The macroeconomic effects of Basel III regulations with endogenous credit and money creation

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Abstract

When banks create credit and money endogenously, how do Basel III regulations affect the macroeconomy? This study develops a simple monetary circuit model based on the stock-flow consistent framework. It analytically solves for the equilibrium where banks comply with the capital adequacy ratio or net stable funding ratio. The growth rates can decompose into the money creation processes. The primary component is lending, which depends on bank spreads (or profitability) and regulatory rules. Moreover, this study reveals a channel through which credit and money creation affect economic growth. Debt ratios of firms are related to their animal spirits and the economy's growth rates, and this relationship implies conditions for firms using debt and going bankrupt. Finally, results reveal that regulations can transfer risk from banks to firms. These findings shed new light on banks' macroeconomic roles and the effects of bank regulations.

Keywords: Money creation, Basel III, Economic growth, Leverage, Banking macroeconomics

JEL classifications: E12, E51, G28

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1. Introduction

Considerable efforts have been made to study the effects of Basel III regulations. In particular, their macroeconomic effects have given rise to a contentious discussion. To examine Basel III regulations, we must develop macroeconomic models incorporating banks. However, incorporating banks as creators of credit and money poses a substantial challenge to most mainstream macroeconomic models.[1] In this study, a monetary model that includes banks' creation of credit and money is developed. The model aims to provide several new insights into the macroeconomic effects of Basel III regulations imposed on banks as creators of credit and money.

My model draws on the monetary circuit (MC) theory (Bossone, 2001a, 2001b; Graziani, 2003; Godley, 2004; Lavoie, 2004) based on the stock-flow consistent (SFC) framework (Lavoie and Godley, 2001; Godley and Lavoie, 2012). The model has three agents: households, firms, and banks. This model is simple and can thus be solved analytically.

Basel III introduces two capital regulations: the capital adequacy ratio (CAR) and leverage ratio (LR). Both regulations will have an impact on the macroeconomy. However, the model incorporates banks with endogenous credit and money creation and does not introduce the processes to influence bank reserves; the LR can be considered a special case of the CAR constraint (explained in Section 5). So, I only take the CAR into account for capital regulations. The net stable funding ratio (NSFR) and the liquidity coverage ratio (LCR) are two additional liquidity regulations introduced by Basel III. However, according to Basel Committee on Banking Supervision (2010) and Angelini et al. (2015), the long-term effects of the NSFR on macroeconomic performance are much more significant than those of the LCR. Therefore, I focus my attention on the NSFR regarding liquidity regulations.

Solving for the equilibria (steady states) subject to the CAR and NSFR constraints yields the effects of the CAR and NSFR. I am mainly interested in the growth and financial stability of the economy. The equilibrium growth rate serves as a gauge for economic growth. Moreover, financial stability is represented by the equilibrium debt ratio (leverage ratio). I assume that only firms can obtain loans from banks. Then, the debt ratio is the ratio of loans to a firm's physical capital. Although the equilibrium subject to the CAR constraint and that to the NSFR constraint are different, they share many fundamental traits and have similar policy implications.

Firstly, the economic growth rates are decomposed into two money creation processes: paying interest on deposits and lending under the CAR or NSFR. Hence, I refer to these equilibrium solutions as credit-creation-driven equilibria.

Secondly, the debt ratios of firms in the equilibrium states are equal to the ratios of their animal spirits to the economy's growth rates. The debt ratios imply the conditions for a firm to borrow money and go bankrupt. Firms begin borrowing when their animal spirits are greater than zero; they fail when their animal spirits outweigh the economic growth rates. Thus, if animal spirits are psotive and lower than or equal to growth rates, firms will demand credit, and banks will create credit and money. These conditions on animal spirits are necessary for the credit-creation-driven equilibria to exist.

