MACROECONOMIC EFFECTS OF BANKING REGULATION IN EMERGING MARKETS
THE ROLE OF COUNTERCYCLICAL BANK CAPITAL REQUIREMENTS

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Abstract

This paper analyzes, in an emerging market context, the effects of financial frictions and bank prudential regulation on the business cycle. It also proposes a prudential rule that smooths the external finance premium, and at the same time, improves the effectiveness of the monetary policy. I hypothesize that the macroeconomic effects of bank capital requirements are procyclical and lead to the amplification of monetary shocks, therefore reducing their effectiveness for fighting inflation. These effects increase the financial system vulnerability in recessions, and could be stronger in emerging markets under dollarization.

As the current prudential regulation could increase banking system vulnerability in a recession, by using a Dynamic Stochastic General Equilibrium Model (DSGE), with banks and prudential regulation, I show that a countercyclical capital requirement could help to reduce these effects and to keep the strength and solvency of the financial system. Therefore it is needed to implement a prudential rule with countercyclical effects, which should complement the monetary rule, and smooth the effects of monetary shocks in the business cycle. This rule supports the Basel Committee for Banking Supervision’s efforts to strengthen the capital accord in Basel III.

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I. INTRODUCTION

The role of financial frictions in the propagation of exogenous shocks in the economy has been the subject of lengthy literature and unfinished debate over its significance and its importance for both the business cycle and the transmission of monetary policy. In the middle of this discussion, the role of the banking system has been highlighted because it can amplify the effects of monetary transmission due to lending and bank balance channels like the bank capital channel.²

There are also several empirical works and evidence about the existence of bank capital transmission effects, and their role in determining movements in loan supply, and consequently in the economic activity of a country.³ Moreover, there is a current discussion on whether banking prudential regulation has an important effect on this bank capital monetary transmission.⁴ This lengthy body of research focused on two different strands. The first one concluded that lending growth after a monetary policy shock depends on the level of bank capital, as explained by Kishan and Opiela (2006), Van den Heuvel (2002 and 2005) and Gambacorta and Mistrulli (2004). They argued that the real effects of monetary policy are generally stronger when small banks have lower capitalization, thus a higher capital requirement could also restrict the scope of monetary policy effects. In the same direction, by assuming regulatory capital requirements, Repullo and Suarez (2008) also provided a clear explanation for the decline of bank loans relative to market lending during episodes of monetary tightening.

Other strands assume that bank capital requirements imposed by banking regulation are needed to keep financial stability, despite their amplification effects on the business cycle. For instance, Dewatripont and

² For a review of monetary transmission channels and macroeconomic models addressing these transmission process, see Walsh (2003).
³ See Kishan and Opiela (2000, 2006), and Gambacorta and Mistrulli (2004) for example.
⁴ See Sunirand (2003) for a role of bank capital in monetary transmission and Repullo and Suarez (2008) for an example of bank regulation procyclicality, among others.
Tirole (1994) provided the most comprehensive approach to the prudential regulation of banks and the effects on banking stability and risk assessment of bank capital requirement, like those recommended by the Basel Committee on Banking Supervision (1988 and 2006). In this strand, the work of Blum and Hellwig (1995) and Blum (1999), showed that there is a link between bank capital and bank lending that could act as an automatic amplifier for macroeconomic fluctuations, leading banks to lend more when times are good and to lend less when times are bad, thus reinforcing any underlying shocks. If banks cannot issue new capital in the worst phase of the business cycle, and firms cannot have alternative sources of funding, this amplification effect may also amplify recessions.

The amplification mechanism works through bank capital, because as banks experience losses, they become capital restricted by the binding constraint that implies minimum regulatory capital requirement. Thus, they react by cutting back lending that is likely to reduce investment, which in turn reduces aggregate demand and current production. As the economy enters into a recession, the bank loan portfolio tends to deteriorate because borrowers cannot repay the loans. That amplifies the initial shock, and the circle comes round again.

Then, it is important to evaluate what is the role of prudential banking in the business cycle. Capital regulation strives to maintain banking system soundness as well as reduce banks’ moral hazards to take more risks\(^5\), but can also be the cause of business cycle amplification (i.e. deepening recessions). So, it is important to evaluate this amplification mechanism in a macro dynamic environment that accounts for special features of emerging market economies like Peru, notably dollarization and imperfect credit market competition through market concentration. The aim of this is to find a suitable countercyclical capital buffer to reduce these effects and to improve the Basel II accord capital regulations, which are already in use in some countries. To do that, in the following sections, I will review the current and proposed bank capital regulations, as well as the relevant literature on the procyclical effects of bank capital regulation, in order

to assist the reader in understanding the macroeconomic dimension behind this issue and to evaluate the countercyclical capital regulation rule proposed in section 3 of this paper.

II. THE BASEL CAPITAL REGULATION IN AN EMERGING MARKET CONTEXT

Banking prudential regulation is composed of a set of tools that are available for banking regulators. The first of these tools is bank capital regulation that imposes minimum capital requirements associated with the bank assets’ risk profile. The Basel Committee of Banking Supervision (1988 and 2006) set out these capital rules (known as Basel Accords). Currently there are two standards: one issued in 1988 based on a standardized methodology, and another issued in 2006 based on risk-sensitivity internal models6.

Following Berger, Herring and Szego (1995) and Santos (2000a and 2000b), there are two important justifications for banking regulation. One is the inability of depositors to monitor banks. On this issue, Dewatripont and Tirole (1994) mentioned that small depositors’ protection is the primary concern of banking regulators and it is the source of moral hazard. The presence of asymmetric information leads to substantial informational problems because it is costly for investors to monitor bank activities. For that reason, they must incur costs such as screening and auditing costs. Nevertheless, since a large number of uninformed depositors primarily hold bank deposits, there is a free riding problem: bank customers have little incentive to perform the various monitoring functions. To solve this problem, banking regulators required banks to follow standard accounting principles, and disclose a wide range of information that helps depositors to assess the quality of a bank’s portfolio.

Gorton and Winton (2000 and 2003) mention that banks also have the incentive to take additional risks once they perceived that there is an underpriced government deposit insurance. Therefore, regulatory capital requirements should be introduced as part of the prudential regulation, to reduce this risky behavior

6 At the time of developing this paper, because of international financial crisis of 2008-2009, there is a lot of discussion of introducing countercyclical bank capital requirements and change some bank prudential regulation in a new framework that will be known as Basel III. See for instance Bank for International Settlements (2010).
and to protect stakeholders that are not protected by insurance deposits. Kashyap and Stein (2004) perceived capital regulation as an instrument to allow banks to internalize the systemic costs of insurance deposits. So, banking capital regulation looks to be the ultimate tool that banking regulators rely on to address moral hazard problems in banking.

The second reason to introduce banking regulation is the systemic risk prevention. Santos (2000a) indicated that bank runs, which are triggered by depositors' panic or bank fundamentals weakness, lead to the premature liquidation of bank assets and trigger contagion effects. It is a dangerous scenario for banking system failure and financial stability issues. So, as this author explains, in order to avoid costly liquidation, banks have to keep in their balance lower-risk liquid assets instead of riskier long-term assets. Koehn and Santomero (1980), Kim and Santomero (1988), Blum (1999) and Rochet (1992) argued that in order to reduce the probability of bank insolvency, capital requirements have to be set as a linear combination of assets risk.

That is the way the Basel Committee of Banking Supervision sets its capital requirements. Calculating the risk-weighted assets, and setting a minimum capital as a percentage of them do it. The capital accord implies that banks should maintain a total risk-weighted capital ratio, defined as the ratio of bank capital to the bank's risk-weighted assets, of at least 8%. Reflecting riskier loan portfolios in their economies, some emerging countries require higher minimum regulatory bank capital. For instance in Peru, Brazil and Argentina, the minimum required is 10%. Many other countries around the world have adopted this capital regulation.

In 2006, the Basel Committee on Banking Supervision released a framework for bank capital requirements, with the aimed to address the major shortcomings of Basel I and foster stability in the financial system. The Basel II framework increased the risk sensitivity of bank's capital requirements. This replaces the constant risk weight of 100% by a risk weight that is obtained by combining probability of

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default and loss given the default of the combination borrower-facility. Under the Basel II, the risk weights used to compute bank capital requirements are determined both by the borrower’s risk profile and by the collateral’s recovery rate in order to reduce regulatory capital arbitrage.

As mentioned in the Basel Committee of Banking Supervision (2006), the Basel II is built on three complementary pillars:

a) Pillar 1 establishes the minimum capital requirements for credit risk, market risk and operational risk.

b) Pillar 2 comprises the supervisory review process, and the ability to require additional capital over the minimum set as a buffer stock, for those risks not addressed in the first pillar.

c) Pillar 3 sets requirements for banks for public disclosures to foster market discipline.

In Pillar 1, banks may adopt one of the following approaches to compute their minimum capital requirements for credit risk:

a) The Standardized Approach, which is similar to Basel I, with the difference being that risk weights are now related to external risk classification made by credit agencies.

b) The Internal Ratings Based (IRB) Approach. Here the estimated credit risk and consequently the risk weights used to compute capital requirements are assumed to be a function of four parameters associated with each loan: the probability of default (PD), the loss given default (LGD), the exposure at default (EAD) and loan’s maturity (M).

Therefore, the IRB approach allows for the use of internal credit risk models by banks to assess the riskiness of their portfolios and to determine their required capital. It also results in a procyclical effect of capital requirements. For instance in a recession, with GDP growth falling, both the borrower’s default

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probabilities and the loss given default of the facility increase, requiring more regulatory bank capital, increasing interest rates and reducing their lending supply, which in turn amplifies the recessionary effect. The opposite occurs in an expansionary phase.

Following Lowe (2002), Allen and Saunders (2003), Catarieneu-Rabell et. al (2003) and Amato and Furfine’s (2004) research, the banking sector was determined to be procyclical due mainly to the existence of asymmetric information and market imperfections, despite the use of bank capital requirements. Bank lending tends to diminish during recessions and expand during booms. In the first case, this behavior exacerbates the economic downturn, as firms find difficult to finance investment. In the second case, economic activities will grow because the funding is easily more available. Therefore, if the bank capital requirement also has procyclical effects, the procyclicality of the banking sector is amplified. The introduction of the Basel II capital requirement may amplify the procyclical behavior of banks with potential macroeconomic consequences.

III. A REVIEW OF LITERATURE

To address the macroeconomic effects of bank capital regulation in emerging markets, it is important to review the literature on this issue. Traditionally, it is assumed that monetary policy could be transmitted to banks through a lending channel\(^9\). By increasing the cost of bank funding or reducing the funds available to lend, central banks can affect loan interest rates. Thus, if the bank-lending channel works, a tighter monetary policy should be reflected in lower credit supply and higher interest rates, as suggested by Bernanke and Blinder (1988). The strength of this channel relies on the assumption that there is neither any other source of financing nor substitutes for bank lending. Another important channel is the one studied by Bernanke and Gertler (1989) and Bernanke, Gertler and Gilchrist (1996 and 1999), who focused on the borrowers’ balance sheet channel and the effect of the external finance premium, the so called “financial accelerator effect”.

\(^9\) See Walsh (2003) to review this aspect.
Bank capital effects are part of a monetary transmission channel, as showed by Van den Heuvel (2002). His partial equilibrium model also assumes that banks are not able to issue new capital, as in Blum and Hellwig’s study (1995). In his model, an increase in federal funds rate increases the bank cost of funding, which in turn reduces banks’ profits. This weakens the bank’s future capital level, constraint lending due to an inadequate level of capital. He named this transmission mechanism as the bank capital channel, because monetary policy affects bank capital and restricts loan supply. He also mentions that the strength of this channel depends on the level of capital adequacy and the distribution of capital across banks. Well-capitalized banks do not transmit the shock because they are not capital-constrained institutions.

Chen (2001), Miyake and Nakamura (2006), Meh and Moran (2004 and 2008), Aikman and Paustian (2006) and Sunirand (2003) also focused on the role of bank capital requirements in the monetary transmission process. Chen (2001) built a model upon Holmstrom and Tirole’s (1997) formulation that includes the presence of moral hazard. The moral hazard in this model occurs because borrowers have incentives to choose riskier projects to enjoy private benefits. To solve this problem, banks ask borrowers to invest their own funds in the project along with the credit granted. On the liability side, banks also have moral hazard because uninformed depositors do not have the technology or resources to monitor banks. Thus, a capital requirement is justified in order to reduce this moral hazard behavior caused by delegated monitoring. Chen’s model predicts that, since both bank capital and firms’ net worth are used as collateral, any changes in these variables will have effects on bank lending and, thus, on the economy’s investment levels.

Similarly, Meh and Moran (2004 and 2008) embedded Holmstrom and Tirole’s (1997) framework within a dynamic general equilibrium model. In their model, tighter monetary policy raises the opportunity cost of banking external funds, and this increase is translated into investment borrower cost. Banks seek to reduce this effect by asking borrowers to finance their projects with their own net worth. Depositors do the same with banks. Therefore, bank lending must decrease to satisfy those market requirements, leading to a contraction in economic activity.
Sunirand’s (2003) model uses Bernanke, Gertler and Gilchrist’s (1999) framework to find more support for the amplification hypothesis. He considers a costly state verification framework, like Townsend (1979), in which lenders must pay a fee in order to observe the borrower realized return. His model is able to separate the amplification effect caused by the moral hazard problem between depositors and banks from the amplification effect caused by the asymmetric information problem between banks and firms. Thus, an increase in capital requirements produces a credit crunch.

