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Abstract

This paper studies the impacts of bank capital regulation on business cycle fluctuations. To do so, we adopt the Bernanke et al. (1999) “financial accelerator” model (BGG), to which we augment a banking sector to study the procyclical nature of Basel II claimed in the literature. We first study the impacts of a negative shock to entrepreneur’s net worth and a positive monetary policy shock on business cycle fluctuations. We then look at the impacts of a negative shock to the entrepreneurs’ net worth when the minimum capital requirement increases from 8 percent to 12 percent. Our comparison studies between the augmented BGG model with Basel I bank regulation and the one with Basel II bank regulation suggest that, in the presence of credit market frictions and bank capital regulation, the liquidity premium effect further amplifies the financial accelerator effect through the external finance premium channel, which in turn, contributes to the amplification of Basel II procyclicality. Moreover, under Basel II bank regulation, in response to a negative net worth shock, the liquidity premium and the external finance premium rise much more if the minimum bank capital requirement increases, which in turn, amplify the response of real variables. Finally, small adjustments in monetary policy can result in stronger response in the real economy, in the presence of Basel II bank regulation in particular, which is undesirable.

JEL codes: E32, E44, G28, E50

Keywords: Business cycle fluctuations, Financial accelerator, Bank capital requirement, Monetary policy

1 Introduction

The crucial role played by the financial sector in an economy can not be emphasized by anything other than the consequences of an unstable financial sector. For instance, among many alleged causes of the 2007/08 financial crisis, the instability of the financial sector, more specifically the banking sector, stands out and is reported to have contributed significantly to the emergence of the crisis.

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For a long time, macroeconomic models have been built without the financial sector, in particular, the credit market frictions which are often the major sources of economic crises (Bernanke, 2007). Since the ground breaking work of Bernanke et al. (1999), there has been a growing interest in research on credit market frictions and how they affect business cycle fluctuations. Most of these studies seem to reach the same conclusion: the existence of credit market frictions tends to amplify and propagate the business cycle fluctuations through what is known as the “financial accelerator”. This line of research has been further extended to study the role of bank capital regulation in business cycle fluctuations and suggests that bank capital regulation also has a big potential of exacerbating this behavior. That is, in an imperfect credit market environment, risk-based capital requirement tends to be procyclical since risk is countercyclical. As a result, the accelerator mechanism generates a feedback loop between credit market and the real side of the economy, amplifying the business cycle fluctuations.

Bank capital regulation has received more attention since the introduction of the Basel Capital Adequacy Accord (Basel I) by the Bank for International Settlements’ Basel Committee on Banking Supervision in 1988. Basel II Accord was introduced in 2004 dealing with the main shortcomings of Basel I, such as the “one size fits all” weighted risk classifications and its inherent. However, though still debatable, it has been discovered that Basel II has an even bigger potential of being procyclical than its predecessor (Kashyap and Stein, 2004).

The objective of this paper is to study the impacts of bank capital regulation on business cycle fluctuations using general equilibrium framework. In particular, our aim is to investigate the procyclical nature of Basel II claimed by most studies (both theoretical and empirical) in the literature. To do so, we augment the BGG model by including a banking sector with bank capital regulations, which allows us to study the dynamic impacts of the financial intermediation on business cycle fluctuations not only from the financial accelerator effect (demand side) perspective, but also from the liquidity premium effect (supply side) perspective. We then calibrate our model to the South African economy¹ and study three different scenarios. We first look at the dynamic response of the key variables to a negative net worth shock as well as a positive monetary policy shock. We then study the impacts of a negative shock to entrepreneurs’ net worth when the minimum capital requirement increases from 8 percent to 12 percent. For all cases, we compare the augmented BGG model with Basel I regulation with the one with Basel II regulation. Our simulation results show that, in the presence of credit market frictions and bank capital regulation, the liquidity premium effect further amplifies the financial accelerator effect through the external finance premium channel, which in turn, contributes to the amplification of Basel II procyclicality. Moreover, under Basel II regulation, in reaction to a negative net worth shock, the liquidity premium and the external finance premium rise much more if the minimum bank capital requirement increases from 8 percent to 12 percent, which in turn, amplifies the response of the real variables, investment and output in particular. However, under Basel I regulation, the increase in the minimum bank capital requirement does not make a significant difference in terms of the dynamic response of the key variables to the shock. Finally, small adjustments in monetary policy rate can result in stronger

¹South Africa is a member of the Basel Committee on Banking Supervision (BCBS), complying with the committee’s legislation. South Africa is among the first group of countries to implement Basel II (in January 2008) and it has been commended for a successful and smooth implementation (IMF, 2008).

response than expected in the real economy, in the presence of Basel II regulation in particular, which is undesirable.

The remainder of the paper is organized as follows. Section 2 briefly reviews the related literature of credit market frictions and bank capital regulation. Section 3 gives a detailed description of the model. Section 4 discusses the simulation results and Section 5 concludes.

2 Related Literature

The realization that financial frictions can shed some light into the analysis of business cycle fluctuations emerged from the work of Fisher (1933) on the role played by debt and deflation in building up to the Great Depression. The pioneers of the recent work on financial frictions are Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Carlstrom and Fuerst (1997), Kiyotaki (1998), Iacoviello (2005), and Liu et al. (2010), in which authors attempt to model financial frictions in a general equilibrium setting. The general theme of these studies is that as long as the pricing of loans is a function of the borrower's default risk, a wedge would open up between the lending rate and the deposit rate, when the borrower's net worth decreases and the default probability increases. As a result, the external finance premium increases, leading to high costs of borrowing, and in turn, reduces investment and output. Bernanke et al. (1999) define this effect as the financial accelerator effect, which is simply the resulting feedback loop between credit market and the real side of the economy². More recently, researchers start incorporating not only credit market constraints but also financial intermediation into general equilibrium models. Among others, Curdia and Woodford (2009) and Andres and Arce (2009) introduce the banking sector along with time varying spread between lending and deposit rates, while Markovic (2006), Van den Heuvel (2008), and Meh and Moran (2008) look at the role of bank capital channel in the transmission of macroeconomic shocks.