Thirdly, I offer policy implications by demonstrating how the growth rates and debt ratios respond to changes in interest rates and regulations under the circumstances necessary for equilibria. My model identifies a channel through which bank credit and money creation influence economic growth rates. On the growth rate, lending under the CAR or NSFR has a significant impact. For simplicity, assume that the regulatory parameters are constant (or insensitive to interest rates). Then, increasing the bank spreads or profitability raises the lending and thus growth rates.[2] The responses of debt ratios to interest rate shocks are opposite to those of growth rates. The implication is that increasing economic growth may help firms with their debt problems. In sum, if policymakers adjust the interest rates to increase bank profits in the credit-creation-driven equilibria, banks can increase credit and money creation to boost economic growth, thus decreasing firm indebtedness.

The responses of growth rates and debt ratios to regulatory changes can be summarised into two main findings. Firstly, as is generally accepted, increasing the CAR or NSFR has a detrimental impact on economic growth.[3] Secondly, the CAR or NSFR transfers risk from banks to firms, and banks can better manage the insolvency or liquidity risk when the CAR or NSFR is strengthened. However, firms are worse off due to increased debt ratios and subsequent bankruptcy risk brought by strengthening the CAR or NSFR. The central message for policymakers is the importance of striking a balance between the two opposing effects caused by the changes in regulations.

The rest of the paper is organised as follows. Section 2 reviews the literature. Section 3 develops the basic framework of the model. Section 4 presents the dynamic equations and equilibrium conditions of the model. Section 5 presents the CAR and NSFR regulatory constraints. Section 6 discusses the equilibrium solutions and effects of regulations. Section 7 concludes.

2. Literature review

This paper is related to three strands of literature: (i) research on banks' macroeconomic role; (ii) studies on financialisation and financial instability and crises using MC or SFC models; and (iii) efforts to examine the macroeconomic effects of Basel III regulations.

Since the 2008 financial crisis, a rapidly growing body of literature has sought to clarify banks' macroeconomic role. Essentially, there are two opposing viewpoints: one considers banks as financial intermediaries, whereas the other sees banks as creators of credit and money. According to McLeay et al. (2014), Werner (2014a, 2014b, 2016), Bezemer (2016), and Li and Wang (2020), banks create credit and money rather than transfer money. Endogenous money creation is a distinguishing feature of post-Keynesian monetary models, particularly MC and SFC models

(Godley and Cripps, 1983; Minsky, 1986; Arestis, 1996; Rochon, 1999a, 1999b; Parguez and Seccareccia, 2000; Fontana, 2003; Lavoie, 2006; Sawyer, 2013). A growing number of papers have recently developed banking models based on banks' creation of credit and money to explore the impacts of Basel III regulations on credit and money supply (Li et al., 2017; Xing et al., 2020; Xiong et al., 2020). These banking models only presented how Basel III regulations affect the creation of credit and money. By contrast, this paper develops a macroeconomic model incorporating banks' creation of credit and money to show the effects of regulations on economic growth and stability.

My paper is also related to the MC and SFC literature on financialisation and financial instability and crises. Banks creating credit and money are viewed as fundamental to the models and underpin discussions of financial stability in this literature. For instance, Skott and Ryoo (2008), van Treeck (2008) and Michell and Toporowski (2012) analysed the macroeconomic effects of a firm's financial decisions, such as dividend payments, share issuances, debt financing, and liquidity holdings. A series of papers published in the aftermath of the 2008 financial crisis shed light on the endogenous causes and evolutions of financial instability. Many incorporated Hyman Minsky's financial instability hypothesis into MC or SFC models (Passarella, 2012; Caverzasi and Godin, 2015; Dafermos, 2018). The work of Ryoo (2013), who linked bank profitability and leverage to firm debt ratios and economic stability, is more closely related to my paper. In addition to classical ideas, a few models consider the recent rise of non-bank financial intermediaries, especially shadow banks. Both shadow banks and commercial banks can be consistently incorporated into MC models, whereas commercial banks are distinguished from shadow banks by money creation. This allows the MC models to distinguish between the roles of shadow banks and commercial banks in influencing the economy (Botta et al., 2015, 2020; Michell, 2017; Sawyer and Passarella, 2017).