Markovic (2006) focused on the asymmetric information relationship between banks and their shareholders extending Bernanke, Gertler and Gilchrist’s (1999) model of financial acceleration. Like the Sunirand (2003) model, banks act as delegated monitors for firms’ projects, incurring auditing costs to find the projects’ realized return. He identifies three distinct bank capital channels, in which a tight monetary policy can have influence:

(i) The adjustment cost channel, which considers the allocation cost necessary to reduce the asymmetric information problem;

(ii) The default risk channel, which arises from the possibility of bank failure;

(iii) The capital loss channel, which is the effect of asset pricing in bank net worth.

All these channels trigger an increase in the required return on bank capital by shareholders, and thus increase the cost of bank capital during a recession. This cost is transferred to firms, leading to a contraction in economic activity.

Aguiar and Drummond (2007) extended the Markovic model to identify a liquidity premium effect of bank capital. This premium works through the increase in bank cost funding by raising new capital in the event of binding capital requirements. They also built their model on Bernanke, Gertler and Gilchrist’s (1999). All of the previous models were focused on a closed, developed economy and there have not been many attempts to study this transmission mechanism in a small, open economy framework, like that of emerging markets.
Covas and Fujita (2006) build a model in which they test the role of time varying capital requirements in a general equilibrium macroeconomic model, with financial frictions coming from agency problems like in Carslstrom and Fuerst (1997). Far from using a costly state verification like the above mentioned paper, as the source of financial problem, they focus the source of entrepreneur moral hazard as in Holstrom and Tirole (1997) model. Their model test not only bank capital requirement but also liquidity needs during the business, and it is found that countercyclical prudential regulation could help to reduce the output volatility. Although their work is related with the model of this chapter, these authors do not test their effects on an emerging market environment like I do.

Finally, Zicchino (2006), Chami and Cosimano (2001), Berka and Zimmermann (2005) and Bolton and Freixas (2006) also considered the effect of issuing bank equity under binding regulatory capital requirements. Issuing equity introduces a cost of outside capital financing for banks by assuming asymmetric information about the profitability of bank loans. Therefore, their model amplifies the effects of the combination of binding capital requirements with a tighter monetary policy, since this policy makes bank capital more expensive. Both effects make borrowers face higher interest, which in turn reduces investment or consumption.

A new breed of macroeconomic models with financial frictions has appeared in the aftermath of the financial crisis. Building on the model by Gerali, et. Al (2009), Angelini, Neri and Panetta (2011) have built a DSGE framework with banking sector in order to assess the interaction between the macroprudential policy and the monetary policy. In their model, they find that macroprudential policy only has a modest benefit for macroeconomic stability over the monetary policy when there are supply shocks. However, these effects are stronger when there is either a financial or housing market shock. The effect in which the macroprudential policy helps to couple the monetary policy in stabilizing the economy goes through the reduction in the volatility of loan interest rate generated by higher levels of firms’ leverage. By changing the sensitivity parameter of a macroprudential rule, they obtained a case for a countercyclical prudential regulation rule in a closed economy environment.
In the same spirit, Angeloni and Faia (2009), introduces banks in a DSGE model in order to prove that the effects of the interaction between monetary policy and the Basel regulation. In their model, bank leverage depends on the uncertainty of projects and that the monetary policy is not enough to offset the procyclical effect of banking capital regulation. However, when there is a financial shock, the monetary policy and the bank capital regulation could be used as optimal combination of tools.

As it is has been discussed early, the literature regarding bank capital requirement is lengthy and prolific. All of these studies support the fact that capital requirement is needed to reduce the moral hazard problem of deposit delegate monitoring, and the incentive to take on more risk in banking loan portfolios. Nevertheless, as capital requirements become more risk sensitive, they amplify the pro-cyclical effects of the banking system. If tight monetary policies are used to fight inflation, bank capital could operate as a prudential regulation that amplifies the business cycle, reducing lending and increasing borrowers’ costs of funding.

This effect has to be understood in an emerging market framework, in which special features like dollarization and imperfect credit market competition arise. Banking systems could act differently in the presence of these effects. For instance, in these markets, more bank fragility could exacerbate the amplification effect of bank capital requirements. Thus, it is necessary to have some regulatory tools to mitigate this problem. One of these remedies, as a mentioned by Turner (2009) could be countercyclical capital buffers or the Spanish dynamic provisioning system. The effects of these policy tools should also be addressed in a small, open, partial dollarized macromodel with imperfect credit markets, in order to evaluate their effectiveness. This is the task to be addressed in the next section.

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10 See for instance Saurina and Trucharte (2007), Perez, Sales-Fumás and Saurina (2008), Delgado and Saurina (2004), and Jimenez and Saurina (2005).
IV. COUNTERCYCLICAL BANK CAPITAL REQUIREMENTS IN A MODEL OF A SMALL, OPEN, DOLLARIZED ECONOMY

In this section, I will close the gap in the reviewed literature in order to model the effects of banking capital regulation in a context of a small, open, dollarized economy. The aim of is to show if, by introducing prudential regulation into a banking system with lending in local and foreign denominated currency, financial accelerator effects are present, because the external finance premium is affected not only by binding capital requirements, but also by the cross effect of dollarization and binding capital requirements. As a corollary of this, I also want to show that by using countercyclical capital buffers, one could also mitigate the amplification effects of unexpected shocks in this environment. The other objective of this section is to show that having dollarization in the banking system reduces the effect of monetary transmission on the external finance premium, but for the latter is reinforced by the effect of the bank capital channel, caused by prudential regulation. This implies that the presence of financial accelerator mechanism and bank capital requirements amplifies business cycle even more under dollarization.

With these objectives in mind, I develop a new Keynesian open economy model in the spirit of Gertler, Gilchrist and Natalucci (2007) with financial frictions and dollarization, in which I evaluate the presence of bank capital requirements and the effects of countercyclical measures to reduce the procyclicality of the credit cycles. The model built in this chapter mimics the behavior of a partial dollarized economy as the Peruvian one, and includes a bank optimization problem and capital requirement as in Markovic (2006). In my model, households own banks and decide how much bank capital to invest, giving binding prudential bank capital regulation. I assemble the model following the approach of the papers mentioned above, which will help me to create an environment similar to the Peruvian economy. However, different from the previous studies, my model evaluates the effects of Basel I and II, as well as, the countercyclical bank capital rule, in order to smooth the effects of prudential regulation on the external finance premium.
A. MODEL DESCRIPTION

In this section, I present a model in the spirit of Bernanke, Gertler and Gilchrist's (1999) financial accelerator feature expanded by Gertler, Gilchrist and Natalucci (2007) for an open economy. In order to see the effects of dollarization on a small open economy, I also closely follow Castillo, Montoro and Tuesta's (2009) example. The first feature of the model developed in this section is the presence of binding bank capital requirements, set by the Basel Committee on Banking Supervision (1998 and 2006), known as Basel I and Basel II, as seen in Aguiar and Drummond (2007) and Markovic (2006). This combination of models allows us to mimic a small open economy with dollarization and financial frictions due to the external finance premium and capital requirements.

The second new feature of this model is that I will use a countercyclical capital requirement rule as in Gordy and Hewell (2006) and Repullo, Saurina and Trucharte (2009), to test if this kind of rule could help policy makers in the setting of monetary policy. It is made in order to reduce the pro cyclicality effect of bank capital requirements and prove that there could be a monetary and financial policy mix that could smooth monetary or productive shocks in credit market frictions.

The model follows a conventional two country model, with home and foreign economies, households, firms, entrepreneurs, banking systems and monetary-financial authority. Households will make decisions of consumption, work and decisions to invest in financial assets like deposits or bank capital stocks. Firms will produce, accumulate and hold physical capital. Entrepreneurs, who run the firms, are the owners of physical capital and pays dividends to households. Banks raise deposits from households, lend to firms and pay returns to households for bank capital holdings. Finally, the financial authority will set the prudential regulation of banks and in this case will also set the monetary rule.

When firms take on debt, they have to pay a risk premium over the funding cost of banks. This generates an external cost of finance, which will depend on their leverage level, as in Bernanke, Gertler and Gilchrist (1999) and Gilchrist, Gertler and Natalucci (2007). The funding cost of banks will be modeled as the weighted
average cost between a deposit rate and the cost of holding bank capital, which allows me to influence firms’ external cost of finance, when bank capital requirement are present and binding. Firms’ risk premiums will depend on the level of debt, and it will be different among them, which allows us to have a real feature: that high-leverage firms will pay more risk premium than low-leverage firms. Because banks’ minimum capital requirement, as established by the Basel Accord (Basel Committee on Banking Supervision (1988, 2006)), depends on incremental risk weighted assets, loans to high-leverage firms will imply higher risk and probability of default and therefore more regulatory capital will be required. Also as seen in Bernanke, Gertler and Gilchrist (1999), an increase in interest rates will reduce the asset value of a firm, which in turn deteriorates its cash flows, and raises the cost of external finance, prolonging the effect of any unexpected monetary shock.

The model has several known features that attempt to resemble the Peruvian economy, as in Castillo, Montoro and Tuesta (2009). Like the above-mentioned model, households and firms are allowed to use two currencies, foreign (US dollars) and local (Peruvian Sol) to make transactions and to take debt. But different to the established model’s approach, I neither focus on price dollarization, defined as the use of dollars to set prices as unit of account, nor transaction dollarization, defined as the use of dollars to exchange goods. I only focus on the problem of financial dollarization.

By modeling financial dollarization, firms’ debt could also be taken in any of the two currencies or in a combination of them. However, firms can combine borrowing in local and foreign currencies in a weighted average way, by exogenously given proportions, so that the expected cost of external finance will also reflect this structure. I also assume that families could take on aggregate demand deposits, by combining the two risk free assets (bank deposits in foreign and domestic currency denomination). This combination among domestic or foreign currency denominated deposits is exogenous. The allocation between both deposits is determined by a fixed parameter $\theta$, the dollarization ratio, which is the same combination that firms uses to borrow in each currency\textsuperscript{11}. That is the assumption made in order to eliminate the bank balance sheet

\textsuperscript{11} Making endogenous the portfolio decision of holding foreign or domestic denominated deposits, is to give deposits a liquidity service and is out for the scope of this paper. The dollarization ratio could also be a function of the interest rate differential or the expected rate of depreciation, which in turn will reinforce the amplification effect of bank capital requirements. I believe that this
mismatched in net long or short balance sheet positions. However, exchange rate induced credit risk is not rule out, as it affects the borrowers’ probability of default and the bank loan portfolio.

Some explanation is needed here. In a partial dollarized economy, like Peru, banks operate in a positive net long position in foreign exchange. This is because a depreciation of the Peruvian Sol will increase the value (in Soles terms) of foreign currency denominated loans faster than the value of foreign currency denominated deposits (in Soles terms), which in turn, will increases bank profits and protect the value of the bank capital, that is expressed in Peruvian Soles, by accounting standards. The counterparty of this traditional bank balance sheet management is the real sector, in which balance sheets are in a positive net short position in foreign exchange. Thus, in the event of depreciation, there exists a foreign exchange induced credit risk in the Peruvian firms, because their debt will increase in value, due to the fact that they have taken loans in foreign currency, but their income to service this debt is in Peruvian soles. Then, loan portfolio deterioration caused by depreciation can also imply that banks need more capital to absorb losses. But if it is costly, banks could react by reducing their loan supply or increasing the risk premium, which would cause a reduction of investment, consumption, and economic activity; a situation that reinforces the effects of binding banking regulation that I want to analyze in this chapter. For that reason, by carrying out the assumption explained before, I focus on the effects of bank capital regulation and on the effects of a foreign exchange induced credit risk, which in the case of depreciation (more likely in partial dollarized economies) is expected to move in the same direction, and reduce economic growth.

Also, as stated by Castillo, Montoro and Tuesta (2009) and in Gertler, Gilchrist and Natalucci (2007), there are four types of firms. Their activities are only separated in order to account for each decision making process. However, nothing is lost if we reduce that number to three firms, having a capital goods industry that could either produce intermediated or input goods and also accumulate capital, like in Bernanke, Gertler and modeling strategy will constitute a good avenue to research in the future in order to explain the portfolio decision of dollarization in the bank liability side.

12 In this model the only source of moral hazard come from the lending side. Bank deposits can also be a function of bank default probability which could lead to bank runs. In this case as there is a government insurance deposit that covers all liabilities, let the bank capital preferred shares as the only one assets to exert market discipline.
Gilchrist (1999). Within the home country, firms are those that produce: a) Intermediate goods, b) retailers of domestic goods, c) retailer of capital goods and d) importers. Firms in class (a) combine capital input and labor to produce an intermediate good that sells to retailers. Retailers (class (b) firms) use intermediate goods to generate composite consumption goods, differentiated only by the tag, in a monopolistic competition environment, which is consumed by households or government. Capital good firms (class (c) firms), use consumption goods as investment to produce capital goods, which in turn are sold to entrepreneurs. Last, but not least, importers bring to their home economy a homogeneous consumption good produced outside in the world market and sell it domestically.

The entrepreneurs, as in Bernanke, Gertler and Gilchrist (1999), accumulate capital and take debt from banks to finance it, in a financial accelerator mechanism. There are credit market frictions, due to moral hazard, because it is costly to monitor the results of the project. As in Townsend (1979) there is a costly state verification, which makes the optimal debt contract as concave function of the project returns. There is also a cut off probability ($\hat{w}$) of the project success, over which banks will receive the loans and the interest set in the contract. However, under this cut off level, entrepreneurs are in default and only banks can seize the assets, which serves as collateral to repay deposits. Appendix A further develops this idea and sets this financial contract.