The drawback of the above-mentioned studies is that they only focus on the demand side of credit market. That is, the external finance premium solely depends on the borrowers' creditworthiness. Hence, in a perfectly competitive environment (assumed in these models), banks seem to operate in a frictionless environment, and in order to survive, banks just have to find their way around credit demand frictions. Models that capture the supply side of credit market are slowly trickling into the literature. Gerali et al. (2010) show that factors of the supply side of credit market, such as the degree of competition in the banking sector, policies on bank rates setting, and banks' financial soundness, play an equally important role as the demand side of credit market in the business cycle fluctuations. Angelini et al. (2010) distinctively allow for credit risk to vary according to borrowers' groups and bring in risk sensitive capital requirement in the model and find that banks' lending activities as well as the real economic activities can be affected by various bank capital regulations.

Financial sector regulation, especially regulating in banking sector, is a challenge to policy makers and regulators because of its bi-purpose nature. The main objective of financial sector regulation is to address market failures such as externalities, market power, and asymmetric information (Drumond, 2008). It also

²Recent work on this topic include Cooley et al. (2004), De Fiore and Uhlig (2005), Christiano et al. (2010), Gertler et al. (2007), and Gertler and Kiyotaki (2009).

has to protect the fundamental functions of the banking sector, such as efficient money lending (Kashyap and Stein, 2004). The bank capital regulation system currently used in most countries is Basel II. Basel II is not a law per se, but a set of minimum capital standards by which banks are expected to abide. The main objective of Basel II is to ensure the soundness and safety of individual banks, hence, the stability of the financial sector and the economy as a whole.

However, as argued by Amato and Furfine (2004), the banking system is already procyclical by nature due to the market imperfection. That is, banks' lending activities co-move with the business cycle fluctuations even in the absence of regulation. Basel II, though it has been designed to foster stability in the financial system, also has the potential to further amplify the fluctuations. As a result, it exacerbates the inherent procyclicality in the banking sector. Moreover, under Basel II, the increase in the minimum bank capital requirement triggered by a downturn can adversely affect the banks' lending activities. Eventually investment and output will decline, deepening the downturn.

The empirical evidence overwhelmingly supports the procyclical nature of Basel II. Drumond (2008) undertakes a thorough survey of the existing literature and reaches the following conclusion: the extent and scale of the procyclicality of Basel II are largely influenced by the way minimum capital requirement changes along the business cycle. In other words, factors such as the composition of banks' asset portfolios, the approach adopted by banks to compute the minimum capital requirement (the standard approach or the internal rating based approach), the type of rating system (through-the-cycle or point-in-time), and the degree of capitalization over and above the regulatory minimum required, play a major role in banks' lending and loan pricing decisions during different phases of the business cycle. The countercyclical nature of credit risk, which is positively related to the minimum capital requirement, is verified as the main driving factor of the observed procyclicality of Basel II. The extent of the procyclicality of Basel II increases when banks use the internal based rating (IRB) approach since capital requirement gets more sensitive to the credit risk, and the magnitude of procyclicality depends on the risk model used by banks and the composition of the pool of banks' clients.

3 A Model with Bank Capital

In order to study how bank capital regulation affects bank lending activities and business cycle fluctuations, we augment the BGG model with a banking sector. The model economy consists of households, entrepreneurs, retailers, banks, and a government. Households supply labor, consume retail goods, save through bank deposits, and invest in government bond and banks' equity. Entrepreneurs produce wholesale goods using labor and physical capital. Physical capital are financed by net worth and the external funds obtained from banks. Banks raise capital by collecting deposits from households and issuing bank equity to households. Banks provide credit to entrepreneurs subject to the risk-based capital requirements. A retailer sector is introduced in the model as a technical modeling device to incorporate price stickiness. The model is closed by including a government that conducts fiscal policy and monetary policy.

3.1 Banks

Banks operate in a competitive market environment with unrestricted entry, in which each bank earns zero profits in equilibrium. We assume that banks raise funds by collecting deposits from households and issuing bank equity to households. Banks are required by the regulator to hold a certain percentage of risk-based capital according to the Basel Accords. In addition, banks have to pay a monitoring cost if they wish to observe entrepreneurs' realized return to capital. Banks maximize their profits subject to the capital requirement constraint (2):

$$\max(R_t^l L_t + R_t B_t - R_t^d D_t - E_{t-1} R_t^s S_t - \mu \Lambda R_t^k Q_{t-1} K_t) \quad (1)$$

s.t.

$$\frac{S_t}{L_t} = \lambda \quad (2)$$

where L_t denotes loans supplied by banks to entrepreneurs, D_t denotes bank deposits, S_t is bank capital raised by issuing equity to households, and λ is the ratio of risk-based capital requirement according to Basel Accords. R_t^l and R_t^d represent the gross return on loans and deposits respectively, while R_t^s is the gross return on bank capital. Government bond B_t appears on the asset side of the bank's balance sheet, which has zero weight in the risk-based capital. The monitoring cost, $\mu \Lambda R_t^k Q_{t-1} K_t$, is explained in detail in Section 3.2.

The optimality conditions imply that the lending rate is a function of the weighted average of the deposit rate and the return to bank equity:

$$R_t^l = \lambda E_{t-1} R_t^s + (1 - \lambda) R_t^d \quad (3)$$

3.2 The financial contract

As in BGG, in order to explicitly motivate lending and borrowing, it is assumed that only entrepreneurs borrow from the banks. Entrepreneurs use physical capital and labor to produce the wholesale goods and sell to retailers. In order to produce the wholesale goods in period t , the representative entrepreneur i (where $i \in [0, 1]$) uses her net worth N_t^i accumulated from previous periods to acquire physical capital K_t^i , for which the entrepreneur pays Q_{t-1} per unit. In a case where the capital expenditure exceeds the net worth, the representative entrepreneur is able to finance the shortfall through the loan L_t^i from a bank made available to her at the cost of R_t^l . Hence, the loan function is given by $L_t^i = Q_{t-1} K_t^i - N_t^i$. Due to the uncertainty (aggregate and idiosyncratic) inherent in this contract, the return to capital observed before the contract is signed is given by $\omega^i R_t^k$, where ω^i is an idiosyncratic shock to each entrepreneur in the market. Moreover, because of the information asymmetry between the entrepreneur and the bank in the financial contract, the entrepreneur can, at no cost, observe the return on her venture beforehand, whereas the involved bank has to pay a monitoring cost to observe the ex-ante risks involved in the entrepreneur's operation. The monitoring cost that the bank has to pay is a fraction of the actual gross payoff of the entrepreneur's capital, $\mu \omega^i R_t^k Q_{t-1} K_t^i$, where $0 < \mu < 1$.