In response to financial instability and crises, bank regulations appear necessary (Dow, 1996). Bank regulations are accompanied by a body of macroeconomic literature that examines the effects of the regulations. Recently, Basel III, the most important bank regulation reform enacted in response to the 2008 financial crisis, has received much attention. Agent based-stock flow consistent models are appropriate for describing bank behaviour under regulations. Cincotti et al. (2012), Neuberger and Rissi (2014), Krug et al. (2015) and Riccetti et al. (2018) have examined most of the Basel III regulations, including the CAR, LR, LCR, NSFR, capital conservation buffer, and countercyclical buffer. However, using these models is difficult in presenting analytical solutions. Goodhart et al. (2012) and Goodhart et al. (2013) developed an analytical macroeconomic framework to investigate the Basel III regulations, which includes the CAR and LCR. Moreover, bank balance sheets are used to describe banks' regulatory behaviour and play an explicit role in their model's design. However, banks transfer funds rather than create credit and money in their model. In fact, almost without exception (see footnote 1 for an exception), banks are described in mainstream macroeconomic models as standard financial intermediaries. For example, the dominant paradigm in macroeconomic research, that is, dynamic stochastic general equilibrium models, are used to discuss the effects of bank regulations by including banks that intermediate funds (e.g. Gerali et al., 2010; Angeloni and Faia, 2013; Angelini et al., 2015; Benes and Kumhof, 2015).

My paper makes four main contributions relative to these three strands of literature. Firstly, using this simple model, I can analytically solve for the equilibria with endogenous money creation under the Basel III regulations. This addresses the need for simple, analytical SFC models (Taylor, 2004, chs. 8–9; Dos Santos and Macedo e Silva, 2009; Caverzasi and Godin, 2014). Secondly, after solving the model, I found that the economy's equilibrium growth rates decompose into money creation processes. That is, the model depicts a channel through which the creation of credit and money affects the economy. Thirdly, firms' equilibrium debt ratios are linked to their animal spirits and the economy's growth rates. This finding clarifies the circumstances under which firms use debt and go bankrupt. Fourthly, as the policy implications show, strengthening the CAR or NSFR increases firm bankruptcy risk.

3. The model

Under Basel III, three types of agents in the economy exist: households, firms, and banks. Firstly, I describe the SFC framework of the MC model. The SFC framework is based on the balance-sheet matrix and the transaction-flow matrix presented in

Table 1 and **Table 2**.

[Insert Table 1 here]

[Insert Table 2 here]

The SFC framework yields the three sectors' SFC budget constraints. The SCF budget constraints are rigid and determined by the macro-accounting relationships. In addition, I adopt the agent behaviour descriptions commonly used in SFC models. Simultaneously, I keep the behavioural descriptions simple to facilitate analytical tractability. Moreover, it provides a clear understanding of the effects of regulations.

3.1 Description

The balance-sheet matrix describes the balance sheets of the three sectors. Columns 1, 2, and 3 in **Table 1** present the balance sheet identities of households, firms and banks, respectively. The transaction-flow matrix shows transactions between the sectors in **Table 2**.

Firms receive total income consisting of household consumption C and firm investment I:

$$Y = C + I. \tag{1}$$

Then, firms pay wages W to households and receive profits F. I use a simple mark-up rule to determine how firms distribute their income between wages and profits. I assume that the mark-up on wages is given by ρ; thus, I obtain

$$Y = (1 + \rho)W; \tag{2}$$

the wages can be written as

$$W = \frac{1}{1+\rho} \cdot Y. \tag{3}$$

Moreover, the current account of firms shown in column 2 in **Table 2** yields

$$C + I = W + F + r_l L, \tag{4}$$

where r_l is the nominal interest rate on loans, L are loans, and $r_l L$ are firms' interest expenses. Indeed, equation (4) is the accounting identity showing that national income equals national product. I substitute equation (3) into equation (4) to obtain the profits as follows:

$$F = \frac{\rho}{1+\rho} \cdot Y - r_l L, \tag{5}$$

Then, firms pay dividends F_d to households. The distributed dividends are equal to a fraction $1 - s_f$ of the profits in equation (5)