The financial accelerator channel in our model includes the effect of dollarization. As firms depend on bank loans, which part are in foreign currency denominated assets, an increase in the exchange rate will increase the firms’ debt value, will weaken firms’ balance sheets and therefore will increase their probability of default, as in Cespedes, Chang and Velasco (2004). That effect leads banks to increase their interest rate, raising the cost of investment and the firm risk premium. Thus, dollarization in our model will have two effects. It will reduce the power of the monetary policy and will amplify foreign interest rate shocks on the economy, but it will empower the bank capital channel.
Lastly, banks different from the following chapter\textsuperscript{13}, will act in a competitive environment in which the expected return of their loans granted to entrepreneurs is equal to the cost of funding the loans, meaning that they have a condition of “zero profits”. As it was mentioned before, the total cost of funding loans is the weighted average of the deposit rate and bank preferred share returns demanded by households.

**HOUSEHOLDS**

a) **PREFERENCES**

The world economy is composed of a continuum of households of length unity. Following Castillo, Montoro and Tuesta (2009), there is a percentage \((n)\) of those families that live inside the domestic economy and the difference \((1 - n)\), live outside the country. However, different from them, each family \(j\), works, consumes and invests its savings in assets, which include deposits (or bonds) in both domestic and foreign currency, and in bank capital preferred shares. Deposits (bonds) pay a nominal riskless rate of return between \(t - 1\) and \(t\) of \(i_{t}\). Banks capital preferred shares pay a nominal risky return of \(i_{t}^{j}\). Households are risk averse and will claim for more compensation (or higher return) if they have to take some risks, in their asset holdings. Each household \(j\) in the domestic economy has a utility function in consumption of a composite basket of goods \(C_{t}^{j}\), money \(M_{t}^{j}\) and leisure \((1 - H_{t})\), such as:

\[ U_{t} = E_{t} \left[ \sum_{s=0}^{\infty} \beta^{s} U \left( C_{t+s}^{j}, \frac{M_{t+s}^{j}}{P_{t+s}} (1 - H_{t+s}) \right) \right] \]

Where \(E_{t}\) is the conditional expectation, \(\beta\) is the intertemporal discount factor, with \(0 < \beta < 1\), \(M_{t}^{j}/P_{t}\) being the real money balance held by the family \(j\) at the period \(t\). The utility form is separable as will be clarified later.

\textsuperscript{13} This is made only for simplify the analysis and focus in how capital regulation acts in a dollarized environment. By introducing imperfect competition, staggered loan interest rate contracts or asset concentration in banking system, as in Mandelman (2005), Kobayashi (2008) and Teranishi (2008), we expect that the estimated effect of capital regulation will also amplify business cycle.

\textsuperscript{14} Here, we do not assume that deposits give a liquidity service as in Van den Heuvel (2005).
I also model the composite consumption good as a weighted average of domestic goods and foreign imported goods. These goods are aggregated by using the following consumption index:

\[
C_i = \left[ \left( \gamma^H \frac{1}{E_H} \left( C_i^H \right)^{E_H-1} E_H \right) + \left( 1 - \gamma^H \right) \frac{1}{E_M} \left( C_i^M \right)^{E_M-1} E_M \right]^{\frac{1}{E-1}}
\]  

(2)

Where \( E_H \) is the elasticity of substitution between domestic aggregated goods \( C_i^H \) and foreign import aggregated goods \( C_i^M \). \( \gamma^H \) also means the share in the total consumption basket in the domestic economy that represents domestically produced goods.

As in Gertler, Gilchrist and Natalucci (2007), \( C_i^H \) and \( C_i^M \) are continuums of heterogeneous good indexes represented by:

\[
C_i^H = \left( \frac{1}{n} \right)^{\frac{1}{E}} \int_0^1 C_i^H (z) \frac{E-1}{E} \, dz
\]  

(3)

\[
C_i^M = \left( \frac{1}{1-n} \right)^{\frac{1}{E}} \int_n^1 C_i^M (z) \frac{E-1}{E} \, dz
\]  

(4)

Here \( E \) is the elasticity of substitution among domestic produced goods \( C_i^H (z) \) and among foreign produced goods \( C_i^M (z) \). By following the two-state budgeting procedure\(^{15}\), I can derive the optimal household demand for both goods. But before that we have to define the price index for both domestic goods and foreign import goods, as:

\[
P_i^H = \left[ \frac{1}{n} \int_0^1 P_i^H (z) z^{-E} \, dz \right]^{\frac{1}{1-E}}
\]  

(5)

\[
P_i^M = \left[ \frac{1}{1-n} \int_n^1 P_i^M (z) z^{-E} \, dz \right]^{\frac{1}{1-E}}
\]  

(6)

In the case of domestic goods, the consumer’s problem will be to choose the basket of goods $C_i^H(z)$ for all $z \in [0, n]$, so as to minimize the total expenditure in these goods, given prices $P_i^H(z)$ in equation (5) and consumption index given by (3). The same procedure applies to the consumer problem choosing $C_i^M(z)$, using equations (4) and (6). Optimal household demands are:

$$C_i^H(z) = \frac{1}{n} \gamma^H \left( \frac{P_i^H(z)}{P_i^H} \right)^{-E} \left( \frac{P_i^H}{P_i} \right)^{-E_H} C_i \quad (7)$$

$$C_i^M(z) = \frac{1}{1-n} (1-\gamma^H) \left( \frac{P_i^M(z)}{P_i^M} \right)^{-E} \left( \frac{P_i^M}{P_i} \right)^{-E_H} C_i \quad (8)$$

We can also derive the consumer price index, by choosing the baskets $C_i^H$ and $C_i^M$ such as the household minimizes the total expenditure on both goods, given prices $P_i^H$ and $P_i^M$ and also subject to aggregate composite consumption good, given in (2). The consumer price index is:

$$P_i = \left[ \gamma^H (P_i^H)^{-E_H} + (1-\gamma^H)(P_i^M)^{-E_H} \right]^{-1}\quad (9)$$

b) **BUDGET CONSTRAINT AND ASSET STRUCTURE**

Following Castillo, Montoro and Tuesta (2009) and Gertler, Gilchrist and Natalucci (2007) we assume that there is a simple asset market composed of four assets: i) two risk free nominal bank deposits (or bonds) which are denominated in domestic and foreign currencies; ii) bank capital preferred shares and (iii) money. Nominal bank deposits pay risk free rates, which are the same as the Central Bank of each country. They relate to each other by the uncovered interest parity condition. We also follow Schmitt-Grohe and Uribe (2003) by assuming that there is a cost of exchanging foreign with domestic deposits in order to obtain results that are stationary\(^{16}\). The latter assumption will be consistent for reflecting the existence of financial frictions or the

\(^{16}\) See for instance Schmitt-Grohe and Uribe (2003) for a through development of this argument.
difficulty in accessing international capital financing by domestic firms and households, which is an extended characteristic in emerging market economies.

Like Markovic (2006), Aguiar and Drummond (2007) and Zhang (2009), there is a special feature in my model to be considered; the presence of bank capital preferred shares. Before setting the optimal decision of the household, it is fair to clarify that households invest in bank capital preferred shares as in a risky debt asset, where the price is set at 1 and does not vary over the time. Even more, the risky return of bank shares is represented by $i_t^z$.

I think that the previous assumptions about the use of bank capital preferred shares need more explanation. First, the addition of bank capital preferred shares in this small open economy model allow me to introduce the effects of bank capital requirements as constraint to the source of funding needed by banks to operate. Bank capital preferred shares behave as a risky debt because as the banking system is under a perfect competition environment with the zero profit condition, risky returns on bank capital preferred shares only matter for the decision to hold them. Risk returns arise from the probability of banking failure, which in turn is affected by the probability of borrower default.

Second, the main reason for not including variation in bank preferred share prices as in Markovic (2006) is because: i) bank capital accounting rules used to calculate Basel capital ratio, depend on bank business results, coming from income and loss reports, capital subscription, generic provisioning, subordinated debt and reserves, and therefore, they are not much subject to changes in the value of bank capital preferred shares; ii) in this model, bank capital will only be affected by actual losses incurred, which depend on the borrower’s probability of default (expressed as less income received or more provisioning set aside), which is the most important effect of the risk-sensitive rating systems that lies behind Basel II framework, and iii) by considering price fluctuations as in the US Financial GAAP, where bank capital should be registered under market value accounting, bank capital could also behave procyclical, therefore amplifying the effect of the business cycle. I will isolate this price effect in order to focus in how capital regulation amplifies the business cycle.
The previous modeling device also implies that moral hazard problem between banks and depositors here are present through the bank loan portfolio. The presence of firms with high leverage in the bank loan portfolio increases the firm default risk, which in turn is related to the bank’s probability of default. By using risk free bank deposits, banks could exploit the moral hazard by increasing their share in highly leveraged firms in the bank loan portfolio. Nevertheless, as bank capital shares are expecting to redeem higher returns, consistent with the bank risk taken, households could affect their optimal choice between risk free assets and bank capital shares. It generates a kind of market discipline in banks’ risk behavior, making it more costly for banks to raise more funding, as the weighted average cost (deposits and bank capital share) increases.

In addition, of the assets mentioned before, the household budget constraint includes their decision to hold money balance. Other factors that are introduced in the budget constraint of this representative household are taxes and real dividends, expressed in units of consumption goods, coming from owning shares of firm and banks. The budget constraint is:

\[
D_t^j + S_tD_t^{m} + M_t^j = \left[ (1 + i_{t-1})D_{t-1}^j + (1 + i_{t-1}^*)V_{t-1}^j \left( D_{t-1}^m \frac{S_t}{P_{t-1}} \right) S_tD_t^{m} + W_t H_t^j \right. \\
- P_t C_t^j + P_t \Gamma_t^j + P_t \Gamma_t^n + M_{t-1}^j + P_t T_t^j + (1 - pd_{t-1})(1 + i_{t-1}^*)Z_{t-1} - Z_t \right]^{(10)}
\]

Where \(pd_t\) is the bank default rate that represents the probability of bank failure, which is affected by the probability of borrower default, as in Zhang (2009) and Markovic (2006). I will show later that this bank default probability is reduced in the presence of minimum capital requirements, as in Rochet (1992), but increases with the risk of the loan portfolio, which in turn, depends on the firms’ leverage\(^{17}\). Other variables in this budget constraint are defined as follows: \(M_t^j\) is the money balance holding; \(S_t\) is the nominal exchange rate; \(i_{t-1}^*\) is the nominal foreign interest rate and \(T_t^j\) are net government transfers (transfers minus lump sum taxes).

\(^{17}\) In Canta (1997) it is shown that the bank probability of default, depends on macroeconomic factors and on bank own variables, like for instance non performing loan ratios, liquidity ratios, among others factors that affect this probability like the exchange rate, GDP growth and inflation rate. That is important because movements in exchange rate not only will affect directly the firm cost of external finance directly, but also will affect it indirectly, through increasing banking probability of default.
Following Castillo, Montoro and Tuesta (2009) each could receive $\Gamma^i_t$ that is the firm real dividends and also $\Gamma^B_t$ that is bank dividends, if any.

$Z_t$ is in the budget constraint represent bank capital preferred share holdings, $D_t^j$ is the local currency denominated deposit (or bond) holdings and $D_t^{j*}$, is the foreign currency denominated deposits (or bonds). In the event of bank default, it is assumed that risk free deposits are assumed to be covered by an insurance deposit fund. As it was explained before, this is the source of banks' moral hazard behavior and market discipline. Finally, the function $\Psi^i_t(\bullet)$ represents the real cost associated to exchange foreign against local currency denominated deposits (bank bonds), as in Schmitt-Grohe and Uribe (2003).

c) **OPTIMAL DECISIONS OF CONSUMPTION, DEPOSITS, WORK AND DEMAND FOR MONEY**

Households maximize (1) subject to (10). First order conditions for consumption of domestic goods and deposits are:

$$\frac{\partial U^j_t}{\partial C^j_t} = (1 + i_t)E_t\left(\frac{1}{P^1_{t+1}/P_t} \cdot \frac{\partial U^j_{t+1}}{\partial C^j_{t+1}}\right)$$  (11)

$$\frac{\partial U^j_t}{\partial C^j_t} = (1 + i_t)E_t\Psi^i_t\left(\frac{S_t D^j_t}{P_t} \cdot \frac{S_{t+1}/S_t}{P^1_{t+1}/P_t} \cdot \frac{\partial U^j_{t+1}}{\partial C^j_{t+1}}\right)$$  (12)

As can be seen in the previous equations, (11) will represent the Euler equation for optimal consumption path, that balance the marginal benefits of savings with their marginal cost, and (12) does the same for the case of having foreign denominated deposits. By using these two equations we can reach an uncovered interest rate parity condition, given by:

$$\frac{(1 + i^*_t)}{(1 + i_t)} = \frac{\Psi^i_t\left(\frac{S_t D^j_t}{P_t} \cdot \frac{S_{t+1}/S_t}{P^1_{t+1}/P_t} \cdot \frac{\partial U^j_{t+1}}{\partial C^j_{t+1}}\right)}{E_t\left(\frac{1}{P^1_{t+1}/P_t} \cdot \frac{\partial U^j_{t+1}}{\partial C^j_{t+1}}\right)}$$  (13)
Condition (3.13) relates the interest rate differential between domestic rates and foreign rates, with the expected depreciation of the exchange rate, as in Gilchrist, Gertler and Natalucci (2001) and Cespedes, et. al (2000).

Money demand also derived through the first order condition will be:

$$\frac{\partial U_{i,t}^j}{\partial M_{i,t}^j / P_t} = \frac{i_{i,t} \partial U_{i,t}^j}{1 + i_{i,t} \partial C_{i,t}^j}$$  \hspace{1cm} (14)

The first order for labor supply is given by:

$$\frac{\partial U_{i,t}^j / \partial H_{i,t}^j}{\partial U_{i,t}^j / \partial C_{i,t}^j} = \frac{W_i}{P_t}$$  \hspace{1cm} (15)

Here $\frac{W_i}{P_t}$ is the real wage, which as usual is equal to the marginal rate of substitution between consumption and labor. Although there exists lengthy literature about labor market imperfection in emerging markets and there is a lot of empirical evidence that supports them, it will not be considered because the focus of the paper is on the credit market imperfections.