Like any contracts in nature, there is a possibility that the entrepreneur may default, in which case the bank loses. Let Z_t^i be a gross non-default loan rate and $\bar{\omega}^i$ be a threshold level, below which the entrepreneur defaults and above which the entrepreneur honors the contract. Put differently, if $\omega^i \geq \bar{\omega}^i$, the entrepreneur pays the bank an amount $Z_t^i L_t^i = \bar{\omega}^i R_t^k Q_{t-1} K_t^i$ and keeps her share of the returns $(\omega^i - \bar{\omega}^i) R_t^k Q_{t-1} K_t^i$. However, if $\omega^i < \bar{\omega}^i$, the entrepreneur defaults and the bank gets $(1 - \mu)\omega^i R_t^k Q_{t-1} K_t^i$ upon paying the monitoring cost.

Given the state-contingent debt form of the optimal contract, the expected return to the entrepreneur is the difference between her gross return to capital and the amount of loan due to the bank:

$$E_{t-1} \left[\int_{\omega^i}^{\infty} \omega R_t^k Q_{t-1} K_t^i f(\omega) d(\omega) - (1 - F(\bar{\omega}^i)) \bar{\omega}^i R_t^k Q_{t-1} K_t^i \right] \quad (4)$$

where $f(\omega)$ and $F(\bar{\omega})$ denote the density and cumulative functions of the probability of default ω^i respectively. In equilibrium:

$$R_t^l L_t^i = (1 - F(\bar{\omega}^i)) Z_t^i L_t^i + (1 - \mu) \int_0^{\omega^i} \omega Z_t^i R_t^k Q_{t-1} K_t^i f(\omega) d(\omega) \quad (5)$$

That is, the bank's portfolio is made up of two components: the loan repayments expected from the entrepreneur and part of the entrepreneur's project proceeds that the bank will retain in an event that the entrepreneur defaults.

Substituting $Z_t^i L_t^i = \bar{\omega}^i R_t^k Q_{t-1} K_t^i$ into (5) and rearranging the function yields:

$$R_t^l L_t^i = [(1 - F(\bar{\omega}^i)) \bar{\omega}^i + (1 - \mu) \int_0^{\omega^i} f(\omega) d(\omega)] R_t^k Q_{t-1} K_t^i \quad (6)$$

As Bernanke et al. (1999) show that the bank's expected return is now expressed as a function of the threshold value $\bar{\omega}^i$, indicating that changes in $\bar{\omega}^i$ can affect the bank's expected return in two different ways. An increase in $\bar{\omega}^i$ raises the non-default payoff and, at the same time, it also raises the default probability which ultimately leads to a low expected payoff.

Solving the optimal contract results in a positive relationship between the ratio of capital expenditure to net worth and the expected discounted return to capital:

$$\frac{Q_{t-1} K_t^i}{N_t^i} = \psi \left(E_{t-1} \left(\frac{R_t^k}{R_t^l} \right) \right) \quad \psi(1) = 1, \psi'(\cdot) > 0 \quad (7)$$

In equilibrium, in order to motivate entrepreneurs to purchase capital, the expected discounted return to capital, $E_{t-1} \left(\frac{R_t^k}{R_t^l} \right)$, must be greater than or equal to one. Moreover, the expected discounted return to capital is negatively related to the share of the entrepreneur's capital expenditure financed by net worth $\frac{N_t^i}{Q_{t-1} K_t^i}$. This relationship is the core of the BGG financial accelerator model as it shows the expected discounted return to capital, which can be interpreted as the external finance premium³, is negatively related to the

³In BGG, $E_{t-1} \left(\frac{R_t^k}{R_t^l} \right)$ is interpreted as the external finance premium. After augmenting the BGG model with the financial intermediation, the expected discounted return to capital becomes $E_{t-1} \left(\frac{R_t^k}{R_t^l} \right)$. We nonetheless interpret it as the external finance premium.

share of the entrepreneur's capital that is financed by net worth (Bernanke et al., 1999, pg. 16).

The entrepreneur's net worth consists of the retained proceeds from previous periods' capital investment and wages earned from labor supply. Normalizing the entrepreneurial labor to one, the aggregate entrepreneurs' net worth equation can be written as follows:

$$N_t = \gamma V_{t-1} + W_{t-1}^e \quad (8)$$

where V_t represents the entrepreneurial equity, W_{t-1}^e represents the entrepreneurial wage income, and γ is the constant probability of entrepreneurs survive to the next period. In equilibrium the aggregate equity held by entrepreneurs in the end of period $t - 1$ is:

$$V_t = R_t^k Q_{t-1} K_t - R_t^l (Q_{t-1} K_t - N_t) - \mu \Lambda R_t^k Q_{t-1} K_t \quad (9)$$

where $\mu \Lambda R_t^k Q_{t-1} K_t$ denotes the aggregate monitoring costs with $\Lambda = \int_0^{\bar{\omega}} \omega f(\omega) d\omega$.

3.3 General equilibrium

In this section, we incorporate the optimality conditions of the financial contract between the entrepreneurs and the banks derived in a partial equilibrium setting in previous section into the general equilibrium model. Variables such as the risk-free interest rates, the return to capital, and the relative price of capital will now be determined by the general equilibrium model⁴.