$$F_d = (1 - s_f)(\frac{\rho}{1+\rho} \cdot Y - r_l L). \tag{6}$$

This setting is also used by Lavoie and Godley (2001), Dos Santos and Zezza (2008) and Skott and Ryoo (2008). Moreover, from equations (5) and (6), the retained earnings can be written as

$$F_r = s_f(\frac{\rho}{1+\rho} \cdot Y - r_l L). \tag{7}$$

Next, firms decide how much to invest in physical capital. The investment function determines the investment. Denote by P the price level, and denote by K the stock of physical capital. I assume that the investment function takes the following form:

$$\frac{I}{PK} = \beta_0 + \beta_1 \cdot \frac{F_r}{PK}, \tag{8}$$

where $\beta_0 \geq 0$ and $0 \leq \beta_1 \leq 1$ are exogenous. The parameter β_0 represents firms' animal spirits that determine their fixed investment. Equation (8) is one of the post-Keynesian models' typical investment functions (Lavoie and Godley, 2001; Dos Santos and Zezza, 2008; Nikiforos and Zezza, 2017; Nikolaidi and Stockhammer, 2017).

Additionally, households consume goods produced by firms. Their consumption can be expressed as

$$C = \alpha_1 \cdot (W + F_d + r_d M) + \alpha_2 \cdot (M + E_f), \tag{9}$$

where r_d is the nominal interest rate on deposits, and $0 \leq \alpha_1 \leq 1$ and $0 \leq \alpha_2 \leq 1$ are exogenous parameters. The parameter α_1 is the marginal propensity to consume out of income, and α_2 is the marginal propensity to consume out of wealth.

3.2 Stock-flow consistent budget constraints

The SFC relationships are given by the transaction-flow matrix in **Table 2** allow me to display the three sectors' SFC budget constraints.

Firstly, I demonstrate the households' SFC budget constraint, as indicated by column 1 in **Table 2**:

$$C + \Delta M = W + F_d + r_d M, \tag{10}$$

where ΔM are changes in money (deposits). Substituting equations (3) and (6) into equation (10), I can rewrite the SFC budget constraint as

$$C + \Delta M = \frac{1}{1+\rho} \cdot Y + \left(1 - s_f\right)\left(\frac{\rho}{1+\rho} \cdot Y - r_l L\right) + r_d M. \tag{11}$$

Secondly, the firms' SFC budget constraint is derived from the two SFC relationships associated with their current and capital accounts. The capital account gives the SFC relationship that their retained earnings and bank loans ΔL finance firms' investment:

$$I = \Delta L + F_r. \tag{12}$$

Indeed, equation (12) implies that in equation (8), β_0 corresponds to $\Delta L/PK$, and β_1 equals 1. That is, firms' animal spirits represent their incentive to borrow. The current account gives the SFC relationship in equation (4), which provides the retained earnings in equation (7). Finally, substituting equation (7) into equation (12) yields the SFC budget constraint of firms as

$$I = \Delta L + s_f\left(\frac{\rho}{1+\rho} \cdot Y - r_l L\right). \tag{13}$$

Thirdly, I obtain the SFC budget constraint of banks using the dynamics of money creation and the banks' balance sheet identity. Column 4 in **Table 2** gives the dynamics of money creation

$$\Delta M = \Delta L + r_d M - r_l L. \tag{14}$$

The model's core is the bank relationship, which explains how credit and money are created. Equation (14) shows that lending and paying interest on deposits create money, whereas receiving interest on loans destroys it. The banking model demonstrated these money creation processes (Li and Wang, 2020). Equation (14) and the bank's balance sheet identity are combined to produce banks' SFC budget constraint:

$$\Delta V_b = r_l L - r_d M, \tag{15}$$

which describes the profits or changes in the net worth of banks.

4. Dynamics and equilibrium

This section combines the SFC budget constraints and behavioural relationships presented in Section 3 to demonstrate the economy's dynamics. I then explain how dynamic equations are reduced to systems of equations to determine the equilibria.