The first order condition for demand bank capital shares is:

$$\frac{\partial U_{i,t}^j}{\partial C_{i,t}^j} = E_t \left[ (1 - pd_{i,t}) \left( 1 + \frac{i_{i,t}^Z}{P_{t+1} / P_t} \right) \frac{\partial U_{i,t+1}^j}{\partial C_{i,t+1}^j} \right]$$  \hspace{1cm} (16)

I assume that the optimal combination share between holding domestic and foreign currency denominated deposits is parameter $\theta$ , the dollarization ratio, defined as the share of local currency denominated deposits, as a percentage of total deposits. Therefore, the total deposit demand by the household is composed as $D_{i,t-1}^* = \theta D_{i-1}^* + (1 - \theta) D_{i-1}^{**}$, and the total return of household deposits is:

$$\left( 1 + i_{i,t-1}^* \right) D_{i,t-1}^* = \theta \left( 1 + i_{i,t-1}^* \right) D_{i-1}^* + (1 - \theta) \left( 1 + i_{i,t-1}^{**} \right) \psi_b \left( \frac{S_{i-1,t} D_{i-1}^{**}}{P_{t-1}} \right) S_{i,t-1}$$  \hspace{1cm} (17)

As was explained in the above paragraphs, the difference between the cost of bank capital and the cost of deposits (assumed to be risk free asset in this model), in the steady state, will be only the risk premium, which in turn depends on the probability of default. By using the first order condition of bank shares in the household...
optimization problem, the non-arbitrage standard condition between the bank capital returns and the composed deposit rate is:

$$E(r^z_t) - r^D_t = \eta(pd_t)$$  \hspace{1cm} (18)

Therefore, the spread is a function of banks' probability of default and dollarization rate which also affects the deposit interest rate and the banks' probability of default, through the firm leverage. With an increase in bank default probability, households will require more compensation in order to hold the risky asset (bank capital shares), as they are risk averse. As it has been mentioned, banks' probability of default will be affected by the borrowers' probability of default, therefore there exists a reinforced effect of the bank capital transmission channel, if the bank portfolio deteriorates. An increase in dollarization rate also cause that the premium paid on bank capital preferred share increases through the exchange rate induced credit risk effect.

Also, as in Markovic (2006) and Aguiar and Drummond (2007), banks' default probability will be higher in recessionary periods than in booms, which is the result of having difficulty in raising bank capital in the former period, because households will ask for higher risk premiums to hold these shares.

**FINANCIAL CONTRACT AND ENTREPRENEURS**

Entrepreneurs are the owners of physical capital. They take on debt from banks, following closely Bernanke, Gertler and Gilchrist (1999). In their model, they set a financial contract between banks and entrepreneurs, for loan funding. As will be made clear in this section, financial intermediaries face an opportunity cost equal to the weighted average cost of their funds, composed of both domestic currency and foreign currency denominated deposits, and bank capital shares. Also, to introduce credit market frictions in the financial contract model, following Townsend (1979), there is a costly state verification problem, in which lenders must pay a fixed auditing cost in order to observe an individual borrower’s realized return. This auditing cost could also be thought of as the cost of bankruptcy, and is a portion $\mu$ of the realized gross payoff to the firm's capital. The financial contract under the conventional problem of costly state verification is found when borrowers maximize
their profits, subject to the bank expected profits, under a competitive banking system framework. As the banking system is competitive, profits are zero and there would be no dividend allocation. That is the reason why bank capital shares are modeled like a debt asset or preferred shares.

I model the financial contract and the role of entrepreneurs as follows: in each period, each entrepreneur acquires capital stock to his/her firm in order produce output in the next period, by combining it with household labor supplied. It means that at time \( t - 1 \), homogeneous capital to be used in the production of \( t \) will be noted as \( K_j \). The ex post return of the firm is subject to an idiosyncratic disturbance to firm \( j \)'s return in the following way: \( \omega^j_t R^k_t \), where \( \omega^j_t \) is the idiosyncratic disturbance and \( R^k_t \) is the ex post aggregate nominal gross return of capital. \( \omega^j_t \) is also a random variable with a continuous and differentiable cumulative distribution function \( F(\omega) \).

At the end of period \( t \), entrepreneur \( j \) has an available net worth \( N_j^t \), which is used, along with loans to buy new capital. To finance a project, entrepreneurs need access to credit markets and use bank loans. They must borrow an amount \( L_j^t = Q_{t-1} K_j^t - N_j^t \), where \( Q_{t-1} \) represents the price paid per unit of capital at time \( t \).

Borrowing from banks will have a cost of \( R^L_t \). However, what is relevant for the bank participation constraint is the rate \( R^wac \), which represents the opportunity cost of banking funds.

As I mentioned before, this financial contract will assume the costly state verification problem, in which banks pay a monitoring cost in order to observe an individual borrower’s realized return. This monitoring cost is equal to a proportion \( \mu \) of realized gross payoff of the firm’s capital:

\[
\mu \omega^j_t R^k_t Q_{t-1} K_j^t,
\]

where \( 0 < \mu < 1 \). The idiosyncratic disturbance is unknown for the entrepreneur and unknown for the bank, before signing the financial contract. However, it becomes known for the entrepreneur after that, which is the source of the borrower’s moral hazard problem in the model. Once a loan is granted, banks should incur the
auditing cost to find out if the entrepreneur’s project return is enough to get the loan repaid. As the loan repayment depends on realized disturbances known by the entrepreneur, banks will have to calculate an expected income from the loan realization, or collect the project procedures minus the auditing cost, if the project return is not enough to repay the loan and the entrepreneur declares bankruptcy, and the bank seize the remaining assets.

Following Bernanke, Gertler and Gilchrist (1999), the optimal contract is similar to standard risky debt contract. The entrepreneur chooses the value of firm capital and the associated level of borrowing, prior to the realization of the idiosyncratic shock $\omega_t^j$. Therefore, given $Q_{t-1}^j$, $L_t^j$ and $R_t^j$, the optimal contract will be characterized by a gross nominal non default loan rate $R_t^j$ and a threshold value of the idiosyncratic shock $\sigma_t^j$, such as for the value of the idiosyncratic shock greater and equal to this threshold value, entrepreneurs will repay the loan at the interest rate $R_t^j$, and keep the remaining as income:

$$\left(\omega_t^j - \sigma_t^j\right)R_t^j Q_{t-1}^j K_t^j$$

(20)

Here $\sigma_t^j$ is defined as:

$$\sigma_t^j R_t^j Q_{t-1}^j K_t^j = R_t^j L_t^j$$

(21)

Therefore, if $\omega_t^j \geq \sigma_t^j$, entrepreneurs repay the lender the amount promised $R_t^j L_t^j$ and keeps the difference equal to: $\omega_t^j R_t^j Q_{t-1}^j K_t^j - R_t^j L_t^j$. If $\omega_t^j < \sigma_t^j$, the entrepreneur cannot pay the contractual return and declares default. In this situation, bank will seize what it finds by paying and auditing cost. Therefore, banks will receive $(1 - \mu)\omega_t^j R_t^j Q_{t-1}^j K_t^j$, and entrepreneurs receive nothing. The interest rate set in the contract will be:

$$R_t^j = \frac{\sigma_t^j R_t^j Q_{t-1}^j K_t^j}{L_t^j}$$

(22)

Given the state contingent debt of the financial contract, the expected return of the entrepreneur is expressed as:

$$E \left\{ \int_\omega \omega R_t^j Q_{t-1}^j K_t^j df(\omega) - \left(1 - F(\sigma_t^j)\right)\omega R_t^j Q_{t-1}^j K_t^j \right\}$$

(23)
Also in the equilibrium, the financial contract gives lenders an expected gross return on the loan such as their expected income of the lending activity is equal to their weighted average cost of bank funding, like:

\[
\left[1 - F\left(\sigma^j_t\right)\right]R^j_t L^j_t + \left(1 - \mu\right)\int_0^{\sigma^j_t} \omega^j_t \cdot R^k_{t-1} Q^k_{t-1} f\left(\omega\right) d\omega = R^{\text{wac}}_t \left(Q_{t-1} K^j_t - N^j_t\right)
\]

Here \(\left[1 - F\left(\sigma^j_t\right)\right]\) represents the probability of loan repayment. By using equations (21) and (24), yields the following expression:

\[
\left[1 - F\left(\sigma^j_t\right)\right] \sigma^j_t + \left(1 - \mu\right)\int_0^{\sigma^j_t} \omega^j_t f\left(\omega\right) d\omega \cdot R^k_{t-1} Q^k_{t-1} K^j_t = R^{\text{wac}}_t \left(Q_{t-1} K^j_t - N^j_t\right)
\]

This equation implies a set of restrictions for each realization of \(R^k_t\). As shown in Appendix A and in Bernanke, Gertler and Gilchrist (1999), banks’ expected return reaches a maximum at a unique interior value of \(\sigma^j_t^*\), which could generate credit rationing in the credit market. But, following these authors, I will also rule out the credit rationing equilibrium by assuming that the equilibrium is also reached below this maximum, with the banks expected return always increasing in \(\sigma^j_t\).

The formal investment problem and the financial contracting problem is then reduced to choose \(K^j_t\) and a schedule for \(\sigma^j_t\), such that the equation of expected return of the entrepreneur (23) is maximized subject to state-contingent constraints implied by the equation of the expected return of the banks (24). Let us now define \(e_t = E_t\left(R^k_t / R^{\text{wac}}_t\right)\) as the expected discount return of capital. For entrepreneurs to buy more capital this variable will be needed to be greater than 1, similar to Bernanke, Gertler and Gilchrist’s (1999) approach. Thus, first order conditions give us the optimal capital purchases that follow the rule:

\[
\frac{Q_{t-1} K^j_t}{N^j_t} = \Omega\left(\frac{E_t\left(R^k_t\right)}{R^{\text{wac}}_t}\right)
\]

This equation describes the link between capital purchases by entrepreneurs and financial conditions, and measures the cost of external financing. Bernanke, Gertler and Gilchrist (1999) point out that this is a key relationship in their model, because it shows that entrepreneur capital purchases are proportional to the entrepreneur’s net worth, with a proportional factor being positively related to the expected discount return to capital. Ceteris Paribus, a rise in the expected discounted return to capital reduces entrepreneurs’ probability...
of default and allows them to expand the firm by taking more loans. Since the expected default costs also increase as the ratio of borrowing to net worth increases, the entrepreneur cannot expand the size of the firm indefinitely.

By inverting the equation (26), we obtain:

$$E_{i} \left( R_{i}^{k} \right) = \Psi \left( \frac{Q_{c-1}K_{i}}{N_{i}} \right) R_{i-1}^{wacc}$$  \hspace{1cm} (27)

Its equivalency under bank capital requirements, as will be clear from the next section is:

$$E_{i} \left( R_{i}^{k} \right) = \Psi \left( \frac{Q_{c-1}K_{i}}{N_{i}} \right) R_{i-1}^{D_{i}} \varepsilon_{Z} \hspace{1cm} (28)$$

Therefore, the expected return of capital will depend on the share of capital purchases that is financed by entrepreneurs' net worth, or in other words, her leverage ratio. The right hand side of the equation can be interpreted as the return of capital required by banks in order to grant loans to firms. It is also called as the opportunity cost of being an entrepreneur or the external finance premium faced by them, as Bernanke, Gertler and Gilchrist (1999) mention. Note here, that this cost also depends on the bank capital requirement regulation, involved in $\varepsilon_{Z}$, as will be explained in the next section.

The net worth $N_{i}$ of the entrepreneur is composed by capital investment and its income from supplying labor. If we assume that they do not supply labor, the total equity of the entrepreneur $V_{i}$ will be affected by a probability to survive in the business $(1 - \gamma)$, as:

$$N_{i} = (1 - \gamma)V_{i}$$  \hspace{1cm} (29)

Here I assume, like in Bernanke, Gertler and Gilchrist (1999), that the fraction of the agents who are entrepreneurs is held constant by the birth of a new entrepreneur for each one that does not survive. Let define the variable $V_{i}$ as:

$$V_{i} = R_{i}^{k} Q_{c-1}K_{i} - R_{i-1}^{L_{i}} L_{i-1}$$  \hspace{1cm} (30)
Thus combining the last two equations, it is straightforward to see that $\mathcal{N}_t$ represents the net worth of entrepreneurs as a function of firms’ earnings net of interest payments to banks. Finally, entrepreneurs that do not survive are not allowed to buy capital and simply consume their residual equity as $C_{\text{entrepreneur}} = \gamma \mathcal{N}_t$.

Note here the effect of dollarization and bank capital requirements on the firm balance sheet. If the dollarization ratio increases in the economy, the relevant cost of bank funding will be represented by the foreign interest rate, thus any external shocks or increase in the exchange rate will reduce the firm’s net worth through an increase in the firms’ debt value that weakens the firm balance sheet, as is shown in equation (30). The effect also represents an increase in borrowers’ risk premium and their probability of default. By looking at equation (28), this shock will be amplified, through the expected return of capital, which in turn will increase the cost of investment. The final effect will be a reduction in consumption, investment and bank loan supply, which will be translated into a reduction in the GDP growth. If we add an increase on bank capital requirement in this scenario, the external shock will be reinforced through the cost of firm funding and the expected return of capital, as is represented in equation (28) by the term $\mathcal{E}_Z$.