3.3.1 Households

The model economy consists of identical, risk averse, and infinitely lived households, who supply labor to entrepreneurs, consume, save (bank deposits), and invest in government bond and bank equity. The representative household chooses $\{C_t, B_t, D_t, S_t\}$ to maximize her expected discounted utility over a composite consumption good C_t , real bank deposits D_t/P_t , and leisure $1 - H_t$:

$$E \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t)^{1-\eta_c}}{1-\eta_c} + \frac{(D_t/P_t)^{1-\eta_d}}{1-\eta_d} - \frac{(H_t)^{1+\eta_h}}{1+\eta_h} \right] \quad (10)$$

where β is the subjective discount factor and η_h is the inverse of the elasticity of work effort with respect to the real wage. η_c is the coefficient of relative risk aversion of household, and η_d is the inverse of the interest elasticity of real deposits demand.

The representative household's budget constraint is given by,

$$C_t + \frac{B_t}{P_t} + \frac{D_t}{P_t} + \frac{S_t}{P_t} \leq \frac{W_t^h}{P_t} H_t^h + \frac{R_{t-1} B_{t-1}}{P_t} + \frac{R_{t-1}^d D_{t-1}}{P_t} + \frac{R_{t-1}^s S_{t-1}}{P_t} + \frac{T_t}{P_t} \quad (11)$$

where W_t^h represents nominal wage for households and T_t is the nominal lump sum transfer from government.

⁴We closely follow the setup of the general equilibrium as in BGG. Here we only briefly describe the modified household sector, and the setup for the entrepreneurial sector as it is critical to the model.

Similar to the money in utility function, bank deposits are included in households' utility function. We assume that households can withdraw the deposits at any point in time to purchase consumption goods. In other words, deposits not only provide riskless return but also liquidity services to households⁵.

3.3.2 Entrepreneurs

Entrepreneurs operate in a competitive market. At the beginning of time period t , entrepreneurs purchase K_{t-1} units of physical capital and hire H_t units of labor to produce the wholesale goods Y_t according to the following aggregate production function:

$$Y_t = A_t K_{t-1}^\alpha H_t^{1-\alpha} \quad 0 < \alpha < 1 \quad (12)$$

where A_t is the exogenously determined technology. At the end of each period, entrepreneurs sell their output to the retailers at price of $\frac{1}{X_t}$, where X_t is the gross mark-up of retail goods over wholesale goods. The rent of physical capital, $\frac{1}{X_t} \frac{\alpha Y_t}{K_t}$, has to be paid in the end of each period. This yields the expected gross return to physical capital:

$$E_{t-1}(R_t^k) = E_{t-1} \left[\frac{\vartheta_t + (1-\delta)Q_t}{Q_{t-1}} \right] \quad (13)$$

where δ is the capital depreciation rate and $\vartheta_t = \frac{1}{X_t} \frac{\alpha Y_t}{K_t}$.

As mentioned in the previous section, to enable entrepreneurs to start their operations with a positive level of net worth, the model assumes that entrepreneurs supply their labor inelastically. As a result, total labor supply H_t is redefined in the following manner: $H_t = (H_t^h)^\Omega (H_t^e)^{1-\Omega}$ with $0 < \Omega < 1$, where H_t^h and H_t^e represent households' labor supply and entrepreneurs' labor supply respectively. Consequently, the production function is redefined as follows:

$$Y_t = A_t K_{t-1}^\alpha [(H_t^h)^\Omega (H_t^e)^{1-\Omega}]^{1-\alpha} \quad 0 < \alpha < 1 \quad (14)$$

Demand functions for labor (both households and entrepreneurs) are derived by equating the respective marginal products to real wages:

$$\frac{W_t^h}{P_t} = (1-\alpha)\Omega \frac{1}{X_t} \frac{Y_t}{H_t^h} \quad (15)$$

$$\frac{W_t^e}{P_t} = (1-\alpha)(1-\Omega) \frac{1}{X_t} \frac{Y_t}{H_t^e} \quad (16)$$

Output can be consumed by households, entrepreneurs, and government, or it may be invested by entrepreneurs, or it may be used by banks to pay the monitoring costs. Thus, the aggregate resource can be described as follows:

⁵See Van den Heuvel (2008).

$$Y_t = C_t + C_t^e + I_t + G_t + \mu\Lambda R_t^k Q_{t-1} K_t \quad (17)$$

At this juncture, two important equations determine the financial accelerator. The first is the aggregated version of (7), the supply function for aggregated investment finance, which shows how changes in net worth affect the cost of capital. The second equation characterizes the inherent variation in entrepreneurs' net worth. It is derived by merging equation (8), (9), (12) and (16), assuming that entrepreneurs supply a single unit of labor:

$$N_t = \gamma[R_t^k Q_{t-1} K_t - R_t^l (Q_{t-1} K_t - N_t) - \mu\Lambda R_t^k Q_{t-1} K_t] + (1 - \alpha)(1 - \Omega) \frac{1}{X_t} A_t K_{t-1}^\alpha (H_t^h)^{\Omega(1-\alpha)} \quad (18)$$

3.4 Basel II

The Bank for International Settlement's (BIS) Committee on Banking Supervision administers the current framework of minimum bank capital regulation. Among other objectives, the Basel accords are meant to promote safety and soundness in the financial system through risk-based capital requirements (BCBS, 2006, pg. 2). Under Basel I, each bank is subjected to a minimum capital requirement of 8 percent, which is measured as a ratio of a bank's capital to its risk-weighted asset. Weights are determined by the committee according to the institutional nature of the banks' clients, presumably revealing their risk profiles (BCBS, 1988). For the trustworthy institutions like government, banks have the liberty of granting loans to them out of deposits without holding any of their capital against such loans. Hence, the weight attached to such loans is zero. In contrast, a weight of 0.2 is applied for loans between banks; 0.5 for loans backed by residential mortgages asset, and 1 for industrial and commercial loans (Drumond, 2008, pg. 12)⁶. This "one size fits all" approach of risk classification is short sighted since it only looks at risk from a general point of view, instead of looking at it on an institution to institution basis. It increases the likelihood of systemic risk through capital arbitrage (cherry picking) since banks can change the composition of their portfolios by acquiring high risk asset in low risk categories without increasing their capital requirements. As such, risk classification under Basel I is not correlated with real banking risk (see Rime (2001) and Drumond (2008)).

