contrast, offshore financial centers have a financial sector that is disproportionately larger than the overall economy.

When one runs a regression of financial development on economic development and structural factors only, policy innovations are captured by the residual. To see this, one can substitute equations (2) and (3) into (1), and get the following reduced form expression:

$$X_t = \left(\alpha + \frac{\beta\alpha''}{\alpha'\alpha'' + \beta'}\right) + \left(\gamma - \frac{\beta\alpha''\gamma'}{\alpha'\alpha'' + \beta'}\right) + \left(\varepsilon_t - \frac{\alpha''}{\alpha'\alpha'' + \beta'}\varepsilon'_t + \frac{\beta\beta'}{\alpha'\alpha'' + \beta'}\nu_t\right) \quad (3.5)$$

The policy innovation factor is now in the residual. When the benchmark is constructed using the economic and structural variables (Y and Z), the distance between the benchmark and the actual level of financial development is assumed to reflect the country's policy environment. Countries with better policies (higher ν) would tend to have more developed financial sectors compared to countries with worse policies. FinStats estimates the last equation via quantile regressions,¹³ using data from 177 countries. It then compares a given country to its own potential (benchmark) or to its comparator countries. In the first approach, the country's benchmark is calculated using its economic and structural

¹³The quantile regressions are used to reduce the impact of outliers and produce different expected values to gauge the range of financial sector performance.

variables in the reduced form equation. In the second approach, comparator countries are chosen based on their similarity with the reference country on two dimensions: GDP per capita and populations. The comparator countries are those with the smallest distance to the reference country, where distance is calculated as follows:

$$\Delta_{i,j} = w_{gdppc}|PR(gdp_i) - PR(gdp_j)| + (1 - w_{gdppc})|PR(pop_i) - PR(pop_j)|$$

Where, PR is the percentile rank of the country. FinStats uses the expected 25th and 75th percentiles.

3.8 Appendix: Tables

Table 3.1: Descriptive Statistics

Variable	Observations	Mean	Std. Dev	Min	Max
Credit to pvt/GDP	168	0.16	0.15	0.01	0.85
Inflation	208	0.05	0.04	-0.09	0.16
GDP per capita	206	6.28	1.03	4.73	8.94
Rule of Law	208	-0.44	0.66	-1.90	1.05
Political Stability	160	-0.26	0.88	-2.28	1.13
Internet per hundred	160	2.55	4.36	0.00	25.00
Credit Coverage	207	2.76	4.84	0.00	21.80
Property Rights	160	38.41	16.51	10.00	75.00

Table 3.2: Correlations

Variable	1	2	3	4	5	6	7	8	9
Credit to pvt/GDP	1.00								
Waemu	-0.26	1.00							
Inflation	0.08	-0.47	1.00						
GDP per capita	0.76	-0.26	0.12	1.00					
Rule of Law	0.72	-0.45	0.09	0.74	1.00				
Political Stability	0.52	-0.10	-0.05	0.58	0.76	1.00			
Internet per hundred	0.86	-0.26	0.11	0.64	0.56	0.39	1.00		
Credit Coverage	0.61	0.03	-0.34	0.44	0.33	0.37	0.65	1.00	
Property Rights	0.65	-0.38	0.03	0.77	0.86	0.58	0.53	0.38	1.00

Table 3.3: Description of Variables

Variable	Description	Source
Credit to pvt/GDP	Credit to the private sector as a percentage of GDP	IMF
WAEMU	Equal to 1 if the country belongs to the WAEMU and 0 otherwise	Constructed
Inflation	Rate of inflation	IMF
GDP per capita	Gross domestic product per capita	IMF
Rule of Law	Extent to which agents have confidence in the rules of the society	World Bank
Political Stability	Likelihood that the govt. will be overthrown by unconstitutional means	World Bank
Internet per hundred	Internet users per 100 people	World Bank
Credit Coverage	Percentage of adult population listed in a credit registry	World Bank
Property Rights	Index showing ability of individuals to accumulate pvt. property	Heritage Foundation

Table 3.4: Regression Results

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Waemu_dum	-0.0028*** (0.005)	-0.003** (0.007)	-0.0029*** (0.007)	-0.010 (0.006)	-0.013 (0.014)	-0.023*** (0.006)	0.012 (0.012)
Inflation	-0.171*** (0.067)	-0.18*** (0.075)	-0.273*** (0.076)	-0.126* (0.072)	-0.063 (0.132)	-0.164*** (0.068)	-0.156 (0.097)
GDP p.c	0.114*** (0.003)	0.083*** (0.003)	0.089*** (0.004)	0.056*** (0.006)	0.074*** (0.011)	0.099*** (0.004)	0.044*** (0.008)
Rule of law		0.078*** (0.006)					0.045*** (0.020)
Pol. Stab.			0.033*** (0.003)				0.009 (0.009)
Internet				0.020*** (0.002)			0.018*** (0.002)
Credit covg.					0.010*** (0.004)		
Property						0.001*** (0.000)	0.001 (0.001)
Constant	-0.52*** (0.021)	-0.30*** (0.024)	-0.35*** (0.027)	-0.22*** (0.030)	-0.34*** (0.067)	-0.48*** (0.023)	-0.15*** (0.054)
Observations	167	132	132	167	132	138	122
Countries	17	17	17	17	17	17	17

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.5: Structural variables in 2010

Variables	Mozambique	Cote d'Ivoire
GDP (constant 2000 US\$)	11,603	8972
GDP p.c (constant 2000 US\$)	588	384
Population (millions)	22.0	21.6
Population density	62.1	29.7
Urban population (% of total population)	50.1	38.4
Rural population (% of total population)	49.9	61.6
Dependency ratios	80.1	89.5

Source: WDI and IFS

Table 3.6: Financial Reforms, 2003 - 2010

Reforms	Mozambique	Cote d'Ivoire
Banking Supervision	Risk based supervision introduced	No reforms enacted
Accounting Standards	IFRS implemented	Still uses SYSCO
Payment Systems	Payment settlement system strengthened	Payment settlement system strengthened
Credit Information	Coverage and range of the credit registry expanded.	No reforms enacted
Judicial Framework	Commercial code reviewed, special commercial courts established, code of civil procedure & Notary office modernized, framework for secure transactions updated	No reforms enacted
Microfinance Institutions	Legislation on microfinance enacted	Legislation enacted but staffing and supervision need to be strengthened. The financial position of this sector is critical.

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