BANKS AND PRUDENTIAL CAPITAL REGULATION UNDER BASEL I

Here, I depart from Castillo, Montoro and Tuesta (2009) and also from Bernanke, Gertler and Gilchrist (1999) by explicitly modeling the banking balance sheet, and specifying its behavior. I model the banking system as financial institutions that collect deposits (in foreign and domestic currency), as well as raise bank capital, in order to buy assets. Assets in our financial system are composed of only banking loans. Domestic and foreign currency denominated deposits pay a free-risk return equal to $(1 + i_t)$ (or $(1 + i_t^*)$, where $i_t$ is the reference rate set by the Central Bank (or $i_t^*$, set by a foreign Central Bank) to do its operations in a Taylor-type monetary rule, as we will see later.
As in Bolton and Freixas (2006) banks are the only institutions that issue equity to build bank capital. Bank capital preferred shares are sold in the market, and bought by households at a constant price\textsuperscript{18}. Potential new shareholders care about bank health and their probability of default, $p_d$, before investing, asking for a risk premium over its deposits, as it was shown in the subsection 1. In addition, as we mentioned before, the probability of bank default will increase in recessions as in the empirical world\textsuperscript{19}.

Bank capital is subject to a legal minimum risk based regulatory capital requirement, set exogenously by the financial regulatory agency, under any of the two international capital requirement frameworks: Basel I and Basel II. As in Aguiar and Drummond (2007) under the Basel I, there is a risk weighted assets/bank capital ratio, like a fixed leverage ratio; this is because all risk weight loan assets are set at 1 and bank reserves are weighted at zero, since they bear no risk given they are kept in Central Bank. Under the Basel II, there is a risk weighted asset/bank capital ratio, which is a function of borrower probability of default. In this section we will assume that banks will work under the Basel I framework, leaving the explanation of the Basel II effects to the next section.

The bank balance sheet is as follows:

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loans ($L_t$)</td>
<td>Deposits ($D_t$ and $D_t^*$)</td>
</tr>
<tr>
<td></td>
<td>Bank Capital ($Z_t$)</td>
</tr>
</tbody>
</table>

The current bank capital is based on the previous bank capital and its results of lending and borrowing bank reserves. Bank capital increases come from the income generated by loans of those entrepreneurs that do not default, the income net of auditing costs generated from entrepreneurs that do default, plus the income generated for borrowing reserves to the central bank. Banking costs are the amounts paid to depositors for

\textsuperscript{18} As we explain before, introducing bank stock prices only will amplify the pro-cyclical effect if the bank capital is valued mark to market. However, it is not the case of emerging markets economies, where bank capital change as results of net interest margins and income-loss statement related variables. An interesting avenue of research is to identify how changes in bank stock prices amplify business cycle and the role of market value accounting in this effect, as discussed in the last international financial crises.

\textsuperscript{19} See Allen and Saunders (2003) for a comprehensive review of how macroeconomic conditions affect probability of default.
holding deposits in domestic and foreign currency denominations, and the cost of raising new capital in the market in terms of preferred shares. As banks work in a competitive environment, the profit function is:

\[
\Gamma_{t+k}^B = \left\{ \left[ 1 - F(\omega) \right] \left[ 1 + i_{t+k}^L \right] L_{t+k} + (1 - \mu) \cdot \int_0^\infty \omega R_{t+k}^k Q_{t+k-1} K_{t+k} df(\omega) \right\} - \left( 1 + i_{t+k}^{D^+} \right) D_{t+k}^+ - E_t (1 + i_{t+k}^{Z^+}) Z_{t+k-1}^+
\]

(31)

Where:

\[
Z_{t+k+1} = (1 - p_{d_{t+k}}) Z_{t+k} + \Gamma_{t+k}^B
\]

\[
\omega R^k_t Q_{t-1}^i K^i_t = \left( R^L_t \right)_t
\]

Bank balance sheet is:

\[
L_t = D_t^+ + Z_t \quad \quad \quad D_t^+ = D_t^+ + D_t^{
}
\]

(32)

The banking regulation is based on the so called Basel Accord. The first Basel Accord – Basel I (whose real name is International Convergence of Capital Measurement and Capital Standards) was set in 1988 (see Basel Committee of Banking Supervision (1988)), and was the first attempt to regulate bank capital in order to reduce the moral hazard problems\(^\text{20}\). It established that bank capital should not be less than 8% (in Peru, 10%) than their risk weighted assets. Risk weighted assets are calculated as follows: each bank’s exposure is allocated to a risk bracket. Each bucket has a special risk weight that in theory depends on the assets’ risk behavior and on the liquidity of the assets. Some risk weights are reduced to account for the value of the collateral. In the Basel I framework, there are only five buckets. Bank exposure in government assets of OECD countries and domestic governments received a zero risk weight, reflecting the low probability of default and low expected losses given a default. Other assets were classified in risk buckets of 10%, 20%, 50% and 100% risk weight. For examples, mortgage loans usually received 50% risk weight, due to the fact that by seizing the collateral, banks could reduce their loss given a default. However, as has been shown in the subprime crises,

the home collateral value is reduced when there is a systemic crisis. Most of the loan assets are allocated in the 100% risk weight bucket. I assume that this is the case with all bank assets.\footnote{Under Basel I, there are not increases in the risk weight for loan portfolio deterioration. In this framework, risk based capital requirement depend more on the asset class type by issuer which is allocated in an initial risk bucket in advance, rather than on the deterioration of the asset. Basel II is more risk sensitive by allowing migration movements in the risk buckets.}

Therefore, when banks optimize the present value of their profits, subject to (32), these are also subject to the minimum capital requirement constraint and the balance sheet constraint:

\[ \frac{Z_t}{L_t} \geq \alpha_z \quad (33) \]

\[ L_t^j = Q_{t-j}K_t^j - N_t^j \quad (34) \]

The probability of bank default is defined as the probability of bank capital failure, and is a function of the borrower probability of default, which deteriorates the bank portfolio and causes loss that erodes the bank capital.

\[ Pd_t = \Pr \left( z_{t+1} < \alpha_z L_{t+1} \right) = f \left( \Pr (w < \alpha) \right) = \begin{cases} \theta \lambda \left( L_t / N_t \right) & \ldots z_{t+1} > \alpha_z L_{t+1} \\ 1 & \ldots z_{t+1} \leq \alpha_z L_{t+1} \end{cases} \quad (35) \]

With $0 < \theta < 1$, being the portion of borrowers that default and $\lambda \left( L_t / N_t \right)$ being the percentage of the aggregate leverage ratio of all borrowers, such as $0 < \theta \lambda \left( L_t / N_t \right) < 1$, which represents that only a percentage of the average borrowers’ probability of default is transmitted to the bank probability of default, when the bank capital ratio is over the minimum required. If the bank capital ratio is under $\alpha_z$, then the probability of default is one, because the supervisory authority will close the bank and will seize the remaining assets in order to compensate for the insurance fund covered in risk free deposits. Any remaining assets will be delivered to households, as compensation of their bank capital shares holdings, once the insurance deposit is covered. Also, if all borrowers default, then bank fails, and loses are assumed by the government in terms of fiscal deficit.
What if there is an unexpected shock that increases borrowers’ probability of default and reduce the loan repayment? In this scenario, the return on bank capital shares is reduced and households will react by moving some resources from bank capital shares to risk free deposits, as they are risk averse. This change in portfolio will reduce bank capital share holdings. The extreme case is a reduction in bank capital share holdings up to the minimum regulatory capital requirement. Banks will survive only if their income can fulfill the cost of minimum capital requirement: $i_t^2 \alpha_t L,_{t+1}$ plus the cost of their deposits. Otherwise, if they cannot fulfill this average cost of bank funding, or if the bank capital share is below the minimum required, the bank is closed.

Using condition (31), we can obtain the following conditions:

\[
\frac{\partial Pd_t}{\partial F_{(\sigma)}} > 0, \quad \frac{\partial Pd_t}{\partial N_t} < 0, \quad \frac{\partial Pd_t}{\partial S_t} > 0, \quad \frac{\partial Pd_t}{\partial \mu} > 0
\]

As we can see in this equation, some macroeconomic factors influence the bank probability of default and create more fragility in the financial system. First is the auditing cost reflected in the costly verification state, as in Townsend (1979). If it is costly for banks to audit borrowers’ moral hazard, they can react by reducing supervision or by being more conservative and reducing the loan supply. In both cases, there would be a negative effect on the bank portfolio that would increase the probability of bank failure. Stopping lending or making it more expensive could make firms fragile as they need bank lending to operate. Thus, policies that increase the moral hazard in credit markets increase the banks’ fragility as well. Second, a negative shock that increases the entrepreneur’s probability of default will also increase the bank’s probability of default. As we have shown in the previous section, an increase in the external finance premium, will lead to a higher probability of entrepreneurs to default on bank loans, therefore increasing the bank fragility in a kind of vicious circle that amplifies the financial accelerator effect. Third, increases in capital requirements make the banking system more sensitive to the effects of the financial accelerator, through the increase in cost of bank funding. Lastly, in our dollarization framework, exchange rate depreciation will also increase the cost of bank funding, which in turn will be translated into higher loan interest rates. The rise in loan interest rates could increase the borrower probability of default and thus the bank probability of default, reinforcing the financial accelerator through the bank capital channel.
First order conditions of banking behavior give us:

\[
[1 - F(\omega)]R_t^L = R_t^{\nuac} = (1 - \alpha_z)R_t^{D_z} + \alpha_z E_t(R_t^Z)
\]  

(36)

As we can see, the loan rate set by banks is a linear combination that represents the weighted average of bank funding cost (the cost of bank capital and cost of holding deposits), weighted by the minimum capital ratio. The return paid for bank capital is thus derived endogenously from the household optimization problem, as in Zhang (2009) and Aguiar and Drummond (2007). Here there is an interesting aspect. The interest rate for loans depends on not only the cost of bank capital, which in turn depends on the probability of default, but also on the household’s optimal choice of bank capital and deposits, given by their risk aversion, which reinforces the bank capital channel.

Using equation (36), I can modify the financial contract set in the previous section to include the cost of bank capital and the effect of the capital requirement ratio on the loan supply. As in Markovic (2006) I can define a variable \( \xi_Z \) as the additional cost of bank liabilities. I do this because by equation (18) in the household optimization problem, the cost of bank capital is a linear function of the composite deposit rate plus a risk premium that is based on the bank probability of default, and by (36) the loan rate is a linear combination of the cost of bank capital and the composite deposit rate. Therefore, the loan rate becomes an additional cost of both the composite deposit rate and capital requirement ratio, being:

\[
\xi_Z = \left(1 + \frac{E_t R_t^Z - R_t^{D_z}}{R_t^{D_z}} \frac{Z_t}{L_t}\right)
\]  

(37)

or:

\[
\xi_Z = 1 + \frac{\eta(pd_t)}{R_t^{D_z}} \alpha_z
\]

Then:

\[
[1 - F(\omega)]R_t^L = R_t^{\nuac} = R_t^{D_z} \left(1 + \eta(pd_t)\alpha_z\right)
\]  

(38)

The loan interest rate becomes:

\[
R_t^L = \frac{R_t^{D_z} \left(1 + \eta(pd_t)\alpha_z\right)}{[1 - F(\omega)]}
\]  

(39)
Higher borrower probability of default (or lower probability of loan repayment $\left(1 - F(\omega)\right)$), as well as higher bank fragility, will increase the loan interest rate in the economy. It is shown in Appendix A, that by using the financial contract established in the previous section, both the cost of bank capital and the banks' probability of default (bank fragility) increases the external finance premium, as in:

$$E_t(R^K_t) = \psi \left( \frac{Q - 1}{N_t} \right) R^{D+}_{t} \xi Z$$

This is an important result in our small open economy dollarized environment. First, it confirms my assumption that not only binding capital requirements affect the cost of the external finance premium, but also banking fragility is important in examining the amplification of the business cycle. Intermediation in a fragile financial system is the source of business cycle volatility, as has been proved in Chang and Velasco (2000), for emerging markets economies. What is important here is that in an open dollarized environment which flexible exchange rate there are some other channels through which a tighter monetary policy could affect the borrower cost of external finance. One channel is directly through the banks' funding cost and the other is through the banks' probability of default that affects the cost of bank capital.

Monetary policy affects a firm's balance sheet through the financial accelerator/bank capital channel. Here, unexpected increases in the monetary policy interest rate will increase the bank cost of funding and loan interest rate, which in turn is amplified by the effect of bank capital requirements. The other channel that goes through the cost of bank funding is the effect of dollarization on the firm's external finance premium, which is embedded in the term: $R^{D+}_{t} \xi Z$. 

\[ \text{\textsuperscript{22}} \text{Remember that} \quad R^{D+}_{t} \xi Z = R^{D+}_{t} \left(1 + \eta(pd_t)\alpha_z\right) = R^{D+}_{t} + R^{D+}_{t} \eta(pd_t)\alpha_z. \quad \text{The term} \quad R^{D+}_{t} \eta(pd_t)\alpha_z \quad \text{is also expressed as} \quad R^{D+}_{t} \eta(pd_t)\alpha_z = \eta(pd_t)\left[\alpha_z(1 + R^D_t) + \alpha_z(1 - \theta)(1 + R^D_t)\psi_B \left( \frac{S_t D^\xi_B}{P_t} \right)S_t \right]. \quad \text{Here the relevant term is} \quad \alpha_z(1 - \theta)S_t R^{D+}_{t} \Psi_B(\bullet). \quad \text{If the dollarization ratio increases} \quad (\theta \rightarrow 0), \quad \text{then the cost of external finance becomes sensible to international interest rate shocks and the domestic monetary policy shocks are irrelevant. Under partial dollarization, international interest rate and exchange rate shocks matters to the firm's cost of external finance, as well as domestic monetary shocks. Thus, in this situation, monetary authority has to balance the effects of monetary policy or exchange terms.} \]
Here is clear that under full dollarization, the exchange rate does not matter, but the firm’s external cost of finance is sensitive to international interest rate shocks and changes in capital requirements. However, under partial dollarization, not only do domestic monetary policy shocks matter for the firm’s cost of funding, but also for the international interest rate and exchange rate shocks, which are also affected by the regulatory level of the capital requirement.