In contrast to Basel I, Basel II is founded on three pillars and each pillar focuses on a particular segment of the banking system. Pillar one, the most relevant one to this study, deals with minimum capital requirements associated with credit risk, market risk, and operational risk. The credit risk calculation is based on not only the broader borrowers' groups, but also the risk profile of individual borrowers within the group (BCBS, 2006). Basel II is designed in such a way that bank capital requirements are more risk sensitive as the amount of capital that a bank has to hold against a given exposure becomes a function of the estimated credit exposure (Drumond, 2008). Another important element of Basel II, which gives it a sharper edge than Basel I, is that it gives banks the liberty to choose from two approaches of credit risk calculation. Under the standard approach, banks can rely on credit rating agencies for assessing their clients' risk. The second one is the IRB approach, which is further sub-categorized into the foundation and advanced formats. Under this

⁶Weights are applied by OECD countries.

approach, the estimated credit risk is a function of four facets: probability of default (PD), loss given default (LGD), exposure at default (EAD), and maturity time of the loan (M). Banks that choose the advanced format have to compute all the four elements themselves, whereas those who use the foundation format only need to compute the probability of default and the rest of the elements are taken as given from the Basel Committee on Banking Supervision (Kashyap and Stein, 2004).

Coming back to our model, the manner that bank capital regulation has been introduced into the model so far does not feature any of the characteristics of Basel II. That is, the setup for banking sector only captures risk based on the “one size fits all” approach. Basel II, on the other hand, engages an approach that the credit risk calculation depends on both the institutional nature of the borrower and the idiosyncratic risk each borrower is exposed to within a group.

Suppose, as documented in Section 3.2, $\bar{\omega}^i$ is a unique threshold, below which the entrepreneur fails to repay the bank. As per the model, it is possible to aggregate entrepreneurs and establish a common threshold level $\bar{\omega}$ since all entrepreneurs face the same external finance premium and leverage ratio at the optimum. By aggregating entrepreneurs coupled with the fact that credit risk is countercyclical, we can study how Basel II accord affects business cycle fluctuations. According to the IRB approach of Basel II accord (BCBS, 2006, pg. 64), the capital requirement (CR) is given by,

$$CR = LGD \times \Phi[(1 - \tau)^{-0.5} \times \Phi^{-1} \times PD + 0.999\Phi^{-1}(\frac{\tau}{1 - \tau})^{0.5}] - PD \times LGD \times M \quad (19)$$

where $\Phi(\cdot)$ is a cumulative distribution function for a standard normal random variable and τ is the asset-value correlation which reflects the dependence among borrowers. τ is assumed to be a decreasing function of PD :

$$\tau = \frac{0.12(1 - \exp(-50 \times PD))}{1 - \exp(-50)} + 0.24 \times [1 - \frac{1 - \exp(-50 \times PD)}{1 - \exp(-50)}] \quad (20)$$

In line with the fact that under the foundation format of IRB approach banks only need to calculate PD , assuming a one-year loan maturity, the capital requirement can then be rewritten as:

$$CR = LDG \times \Phi[(1 - \tau)^{-0.5} \times \Phi^{-1} \times PD + 0.999(\frac{\tau}{1 - \tau})^{0.5}\Phi^{-1}] \quad (21)$$

Finally, the risk-weighted asset are expressed as $CR \times 12.5 \times EAD$, which results in the following capital to risk-weighted asset ratio:

$$\frac{S_t}{CR_t^* L_t} \geq \lambda \quad (22)$$

where $CR_t^* = CR_t \times 12.5$. At this point, due to the aggregation made earlier, it is possible to impose the same CR_t for all the entrepreneurs since they are subject to the same PD_t and ratio of capital to net worth. The objective of making capital regulation more sensitive to credit risk is achieved in such way that CR_t^* co-moves with PD_t , which in turn, depends on $\bar{\omega}$. Through the financial contract, the positive relationship between $\bar{\omega}$ and the ratio of capital to net worth implies that CR_t^* is also positively related to the ratio of

capital to net worth. Aguiar and Drumond (2007) approximate this relationship as follows:

$$CR_t^* = -1.65 + 1.23\left(\frac{Q_{t-1}K_t}{N_t}\right) \quad (23)$$

Thus the banking sector's problem under Basel II bank regulation can be written as follows:

$$\max(R_t^l L_t + R_t B_t - R_t^d D_t - E_{t-1} R_t^s S_t - \mu \Lambda R_t^k Q_{t-1} K_t) \quad (1)$$

subject to

$$\frac{S_t}{L_t} = \lambda(-1.65 + 1.23\frac{Q_{t-1}K_t}{N_t}) \quad (24)$$

The first order condition for L_t becomes:

$$R_t^l = [1 - \lambda(-2.88 + 2.46\frac{Q_{t-1}K_t}{N_t})]R_t^d + [\lambda(-2.88 + 2.46\frac{Q_{t-1}K_t}{N_t})]E_{t-1}R_t^s \quad (25)$$

The banks' optimality conditions imply that bank deposit rate equals to the government bond rate, $R_t^d = R_t$. Substituting $R_t^d = R_t$ into the linearized version of (25) and assuming the expected return to bank capital equals to the expected return to physical capital over the business cycle⁷, that is $E_{t-1}R_t^s = E_{t-1}R_t^k$, yields:

$$E_{t-1}r_t^k - r_t^l = [1 - \lambda(-2.88 + 2.46\frac{R^s}{R^l})](E_{t-1}r_t^s - r_t^d) - \lambda[-2.88 + 2.46(\frac{R^s - R^d}{R^l}\frac{QK}{N})](q_{t-1} + k_t - n_t) \quad (26)$$

(26) shows that the external finance premium, $E_{t-1}r_t^k - r_t^l$, is positively related to the liquidity premium⁸, $E_{t-1}r_t^s - r_t^d$, and negatively related to the net worth. It is clear that liquidity premium has a stronger impact on the external finance premium than the net worth does. This is the key relationship in our study, since through it, we are able to link the liquidity premium effect to the financial accelerator effect.

In the case of Basel I bank regulation, this key relationship between the external finance premium and the liquidity premium is derived from the linearized version of (3):

$$E_{t-1}r_t^k - r_t^l = (1 - \lambda\frac{R^s}{R^l})(E_{t-1}r_t^s - r_t^d) \quad (27)$$

It is clear that under Basel I bank regulation, the positive relationship between the external finance premium and the liquidity premium also holds. (26) and (27) show that, under bank capital regulations (both Basel I and Basel II), entrepreneurs face a much higher external finance premium if the liquidity premium increases. That is, the liquidity premium effect further amplifies the financial accelerator effect through the external finance premium channel, which in turn, contributes to the amplification of the procyclicality of bank capital regulations.

⁷To avoid asset arbitrage, the model assumes that households are not allowed to hold physical capital and entrepreneurs cannot hold bank capital. Therefore, any difference in returns that may occur as a result of exogenous shocks becomes insignificant since these two types of capital are affected by the same risk and they cannot provide liquidity services.

⁸We refer the difference between the rate of return to bank capital and bank deposit rate as the liquidity premium.

4 Simulation and Results

The baseline model is the BGG model augmented with financial intermediation, in which the financial accelerator effect and the liquidity premium effect play the central role in affecting business cycle fluctuations. The financial accelerator effect emerges from the demand side of bank loans, whereas the liquidity premium effect comes from the supply side. Net worth is procyclical as it is determined by the value of asset, and the prices of asset co-move with the business cycle. On the other hand, the external finance premium is countercyclical. This is because the lesser the entrepreneurs' net worth the higher the external finance premium is, which in turn, results in high costs of borrowing and decline in investment and output. The presence of bank capital regulation leads to the emergence of the liquidity premium, which further inflates the entrepreneurs' costs of borrowing since it is positively related to the external finance premium. All these effects generate a feedback loop, where now, the negative impact on the real side of the economy is transmitted back to the credit market, starting the process all over again. In this way, the downturn ends up being even deeper than it would be in the absence of bank capital regulation.

4.1 Net worth shock

The impacts of an unanticipated negative shock to entrepreneurs' net worth (Figure 1) work through the financial contract between banks and entrepreneurs, where the weakened financial status of entrepreneurs increases the expected monitoring costs which ultimately leads to a higher external finance premium. More importantly, a negative shock to net worth increases the riskiness of entrepreneurs' projects, and in turn, leads to an increase in the default probability. The probability of default, which depends on the ratio of capital to net worth, determines the minimum capital requirements for the banks. Furthermore, because of the higher risk and the increase in bank capital, households demand high liquidity premium to hold bank capital as it is expensive to raise capital during the downturn⁹. Banks then shift the burden to entrepreneurs by further increasing the lending rates, which makes it even more expensive for entrepreneurs to obtain the external funds. The decline in entrepreneurs' net worth leads to a fall in the demand of physical capital, which then drags down the price of physical capital. As a result, physical capital falls along with investment and output.

It is worth noting that both entrepreneurs' net worth and the price of physical capital revert to their steady states within 20 quarters after the shock, whereas physical capital continues to decline. Intuitively, it takes a much longer time to rebuild capital stock since it is the end product of factors such as investment and net worth, which must recover themselves first in order to facilitate capital accumulation.

The response of all key variables to the shock are much stronger under Basel II regulation than those under Basel I regulation. As shown in Figure 1, the liquidity premium increases much more under Basel II regulation than it does under Basel I regulation. As (26) indicates that the external finance premium depends positively on the liquidity premium and negatively on the net worth. Under Basel II regulation, both the decline in entrepreneurs' net worth and the increase in the liquidity premium contribute to the

⁹This is also the case if policy rate increases.

Figure 1: Negative net worth shock: Basel I (solid line) vs. Basel II (dashed line)

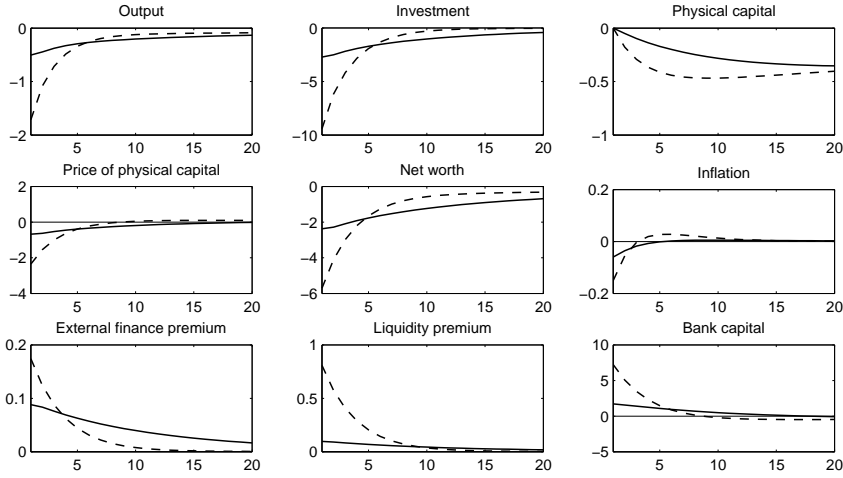
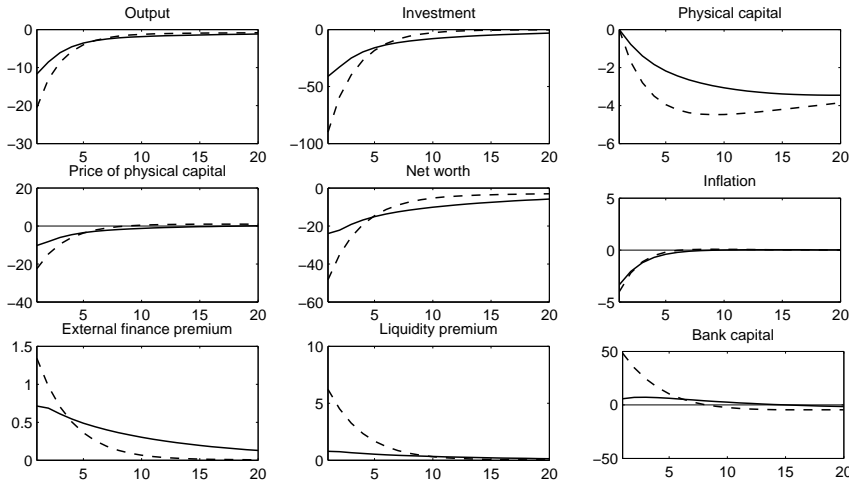