Thus, in this scenario the monetary authority has to balance monetary and exchange rate policies. If there is pressure for exchange rate depreciation (like speculative attacks or capital outflows), Central Banks will react by increasing interest rates in order to defend the domestic currency. As both the exchange rate and domestic interest rates could be rising at the same time, the firm’s cost of funding will increase, as well as their probability of default, which lead to a higher banks’ probability of default and a higher loan interest rate, even more than the initial shock. Then the bank capital channel amplifies the financial accelerator effect in the dollarization framework.

Therefore, the business cycle is amplified by the choice of the monetary and exchange rate policies, which in turn are affected by the bank capital requirement position. Changes in the regulatory level of the capital requirement will expand the previous mentioned effects. Thus, using countercyclical regulatory capital buffers could help to compensate for the business cycle effects of external shocks on the firm’s external finance premium. In a non dollarization case, both the effect of tighter monetary policy and the effect of binding bank capital regulation are expected to work together as the monetary policy is more effective, but bank capital channel is less important than in the dollarization case.

Another important result here is the bank’s probability of default channel. Riskier banks tend to collect higher loan rates, as empirical evidence shows. However, these riskier banks are in a weak position to absorb unexpected shocks, which weakens their bank portfolio and increases their bank default probability. An rate policy in the firm cost of funding. Then in dollarization framework there is an exchange rate induced credit risk, the financial accelerator and the capital channel reinforce each other despite that monetary policy is less effective.
increase in bank default probability will also reinforce the effects of capital requirements on the firm's cost of funding, causing a recession and reduction in production activity. Banking crises, during which banks can default, will deepen these effects on the economy. This claim is enough to sustain the need of better prudential regulation and better supervisory processes in the financial system.

V. PRUDENTIAL REGULATION: BASEL II

As Aguiar and Drummond (2007) and Markovic (2006) mentioned, the introduction of new bank capital requirements in Pillar 1, may accentuate the procyclical trends of banking, causing an important impact on macroeconomic conditions, because the risk weights are a positive function of borrowers' probability of default. In recessions, probability of default increases, making risk weights increase in turn, with the consequence of requiring more regulatory capital to banks. In this scenario, raising new capital should be a difficult task to fulfill. Therefore, it can become a binding restriction, with effects on loan supply. Although both authors show an important link between capital requirements and monetary policy transmission, their model is done in a closed economy framework.

Using the framework described above, I model how the Basel II accord could enter into our small open dollarized economy. To do that, I will closely follow Aguiar and Drummond's (2007) example, by defining that the Basel II risk weights depend on the borrower probability of default. As Bemanke, Gertler and Gilchrist (1999) have shown, there is a linear relationship between borrower probability of default and the firm leverage ratio. It make a lot of sense, because it says that when a firm is over indebted (a firm with higher leverage), it will find it more hard to fulfill its debt contract, following an unexpected shock that reduces its profits or makes a project's realization more difficult.

Closely following Aguiar and Drummond (2007), under the Basel II IRB rules, the risk weight depends on the credit risk of each exposure. In the Bemanke, Gertler and Gilchrist (1999) model, firms default if there is an unexpected shock that reduces the idiosyncratic disturbance $\omega^j_t$ below the cutoff value $\sigma^j_t$. Since it
depends positively of the firm's leverage ratio \( (Q_{t+1}K_i \div N_i) \), the risk weight capital requirement will too depend positively on the leverage ratio. Then, the capital requirement under the Basel II will be:

\[
CR_{BII}^t = a + b \frac{Q_{t+1}K_i}{N_i} = a + b \left( \frac{L_t}{N_t} + 1 \right)
\]

(41)

\[
\frac{Z_t}{L_t} \geq \alpha_Z \left(a + b \frac{Q_{t+1}K_i}{N_i}\right)
\]

(42)

Now again banks will choose loans and deposits that maximize (31) subject to the same constraints as before, plus the replacement of constraint (33) for the constraint (42). First order conditions will be:

\[
(43) \left[ 1 - F(\sigma) \right] R^L_t = \left( 1 - \alpha_i \left(a + b \frac{L_t}{N_t} \right) \right) R^{D^*} + \alpha_Z \left(a + b \frac{L_t}{N_t} \right) E_t R^Z_t
\]

(44)

Thus, as it can be observed from equation (44), that bank capital regulation based on risk-weighted assets, which are more sensitive to borrower solvency and risk, as in the Basel II, introduces a more procyclical behavior, which amplifies the business cycle. For instance in expansionary periods, as the firm's balance sheet is stronger, their leverage ratio is reduced as well as their cost of funding, because banks will have to keep lower levels of capital requirements and will expand their loan supply fueling economic growth. However, under recessionary periods, the firm's balance sheet is weak, as their leverage ratio is increased. It increases the loan interest rate sensitivity to bank capital requirements, as well the firm's cost of funding. Therefore banks will have to keep higher capital requirements. This will affect their loan supply and reduce economic growth.
COUNTERCYCLICAL CAPITAL REQUIREMENTS

We have shown so far in this paper that binding capital requirements and bank fragility will increase the entrepreneur's external premium cost of finance, adding a stronger impact to any unexpected shock, and causing amplification of and more volatility in the economic business cycle. But we also mentioned at the beginning of this chapter that the actual regulatory concern is how to reduce the procyclical impact of capital requirements and how to smooth its effects on the business cycle. As Repullo, Saurina and Trucharte (2009) pointed out, there is widespread concern among banking regulators that the Basel II might amplify even more the effect of binding capital requirements, if the economy goes into a recession. I have also shown in this chapter, that the impact under the IRB method is amplified by a factor that depends not only on the bank default probability (the bank fragility effect), but also the entrepreneur’s leverage ratio, which represents the risk weight based on their probability of default that is assigned to their debt.

As is clear from empirical evidence shown in Altman, et. al (2005), capital requirements that are increasing in terms of the debtor’s probability of default and the loss incurred given the default of credit for each borrower, are likely to rise in an economic downturn, worsening the debtor’s risk profile, deteriorating the bank portfolio and asking for more capital requirement. When this happens, banks could have difficulties in raising new capital and borrowers will find it more difficult to switch to more costly sources of banking funding.

In this section, I will modify the capital rule in order to introduce countercyclical capital requirements as in Gordy and Howells (2006) and in Repullo, Saurina and Trucharte (2009). In their work, they empirically tested two competing rules in order to smooth the capital required in the recessionary phase of the business cycle, but they did not develop any microfoundation macroeconomic model to support their rules. Here I am modeling these rules, introducing them into my small open dollarized economy and I will find the necessary condition that the countercyclical rule must follow in order to eliminate the binding capital requirement effects on the external finance risk premium. As is mentioned by Repullo and Suarez (2008), even when banks have incentives to hold capital buffers to reduce their need to access capital markets to raise new capital in recessions, this is insufficient in expansionary phases, and therefore it is important to find the level of capital buffer required to absorb loan portfolio losses in recessions.
Before we develop that, and in order to be clear with the objectives of this section, I must state that I do not attempt to solve the moral hazard problem that causes the presence of the financial accelerator. It is because it depends on the costly verification state of the bank contract, which only can be solved by establishing an optimal contract with separated equilibrium in which debtors identify themselves as risky or not, and also by reducing the opacity in the bank loan markets; an extension use of Pillar III in the Basel II accord.

Following Gordy and Howells (2006) there are three ways to smooth the pro cyclicality effects of the Basel Accord. The first one should be smoothing the inputs in the IRB method, by adopting through-the-cycle methodologies; the second one should be flattening the capital requirement function to reduce its sensitivity to risk, and the third should be smoothing the capital requirement. As is pointed out by Pederzoli and Torricelli (2005), the first two ways could not be good solutions because they represents that the calculated capital requirement does not measure the risk taking of banks. The third way to address this problem looks more promising. Gordy and Howells (2006) defined a variable \( CR_i \) as the unsmoothed capital requirement that by using the Basel II’s IRB methods, bank \( i \) at time \( t \) has to build. They also defined a new variable, \( \hat{CR}_i \), which now represents the corresponding minimum capital requirement applied to banks. A simple smoothing rule is represented as such an autoregressive process:

\[
\hat{CR}_t = \hat{CR}_{t,t-1} + \alpha \left( CR_t - \hat{CR}_{t,t-1} \right)
\]  

(45)

The Basel II accord capital requirement output is achieved by setting \( \alpha = 1 \), and the Basel I accord capital requirement output is achieved by setting \( \alpha = 0 \). Therefore as the authors above pointed out, by setting a value of \( 0 < \alpha < 1 \), one could smooth its sensitivity to the business cycle and reduce the additional amplification effect imposed by more risk sensitive framework such as Basel II.

Repullo, Saurina and Trucharte (2009) established another procedure to smooth Basel II output. They define:

\[
\hat{CR}_i = \alpha' CR_i
\]  

(46)

\[
\alpha' = 2\phi \left( \frac{(GDP_i - GDP)}{STD(GDP)} \right), \quad \phi \sim N(0,1)
\]  

(47)

Here \( \hat{CR}_i \) is the smoothed capital requirement and \( CR_i \) is the calculated capital requirement under the Basel II formula. As noticed, \( \alpha' \) is the adjustment parameter, which is a function of the deviation of actual GDP over a long run average GDP. To smooth the capital requirement, they use \( \alpha' \) in combination with the function \( \phi \),
which represents the cumulative distribution function of a normal random variable, that is increasing in $GDP_t$, and is equal to 1 when $GDP_t$ is equal to its long run average value. They show that their formula works well to smooth capital requirements for data on Spain.

Here I am going to use the formula recommended by Repullo, Saurina and Trucharte (2009), but I will make a minor change. As shown in Koehn and Santomero (1980) and Rochet (1992), capital requirement should reflect banks’ risk taking in order to be an efficient way to protect bank stability. That is the reason for building an additional capital buffer, as the one recommended in the Basel II’s second pillar, which works as a cushion to be used in the recessionary phase of the business cycle. Therefore, the minimum capital required should be the one in Basel I or Basel II capital calculation, plus a function, similar to the one recommended by Repullo, Saurina and Trucharte (2009), but instead of using GDP long run average growth, it will used the difference between actual GDP growth rate and the lowest GDP growth rate in a recession.

By implementing this small twist, required regulatory capital will be always higher in the expansionary phase of the business cycle, during which banks would not have problems raising additional capital from households, which allows the building of a buffer that is complete erased when the GDP growth rate reaches the lower GDP growth rate in the worst recessionary phases, as previously experimented. To calibrate the formula it is necessary to have complete business cycle data in order to see the lower rates of GDP growth in a country’s economic history. As business cycles are not the same over time, the method described here would only resemble the worst-case scenario of the last business cycle experimented in a small open economy. Therefore, as it is shown below, the rule of adjustment should be reached by equalizing the marginal increase in bank default probabilities during a recessionary phase, with the rate of accumulation of the additional countercyclical capital buffer.

Let’s define the function $\phi(Y_t - Y_t^{\text{min}})$, continuous and differentiable, which is increasing with the GDP growth rate $Y_t$ and decreasing with $Y_t^{\text{min}}$, the lower rate of growth of GDP in past business cycles, $\phi = 0$ if $Y_t = Y_t^{\text{min}}$. The new capital requirement under the Basel I and Basel II should be:

$$\alpha'_Z = \alpha_Z + \phi_Z(Y_t - Y_t^{\text{min}})$$
In order to reduce procyclicality facing a tighter monetary policy as was mentioned in the above sections, the conditions to smooth the financial accelerator effects due to binding capital requirements should be reached when the additional cost of bank capital is eliminated and $\varepsilon_Z^* = 1$, such that $R_t^k = \Psi(Q_t, K_t/N_t)R_t^{DP}$. Therefore:

$$
\varepsilon_Z^* = 1 + \eta(pd)\alpha_Z' = 1
$$

(49)

$$
\eta(pd)\alpha_Z' = 0, \text{ implies total differentiation with respect to } Y
$$

(50)

$$
\Rightarrow \eta'(pd)\alpha_Z' + \eta(pd)\phi'(Y_t - Y_t^{MIN}) = 0
$$

$$
\Rightarrow \eta'(pd) = -\frac{\phi'(Y_t - Y_t^{MIN})}{\alpha_Z + \phi(Y_t - Y_t^{MIN})}
$$

$$
\varepsilon_Z'' = 1 + \eta(pd)\alpha_Z' 2b\left(\frac{L_t}{N_t}\right), \text{ doing the same as before:}
$$

(51)

$$
0 = \eta'(pd)\alpha_Z' 2b\left(\frac{L_t}{N_t}\right) + \eta(pd)\phi'(Y_t - Y_t^{MIN})2b\left(\frac{L_t}{N_t}\right)\left[\partial \left(\frac{L_t}{N_t}\right) / \partial Y_t\right]
$$

(52)

$$
\eta'(pd) = -\frac{\phi'(Y_t - Y_t^{MIN})}{\alpha_Z + \phi(Y_t - Y_t^{MIN})}
$$

The above equations (50) and (52) are the conditions in order to smooth the capital requirement effects of financial accelerator amplification. Notice that in both cases, the marginal increase of the bank’s probability of default due to increase in GDP should be matched to the reduction of the additional capital buffer in recessionary times. This implies that a policy of “saving for a rainy day” is good to reduce the business cycle effect of capital requirements, if the amount saved in the expansionary phase is enough to absorb potential losses incurred during recessionary phases. Banks could reduce their additional capital buffers in recessions to account for portfolio losses before raising new capital, because regulatory bank capital is not a binding constraint.

However, a cautionary note needs to be raised here. By asking banks to keep more capital in expansionary phases, the cost of bank loans could be increased by this additional requirement, because bank shareholders could ask for a higher return to keep more capital than needed. It means that the complete business cycle is smooth, because it will be more costly to raise funding in good times. Although GDP growth in the economy will be lower than the case without additional buffers, it is compensated by holding the buffer. This is because
the fall in GDP growth will also be lower than in the case of not having additional buffers in recessions, because as banks do not need capital to absorb losses and rise up in these times, they do not have the incentive to increase bank loan costs during a recession.

Notice that the introduction of the Basel II accord implies that a countercyclical capital requirement should take into account the effect of GDP growth on borrower leverage. It is an important issue because it is well documented that borrowers increase their access to debt in expansionary phases. Thus, to be consistent, this expansion in debt can cause a deep impact in borrowers’ ability to repay loans due to an increase in their leverage when the business cycle is reversed. So, the rule implies that the accumulation for rainy days is higher under the Basel II framework, than under the Basel I framework, in order to compensate the bank capital channel amplification effect caused by risk sensitive bank capital requirements.

**MONETARY AND FISCAL POLICY**

In this model, the Central Bank set its monetary policy by using a Taylor-type rule that fixes its nominal reference rate $i_t$. The monetary rule depends on the inflation rate target, exchange rate volatility and GDP growth, in the following combination:

$$\frac{1+i_t}{1+i} = \left(\frac{1+i_{t-1}}{1+i}\right)^\psi \left[\left(\frac{\pi_t}{\Pi}\right)^\psi_x \left(\frac{S_t/S_{t-1}}{S/S_{t-1}}\right)^\psi_y \left(\frac{Y_t}{Y_{t-1}}\right)^\psi_y^{-1}\right]^{1-\psi_x}$$

Note here that the Taylor rule evolves according to the economic stance. For instance, increases in the inflation rate over the target rate, or a depreciation of exchange rate, will increase the Central Bank’s nominal reference rate.

The government budget constraint is written in a traditional form where government net transfers are financed only by printing money, such as:

$$M_t = M_{t-1} + T_t - P_t G_t$$

As it was mentioned before, I assume that the government purchases in the economy are composed of a basket of domestic and foreign goods in the same way as households consume and use the same consumer price index. I introduce in the government expenditure any cost caused of banking crisis due to the insurance deposit coverage.
EXTERNAL RESOURCE CONSTRAINT

By replacing government budget constraints, firms profits, the entrepreneur net worth dynamic equation, the credit market equilibrium that balances entrepreneur debt (banking loans) with household deposits and bank capital stock holdings, I can obtain the balance of payments:

\[
S_t \frac{D^*_t}{P_t} - S_{t-1} \frac{D^*_{t-1}}{P_{t-1}} = \left\{ \frac{P^*_t}{P_t} Y_t - \left( C_t^{fam} + C_t^{emp} + G_t + INV_t \right) + \left( \frac{1 + i_{t-1}^t}{\Pi_t} \right) \Psi^t \left( \frac{D^*_{t-1}}{P_{t-1}} \right) \frac{S_t}{S_{t-1}} - 1 \right\} S_{t-1} D^*_{t-1} + OTHER
\]

\[
OTHER = \left( \frac{P^M_t}{P_t} \left( 1 - MC_t^M A_t^M \right)^{P_t^M} - \left( 1 + \Psi \left( \frac{L_{t-1}}{N_{t-1}} + 1 \right) \right) \left( 1 + r_{t-1}^L \right) \frac{L_{t-1}}{P_{t-1}} \right) + (1 - pd_{t-1}) (1 + r_{t-1}^Z) \alpha Z \frac{L_{t-1}}{P_{t-1}}
\]

Note that binding bank capital requirement effects affect balance of payment results. This means that more banking fragility could generate a balance of payment crisis, as was the case in the Asian Crisis. It is important to mention that increasing cost of external finance due to a tighter monetary policy and under binding capital requirements could also deteriorate the balance of payment results, by increasing the probability of entrepreneur default, the external cost of finance, and deteriorating banks' loan portfolio. Therefore, the financial accelerator effect is amplified when both binding capital requirements and banking fragility are present, which in turn deteriorates the balance of payment results, facing a tighter monetary policy that weakens the banking system.

B. SOLUTION AND CALIBRATION RESULTS

The model is solved by using Uhlig’s (1999) log linearization technique for solving dynamic new Keynesian macroeconomic models. The model has been calibrated for Peruvian data, in a quarterly frequency. All macroeconomic data comes from the Central Bank’s statistics, whereas financial data comes from the Superintendency of Banking and Insurance statistics.
I borrow from Castillo, et. Al (2006) the parameters for the Peruvian economy used in the calibration. They set the γ parameter fixed at 0.6, meaning that the share of import goods in the consumer price index is 40%. The elasticity of substitution between domestic and foreign goods is set at 0.75. The elasticity of substitution among goods is set at 7.66, and the mark up margin is set at 15%. Also the labor substitution rate of different goods is 7.66. The volatility of investment with respect to GDP is set at 3.5, reflecting the average level of this parameter for the Peruvian economy in the last 15 years. The steady state investment-GDP ratio is set at the level of the average ratio between 1994 and 2007, which was 20%. The depreciation rate is set at 0.025. Moreover, the parameter of uncovered interest risk parity is set at 0.8, which is consistent with the low volatility of the Peruvian sol in the last 7 years. In terms of the good domestically produced the probability of firm price changes is 0.66. The pass-through between exchanges rate and inflation in the Peruvian economy is set at 20%, as in Armas, et. Al. (2006).

In terms of financial variables, the elasticity of the external finance premium is set as in Dib and Christensen (2006) at 0.1. The coefficients of the Central Bank interest rate Taylor rule are 2 for the effect of inflation in the reference rate, 0.25 for the effect of the output gap and 0.7, which are the values used by the Peruvian Central Bank in its Taylor rule. The dollarization parameter is set at 0.6, which is consistent with the average dollarization ratio shown in the previous chapter. All other parameters have been taken from Castillo, et. al (2006).

The capital requirement ratio is set at 10% which is the minimum required under Peruvian banking law. Under the Basel II, the parameters will be a = 0.1 and b = 3, which makes sense in terms of the high sensitivity of the firm leverage on the risk weighted capital, showing that highly leveraged companies will be riskier than others. Finally, all shocks are modeled as AR(1) processes, their persistency coefficient being 0.86 for productivity shocks, 0.90 for international interest rate and world GDP shocks, 0.65 for a monetary policy shocks, and 0.48 for inflationary shocks, with a standard deviation of 0.01 for productivity and inflation shocks, 0.002 for international and world GDP shocks, 0.05 for monetary policy shocks, which are consistent with previous
estimations for the Peruvian economy. The list of main parameters estimated and shocks autocorrelations are shown in Table 1.

THE EFFECT OF DOLLARIZATION AND BANK CAPITAL REQUIREMENTS

Tables 1 and 2 summarize the main result of the model under two basic scenarios, an economy with dollarization and one without dollarization. In these tables, I also show the effects of different prudential regulations like the Basel I and Basel II, as well as the countercyclical bank capital rule, in order to understand the contribution and the effects of dollarization on the economy, under different bank capital regulation.

As the estimated second moment shows, there is more volatility in an economy with dollarization scenarios, than under non-dollarization. This is consistent with the issue that the presence of dollarization generates potential negative effects on firm balance sheets, making the economy more vulnerable to external shocks. As firms depend on bank loans, which in part are lent in foreign currency denominated assets, an increase in the exchange rate under dollarization will increase the firms’ debt value, will weaken firms’ balance sheet and therefore will increase their probability of default, as in Cespedes, Chang and Velasco (2004) and Faia and Monacelli (2002). Even more, the presence of dollarization lowers the power of the monetary policy to stabilize the economy, therefore, making it more vulnerable and more volatile.

By looking at the same tables, the impact of different capital requirement is stronger under the dollarization framework. The reason for that is because in a dollarization scenario, a depreciation of the domestic currency leads Central Banks to react by raising interest rates. Therefore, the increase in interest rates as well as the depreciation generates an initial pressure over the bank funding costs, which could be amplify by binding capital requirements. Thus, the effect is translated to the firms’ expected return of capital, which makes investment more expensive. That reduces GDP growth lower than in the case of non-capital requirement regulation or in the case of capital requirements under a non-dollarized framework, in which case the effect of a depreciation and the exchange rate induced credit risk are not relevant. Therefore, the impact of bank capital requirements under a dollarized framework will be higher than in the case of non-dollarization.
Here it is relevant to stress the functioning of financial accelerator mechanism under dollarization. As Castillo, et al (2009) mention, higher vulnerability to external shocks could be translated into a currency depreciation which generates a balance sheet effect. This effect reduces private investment and is not compensated by the potential beneficial effects of depreciation on exports, due to the fact that the real exchange rate is also increased because of domestic price rigidity. Without a balance sheet effect, the increase in the real exchange rate creates an increase in exports and expands GDP. Thus, under a dollarization framework, the financial accelerator mechanism makes private investment and GDP prone to external shocks.

The Basel II’s prudential bank capital requirement as expected generates more volatility in the economy than the Basel I’s prudential bank capital requirements. The reason for that is when prudential capital requirements are more risk sensitive (as in the Basel II), it creates additional effects that go through the expected return of capital and the cost of investment. In the case of the Basel II, the loan interest rate has an additional term (its sensitivity to firm leverage that represents the borrower probability of default), which has pro cyclical effects. If there is a shock in the economy that weakens the firm’s balance sheet or if there is over borrowing, the borrower’s probability of default increases, making banks react by raising the additional bank capital needed or reducing loan supply. Both reactions cause an amplification effect that affects GDP and Investment volatility. For the Basel I capital requirements, this additional effect of firm leverage is not included due to the fact that it is not risk sensitive, and their risk weights are based on the type of credit, rather than the risk involved in the credit. Thus, risk sensitive capital requirements generate procyclical behavior of bank loans which make a case for countercyclical rules of bank capital requirements. In the case of having countercyclical capital rules in place, GDP and Investment volatility is reduced as it is shown in Tables 1 and 2.

THE EFFECT OF A MONETARY SHOCK

The following impulse-response functions in Figure 1 show the dynamic behavior of the monetary transmission mechanism in our partial dollarized economy with binding capital requirements, over the main variables of the model. Shown here is the effect of a positive 1% shock to the Central Bank’s reference rate and the response
of return of capital, inflation, GDP, dollarization weighted average deposit interest rates, consumption and investment.

The responses are consistent with the theory presented above. An unexpected shock in monetary policy will increase the entrepreneur’s return of capital, by financial accelerator effects that work on the expected return of capital, through the external risk premium, as in Bernanke, Gertler and Gilchrist (1999), independent of being in a dollarized or not dollarized economy. However, when I introduce risk sensitive capital requirements as in the Basel II, this shock is amplified and persistent, meaning that the monetary has some lags.

The general effect of an increase in the reference rate reduces GDP and investment, with a higher multiplicative effect under the Basel II than under the Basel I. It also generates that, being more expensive to take debts, firms will reduce their debt position, but as the interest rate has risen, there is a weakness in the firm’s net worth, which in turn reduces the bank loan supply, amplifying the initial effect. Expected return of capital increases, as well as the risk premium paid by the firm. After the shock, the Taylor rule will be working to lead the economy to its steady state equilibrium after some quarters. If the countercyclical capital buffer rule is present, this also contributes to smoothing the fall in GDP and investment, and allows for a lower effect on the firm’s net worth and the expected return of capital, allowing the economy to recovery quicker than in the case of a non-countercyclical rule.

The shock under the Basel I accord implies an increase in expected return on capital that remains for almost 10 months. However, as soon as the banking system is under the Basel II, which is more risk sensitive, this effect is stronger and has more persistence, because it lasts up to 15 months. This is because while fixed capital requirements could force banks to be binding in the lower phases of the business cycle, it does not have a cross effect of increasing the bank portfolio risk. Under the Basel II for instance, this shock will increase not only the cost of the entrepreneurs, but also generate a weakness in the borrower’s balance sheet, with the corresponding increase of their risk. Thus, the Basel II capital requirement is reinforced by the deterioration of borrower risk classification which will in turn increase the bank needs of capital requirements to fulfill the prudential regulation, which increases the interest rate again
If we can appreciate the macroeconomic effect of this shock, GDP and Investment becomes more volatile under the Basel II accord. This volatility is persistent and deeper in both variables than in consumption. That result is consistent with the fact that the transmission channel of increasing financing costs is through project investments and production. Consumption is not directly affected by the external finance premium maximized by binding and with pro cyclical effects of capital requirements. If I expand the model to finance and some portion of their consumption through the banking system, I expect that consumption will have the same volatility as the other real variables. This scenario is highly complicated because consumers could be harmed deeper in the middle of a recession when banks face constrains in their capital requirements.

The effect of monetary shocks on inflation and on deposit interest rates is quite small and non-significant. As the capital requirement amplifies the monetary shock and makes investment more volatile, the economy faces a reduction in the aggregate demand, which in turn will be reflected in the first reduction of the inflation rate. Due to the staggered contracts in some firms, prices are not fully flexible and take time to come back to the steady state. Without these rigidities, the impact of monetary policy in the short run will be large. Another consistent explanation is that the increase in the central bank reference rate causes a reduction of inflation after some periods, because central banks withdraw money from the economy.