Figure 2: Positive monetary policy shock: Basel I (solid line) vs. Basel II (dashed line)



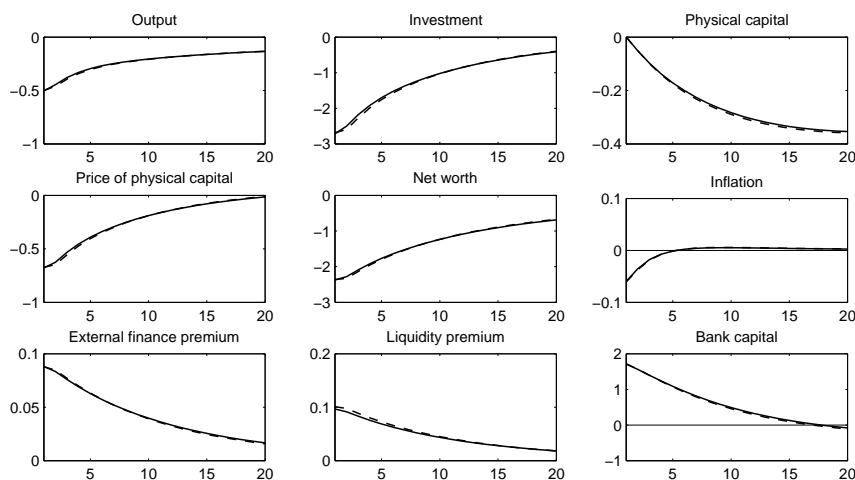
increase in the external finance premium. However, under Basel I regulation, net worth only has a direct impact on the financial accelerator effect.

4.2 Monetary policy shock

The monetary policy shock (Figure 2) operates through the standard asset price channel and the interest rate channel of the monetary policy transmission mechanisms. An unanticipated temporary positive monetary policy shock reduces entrepreneurs' net worth because net worth is positively related to asset prices, whereas asset prices are negatively related to the policy rate. Low net worth tarnishes entrepreneurs' creditworthiness, which then increases the external finance premium. From this point of view, the financial accelerator effect unfolds: less net worth is accumulated, resulting in a lower level of capital stock in the economy and a decline in investment and output.

It is worth noting that variables respond more strongly to the monetary policy shock than to the net

Figure 3: Negative net worth shock under Basel I when bank capital requirement increases from 8% (solid line) to 12% (dashed line)



worth shock. Part of the reason for this behavior is related to the interest rate channel of the monetary policy transmission mechanism. The policy rate not only affects the demand for loans through its impact on net worth, but also discourages entrepreneurs to borrow through its impact on the lending rates. In this way, a contractionary monetary policy leads to a much higher borrowing cost to entrepreneurs than the negative net worth shock does. Eventually, investment and output decrease much more in response to a contractionary monetary policy shock than to a negative net worth shock. This indicates that small adjustments in monetary policy can result in stronger response in the real economy, in the presence of Basel II regulation in particular, which is particularly undesirable.

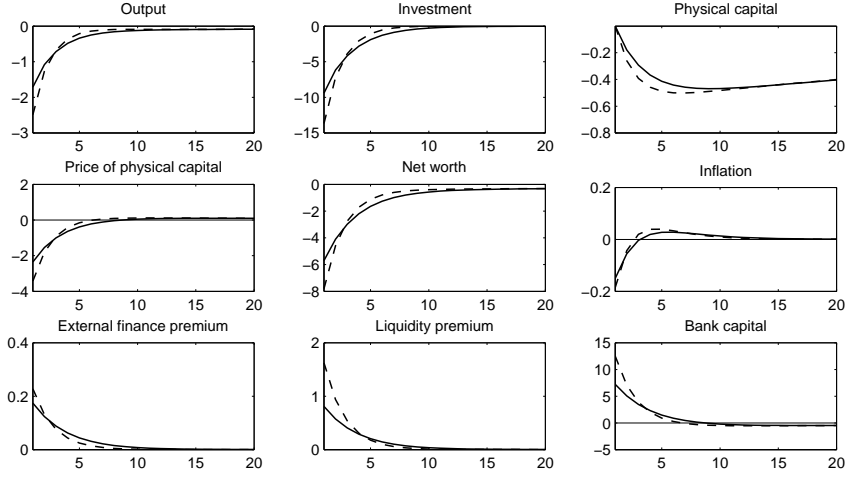
Both studies show that the dynamic response of all variables to both shocks are much stronger under Basel II regulation than those under Basel I regulation. This is due to that the credit risk calculation under Basel II regulation is based on not only the broader borrowers' groups, but also the risk profile of individual borrowers with the group. In other words, bank capital requirements are more risk sensitive under Basel II regulation, resulting in a greater increase in bank capital after the shocks as shown in Figure 1 and Figure 2.

4.3 Increasing minimum capital requirement from 8 to 12 percent

South African banks, even though by choice, have had an average risk-weighted capital adequacy ratio of approximately 12 percent between 2003 and 2009 (SARB, 2009). This situation, coupled with calls from world leaders for banks to increase their capital holdings in the aftermath of the 2007/08 financial crisis, leads to the idea of looking at the scenario where the minimum capital requirement increases from 8 percent to 12 percent. We therefore compare the impacts of a negative net worth shock on business cycle fluctuations when the minimum capital requirement increases from 8 percent to 12 percent under each accord.

The results show that Basel II is more procyclical than its predecessor. While increasing the ratio of bank capital to risk-weighted asset from 8 percent to 12 percent has a very minimal impact under Basel I regulation (Figure 3), however, it does result in stronger response in all key variables under Basel II

Figure 4: Negative net worth shock under Basel II when bank capital requirement increases from 8% (solid line) to 12% (dashed line)



regulation (Figure 4). The small difference observed under Basel I regulation can be attributed to the fact that bank capital requirements are less risk sensitive. That is, the general approach of assessing risk used under Basel I, feeds little information regarding the actual risk into the capital requirements. Under Basel II regulation, however, the higher minimum capital requirement implies that banks have to raise more capital from households than under Basel I regulation, which results in an increase in liquidity premium and, hence, the external finance premium. The high cost of borrowing eventually affects investment and output adversely. Moreover, when the minimum capital requirement increases from 8 percent to 12 percent, key variables not only deviate from the steady states by a greater magnitude, but also converge to their steady states more rapidly, further showing the procyclical nature of Basel II.

5 Conclusions

This paper aims to investigate the impacts of bank capital regulation on business cycle fluctuations, the procyclical nature of Basel II in particular. To this end, we calibrate a general equilibrium model with financial intermediation to the South African data. In our model, besides the financial accelerator effect existed in BGG, the liquidity premium effect further amplifies the financial accelerator effect through the external finance premium channel, which in turn, contributes to the amplification of Basel II procyclicality. Our simulation exercises also suggest that, in the presence of Basel II regulation, small adjustments in monetary policy can result in stronger response in the real economy through a decline in investment, physical capital, and net worth, while the response of inflation is largely unchanged. This consequence would be highly undesirable.

Some areas of future research can be identified as follows. To further evaluate the empirical performance of the augmented New Keynesian model with bank regulation developed in this paper, it is necessary to estimate the model using the real time series data. In addition, it is useful to use alternative models, such

as the recent Global Projection model of the IMF (e.g., Carabenciov et al., 2008), to see if one can reach the same conclusions as what we found in this paper.

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Appendix: Calibration

The model is calibrated to the South African economy using data from the South African Reserve Bank except for values of some parameters are borrowed from the literature (see Table 1).

The steady state ratios of households' consumption to output, government expenditure to output, investment to output, output to capital, and entrepreneurs' consumption to output are calibrated using real time series data: $\frac{C}{Y} = 0.58$, $\frac{G}{Y} = 0.19$, $\frac{I}{Y} = 0.16$, $\frac{Y}{K} = 0.11$ and $\frac{C^e}{Y} = 0.05$. The aggregate capital depreciation rate δ is 0.019 per quarter and capital output share $\alpha = 0.26$, values borrowed from Liu and Gupta (2007). Due to the unavailability of the exact entrepreneurs' net worth time series data, the ratio of capital to net worth $\frac{K}{N}$ is set at 2 as in BGG.

The ratio of entrepreneurs' net worth to loans, $\frac{N}{L}$, is calibrated at 1.685; the ratio of loans to bank capital, $\frac{L}{S}$, is calibrated at 8.35; and the ratio of loans to deposits, $\frac{L}{D}$, is calibrated at 2.15. We use the approximated measurements for entrepreneurs' loans and bank capital time series to calculate the above mentioned steady state ratios. Entrepreneurs' loans are obtained by subtracting mortgage loans for residential purposes from the total loans and advances to the private sector, whereas the series of share capital and reserves of liabilities of banking institution is used as the approximation of bank capital.

As far as the rates of interest are concerned, the steady state ratio of return to physical capital to the lending rate, $\frac{R^k}{R^l} = 1.092$, and the ratio of deposit rate to the lending rate, $\frac{R^d}{R^l} = 0.72$, are calculated using the approximated measurements. We use the rate of return on Eskom bonds as an approximation for the return to physical capital. The intuition is that, in the long run, the second best investment to capital projects may be bonds of a parastatal company like Eskom. The lending rate is approximated by subtracting the 91-days Treasury bill rate from the prime overdraft rate, and adding the deposits rate. Intuitively, banks request from borrowers a rate equals to what they pay for deposits plus a certain spread, which in this case, we use the spread between the overnight lending rate and the short-term interest rate.

Table 1: Calibration

Parameter	Value	Comments
$\frac{C}{Y}$	0.58	Household consumption-output ratio
$\frac{C^e}{Y}$	0.05	Entrepreneurial consumption-output ratio
$\frac{I}{Y}$	0.16	Investment-output ratio
$\frac{G}{Y}$	0.19	Government expenditure-output ratio
$\frac{K}{N}$	2	Physical capital-net worth ratio
$\frac{Y}{K}$	0.11	Output-physical capital ratio
θ	0.75	Calvo sticky price parameter
Q	1	Price of physical capital in steady state
φ	0.25	Elasticity of the price of physical capital to investment-capital ratio
α	0.26	Physical capital share of output
X	1.1	Gross markup of retail goods over wholesale goods
β	0.99	Discount rate
η_h	3.85	Household labor supply elasticity
ω	0.985	Share of income accruing to households
δ	0.019	Physical capital depreciation rate
γ	0.973	Survival probability
v	0.052	Steady state elasticity of external finance premium to leverage
$\frac{R^k}{R^l}$	1.092	Ratio of return to physical capital to lending rate
$\frac{R^d}{R^l}$	0.72	Ratio of deposit rate to lending rate
$\frac{K}{L}$	3.37	Ratio of physical capital to loans
$\frac{N}{L}$	1.685	Ratio of net worth to loans
$\frac{L}{S}$	8.35	Ratio of loans to bank capital
$\frac{L}{D}$	0.91	Ratio of loans to deposits