The effect on the deposit interest rate is also interesting. As Castillo et. al. mentioned, the pass-through of the exchange rate in the dollarized portion of the deposits, is small and asymmetric in an economy with low volatility of exchange rate, as in the case of Peru. Thus, the dollarization effect of the shock does not have a significant contribution to the impact of capital requirements on the deposit rate. Nevertheless, as capital requirements become binding, banks need to attract household deposits for financing their operations. That is why the deposit rate also increases with the shock. However, that increase is in the short run (less than 5 months), and after that banks tends to stabilize the deposit interest rate.

These results are consistent with the findings on Christiano, Motto and Rostagno (2009), which found that financial shocks are responsible for economic fluctuation and besides the financial accelerator channel; they
found a Fisher deflation channel that works through the entrepreneur net worth and its probability of default. This channel reinforces the financial accelerator mechanism causing a significant drop in output. Then, firms' balance sheet play a crucial role in amplifying shocks in the economy, like I have proved in this chapter.

When countercyclical rules of capital requirements are introduced, the monetary shock is smoothed as expected. All the amplification effects of binding capital requirements are reduced, leaving the economy isolated and more stable. When the capital rule follows the premise that bank capital requirements increase when GDP increases, the effect leads to reduction of the volatility of GDP and Investment. In a recession, the effect of this rule works as an automatic stabilizer. A fall in GDP leads to less bank capital required, thus it gives banks some space to continuing lending. Nevertheless, I have to be cautious here. The policy recommendation is not a reduction of the minimum capital requirement, but is the building of a buffer stock capital rule, which could accumulate reserves in good times, in order to use as capital in recessions; this is how the dynamic provisioning model in Spain works (Saurina and Trucharte, 2007). This policy rule is nowadays under evaluation, especially after the subprime crisis, by the Basel Committee on Banking Supervision, to be implemented in a new set of rules that will be in place in 2014. Using this rule as cushion, its effect is to reduce business cycle volatility, which subsequently stabilizes and strengthens the financial system.

THE EFFECT OF A PRODUCTIVITY SHOCK

Figure 2 shows the effects of a productivity shock on both dollarization and non-dollarization. A positive 1% productivity shock, under dollarization, causes an increase in GDP, and causes investment under bank capital requirements to be higher than in other scenarios. Here, binding capital requirements introduce again high volatility in the real sector.

The positive productivity shock increases GDP and Investment, with a higher effect under the Basel II accord than under the Basel I. It also reduces the inflation rate. Firms react by taking on more debt, due to the fact that there is a reduction in the cost of financing and in the risk premium paid. As the firm’s net worth grows higher than the new debt issued, the expansionary shock leads to a reduction in the firm's leverage ratio and
therefore in the borrower’s probability of default. Thus, lower bank capital is required, and loan supply expands. These effects amplify the positive effect of a GDP expansion, deepening the business cycle effect of the bank capital requirements.

Also, after an initial reduction of interest rates, due to the positive shock, as the Taylor rule comes into effect, the interest rates climb again and persist during some terms, as a result of substituting future consumption for current consumption, which in turn will reduce the IS demand and will push down the interest rates. Then, the demand pull will again be translated into some portfolio deterioration, which in turn leads banks to cope with the increase in loan interest rate and forces the loan portfolio’s deterioration to increase, after some periods. The multiplicative effects of capital requirements increase the external finance premium after the initial positive effect in the opposite direction. Inflation rates and deposit rates are also reduced at the beginning of the shock. However, after some months inflation rises again to adjust to the shock effect. As before neither the inflation nor the deposit interest rate is affected by the multiplicative effect of binding capital requirements.

As in the case of monetary shocks, bank capital requirements amplify business cycle shocks, and in particular the Basel II accord. That is a case for implementing a rule that can work as a counterbalance to the shock effect; as an automatic stabilizer.

As we can see in this example, the countercyclical effect of capital requirements will reduce output volatility and will help to keep the strength and solvency of the financial system. Their application implies the reduction in the firm’s debt position needed but also a lower accumulation of dividends and the firm’s net worth, which in turn represents higher bank capital required during shocks under the Basel II, rather than in the Basel I capital accord. Thus, the countercyclical rule allows for a smoothing of GDP growth and the investment expenditure.

THE EFFECT OF AN INTERNATIONAL INTEREST RATE SHOCK

The effect of a 1% increase in the international interest rate, under dollarization and non-dollarization and different bank capital rule, is shown in Figure 3. An increase in the international interest rate has a strong effect on the depreciation of the exchange rate, which is translated to inflation. Higher inflation induces the
monetary authority to initially increase the reference interest rate, by following a tighter monetary policy. This tighter monetary policy has the effect of reducing GDP, but that is almost compensated for because of the effect of exchange rate depreciation on exports.

The increase in international interest rate makes the economy prone to external vulnerabilities. As the domestic loan interest rate is also increased, and by the rising bank cost of funding, the firm’s level of debt increases, and raises the firm’s leverage while reducing its net worth. Thus, the investment cost of financing, as well the expected return of capital and the risk premium are higher and cause a reduction of investment and pressure for a reduction of GDP. That is the effect of the financial accelerator channel under a dollarized economy, and is recognized in Castillo, et. al (2009), and Gertler, Gilchrist and Natalucci (2007). Here bank capital increases the effect of loan interest rate due to the effect of the exchange rate induced credit risk, which deteriorates bank portfolio. This effect will increase banks probability of default, which in turn will raise again the loan interest rate amplifying the cycle.

Under different bank capital requirements, the effect is amplified under the Basel II rather than the Basel I as expected. The higher level of leverage increases the borrower’s probability of default, which in turn generates a higher volatility in real variables under the Basel II, due to the increase in the bank capital requirements affected by the sensitivity of the loan interest rate to firm leverage (as a proxy of borrower probability of default). Thus, the higher volatility under the Basel II is translated into a larger effect of the shock in real variables, as was expected in the model. In this scenario, the countercyclical bank capital rule smoothes the effect of the external shock and leads the economy to lower vulnerability. However, the effect of the bank capital countercyclical rule is limited in inflation, because it does not fully compensate for the additional effect of the depreciation of the exchange rate in the financial accelerator transmission mechanism.

**THE EFFECT OF A SHOCK IN THE WORLD GDP THAT INCREASE EXPORTS**

Figure 4 shows the effect of a 1% positive shock in the world GDP that increases exports. Here it is also important to evaluate the effect under different bank capital requirement rules. An increase in the world
GDP implies a raise in the economy exports to the world. This increases the local GDP, which leads to a reduction in the local interest rates and in the firm’s risk premium. This effect leads firms to increase investment expenditure as well, and the positive environment leads to higher firm net worth, which reduces their leverage and also their borrower’s probability of default.

All these effects are magnified under the Basel II capital requirements. The reduction in the borrower’s probability of default lowers the bank capital required and expands loan supply. This in turn reinforces the reduction in the loan interest rate and in the firm’s cost of finance, boosting investment and GDP more than in a situation without risk sensitive bank capital requirements. Thus, the Basel II is more pro cyclical than the Basel I, as the model predicts.

The countercyclical bank capital rule, again smoothes the effects of a positive shock in the world market that increase Peruvian exports. Banks have to accumulate more capital in good times and less in recessionary times. Thus, the reinforced effect of pro cyclical bank capital requirements as in the Basel II compensates for the rule, and leads the economy into a state of lower GDP growth than in the previous case without the countercyclical capital rule.

VI. CONCLUDING REMARKS

In this paper, I have modeled the effects of bank capital regulation on a small-dollarized open economy, by introducing costly state verification contracts as in Bernanke, Gertler and Gilchrist (1999), and Gertler, Gilchrist and Natalucci (2007). These credit market imperfections amplify the effects of monetary policy shocks or economic downturns in a classical financial accelerator process. Capital regulation in this open economy environment shows to be procyclical and will also have an additional effect on the financial accelerator has been shown, for the case of a closed economy, by Markovic (2006) and Aguiar and Drummond (2007).

In the calibration results I have demonstrate that bank capital requirements lead to an amplification of the monetary or productivity shocks in the economy, through the external finance premium. If we compare
regimes, the Basel II capital framework will have more procyclical effects than the Basel I capital framework. Under the Basel II, the effect of over investment is amplified because firms faces higher interest rates, which in turn increases the return of capital required on the projects. That effect causes deeper recessions than in the case of the Basel I capital requirements that are not borrower risk sensitive.

The presence of dollarization tends to reduce the impact of domestic monetary policy and affects the effect of bank capital requirements. As it has been seen in the calibration exercise, a partial dollarized economy will introduce balance sheet effects that reinforce the capital requirement effects in the presence of an external shock. A depreciation of the exchange rate also makes firms’ balance sheets vulnerable to financial shocks when capital requirements are binding. Banks tends to translate the effects of depreciation in their portfolio to the firm’s cost of financing funds. If the economy is in the middle of a recession with capital outflows, when banks are competing for raising new funds or having enough capital cushion to cope with the recession, firms will face an increase in their external finance premiums and increase their probability of default, amplified by the bank capital requirement regulatory restriction.

I can derive several insights from the procyclicality role of bank capital requirement in the described environment. First in dollarized economies, binding bank capital requirements tend to increase firms’ costs of external finance, by increasing a risk premium that depends on the bank probability of default, and by amplifying the effects of depreciation in the exchange rate. Second, increases in the bank probability of default, as well as bank fragility due to unexpected shocks that reduces firms’ income and ability to repay loans, will also reduce current account and balance of payment results. This is the channel through which a twin crises works, as empirically shown by Kaminsky and Reinhart (1999). Banking fragility is exacerbated by a contractionary monetary policy in the presence of bank capital requirements, which in turn, not only increase the cost of external finance for firms, amplifying exchange rate shocks when dollarization exists as in Castillo, Montoro and Tuesta (2009), but also cause a fall in the current account results, because of the reduction in domestic economic activity. Thus, dollarization makes it more difficult for the monetary authority to perform its role of implementing stabilization policies, because it is not only constrained by the effects of their policies on
exchange rate but also the effects of the exchange rate on borrowers’ balance sheets and the bank probability of default, amplified by binding bank capital requirements.

As we have seen in this paper, by introducing countercyclical buffer capital rules, in the simplest way as a positive function of economic activity, we have derived the condition under which bank capital requirements do not amplify monetary shocks in the economy. The Basel II has this possibility in its second pillar. However, the additional capital buffer that is recommended does not consider the business cycle effects and keeps the procyclicality of the first pillar. A modification of this additional buffer in the second pillar, to introduce countercyclical requirements, can be seen in Spain’s dynamic provisioning system (Repullo, Saurina, and Trucharte (2009)), and needs to be considered.

The model also helps us to determine that a monetary and financial policy mix is the combination of a Taylor-type rule and a countercyclical capital requirement. These kinds of bank capital rules are nowadays the center of the regulatory discussion in the midst of the international financial crises, because of their role to potentially dampen unexpected negative demand shocks and keep the financial system stable, as mentioned in FSB (2009). Nevertheless, as it was shown, countercyclical buffers are not enough to eliminate the financial accelerator process, which is consistent with Repullo and Suarez (2004 and 2008). The external finance premium will only be reduced if the costly verification of loans is reduced. That can only be achieved by more transparency in credit markets (which in turn reduces the auditing cost) as recommended in the Basel II’s third pillar.

Last, but not least, Basel II capital regulation, even though procyclical, is needed to identify, control, measure and manage banking risk in a comprehensive coherent empirical and theoretical framework. Nevertheless, as recent financial crises have shown, some minor adjustments should be carried out in an effective way in order to deter banks from taking unnecessary risks that could put strong pressure on financial stability. One of them, as we have shown in this chapter, could be the presence of a countercyclical buffer rule and a stronger role for transparency in the credit market, like the proposed Basel III accord.
VII. BIBLIOGRAPHY


### Table 1

Main variable volatilities (In percentage)

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>Basel I Model</th>
<th>Basel II Model</th>
<th>Countercyclical Rule</th>
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<table>
<thead>
<tr>
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<th>NON DOLLARIZATION VS DOLLARIZATION</th>
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### Table 2

Effect of different bank capital requirements rule on main variable volatilities

<table>
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Notation: variable (DD) is the firm debt, (INV) is investment, (NN) is the firm net worth, (RP) is risk premium paid by entrepreneurs to banks over the bank cost of funding, (RR_K) is expected return of capital (YY) is the domestic output. All figures are variable second moments (std. and variance) estimated by the model under different type of prudential regulation. Negative values imply reduction in volatilities generated by the countercyclical capital rule.
Figure 1: Monetary Shock under Partial Dollarization

Note: All variables are shown as percentage deviations from steady state. The blue line is the benchmark model with capital requirements as in Basel I type capital requirements. The green line is the model with Basel II type capital requirements. The red line is the model with Basel capital requirements and the countercyclical capital rule.
Figure 2: Productivity Shock under Partial Dollarization

Note: All variables are shown as percentage deviations from steady state. The blue line is the benchmark model with capital requirements as in Basel I type capital requirements. The green line is the model with Basel II type capital requirements. The red line is the model with Basel capital requirements and the countercyclical capital rule.
Figure 3: International Interest Rate Shock under Partial Dollarization

Note: All variables are shown as percentage deviations from steady state. The blue line is the benchmark model with capital requirements as in Basel I type capital requirements. The green line is the model with Basel II type capital requirements. The red line is the model with Basel capital requirements and the countercyclical capital rule.
Figure 4: World GDP shock that increases Peruvian Exports under Dollarization

Note: All variables are shown as percentage deviations from steady state. The blue line is the benchmark model with capital requirements as in Basel I type capital requirements. The green line is the model with Basel II type capital requirements. The red line is the model with Basel capital requirements and the countercyclical capital rule.