4.1 Dynamic equations

The dynamic equations are classified into four groups: (i) the income-expenditure identity in equation (1); (ii) the SFC budget constraints of households in equation (11), firms in equation (13), and banks in equation (15); (iii) behavioural relationships given by the investment function in equation (8) and consumption function in equation (9); and (iv) bank regulations (which I will provide in Section 5). Combining equations (11) and (13) results in equation (14), indicating that money creation has been considered.

4.2 Equilibrium

SFC model equilibrium is defined as a steady state in which the ratios of any two variables remain constant over time (Godley and Lavoie, 2012). In equilibrium, the economy can still expand or contract.

To find the equilibrium, I need to see the dynamics of the ratios. I divide the variables in the dynamic equations by physical capital PK. Let lower-case variables denote ratios of the corresponding upper-case variables to PK. That is, for a flow variable FV, I obtained FV per unit of physical capital as

$$fv = \frac{FV}{PK}. \tag{16}$$

For a stock variable SV, I have SV per unit of physical capital as

$$sv = \frac{SV}{PK}. \tag{17}$$

The equilibrium means both $\Delta fv = 0$ for all fv and $\Delta sv = 0$ for all sv. The dynamic equations include changes in stock variables in addition to flow and stock variables. From equation (17), changes in SV can be written as

$$\Delta SV = \Delta sv \cdot PK + sv \cdot \Delta(PK). \tag{18}$$

Therefore, in equilibrium, equation (18) becomes

$$\Delta SV = sv \cdot \Delta(PK). \tag{19}$$

Denote by $\widetilde{\Delta SV}$ the ratio of changes in the stock variable ΔSV to PK. Then,

$$\widetilde{\Delta SV} = \frac{\Delta SV}{PK} = sv \cdot \frac{\Delta(PK)}{PK}. \tag{20}$$

Because firms' investment leads to the accumulation of physics capital,

$$I = \Delta(PK), \tag{21}$$

equation (20) can be written as

$$\widetilde{\Delta SV} = sv \cdot \frac{\Delta(PK)}{PK} = sv \cdot \frac{I}{PK} = sv \cdot i, \tag{22}$$

where $i = I/(PK)$ is the rate of physics capital accumulation.

Using equations (16), (17), and (22), I present the equilibrium conditions from the dynamic equations given in Section 4.1 as

$$y = c + i \tag{23}$$

$$c + m \cdot i = \frac{1}{1+\rho} \cdot y + \left(1 - s_f\right)\left(\frac{\rho}{1+\rho} \cdot y - r_l l\right) + r_d m, \tag{24}$$

$$i = l \cdot i + s_f\left(\frac{\rho}{1+\rho} \cdot y - r_l l\right), \tag{25}$$

$$v_b \cdot i = r_l l - r_d m, \tag{26}$$

$$i = \beta_0 + s_f\left(\frac{\rho}{1+\rho} \cdot y - r_l l\right), \tag{27}$$

$$c = \alpha_1 \cdot \left(\frac{y}{1+\rho} + (1 - s_f)\left(\frac{\rho}{1+\rho} \cdot y - r_l l\right) + r_d m\right) + \alpha_2 \cdot (m + e_f). \tag{28}$$

Equations (23), (24), (25), (26), (27), and (28) are the equilibrium conditions belonging to groups (i), (ii), and (iii). The following section describes group (iv): the equilibrium conditions given by the regulatory constraints.

5. Bank regulations

This section briefly describes the bank regulations. Firstly, I show the definitions of the CAR and LR. The CAR or the LR requires banks to maintain sufficient capital to absorb negative capital shocks. They restrict the creation of credit and money by banks. Basel Committee on Banking Supervision (2011) defines the CAR as follows:

$$\frac{Capital}{Total\ risk\text{-}weighted\ assets} \geq car, \tag{29}$$

where the total risk-weighted assets are the sum of bank assets multiplied by their risk weights, and car is the minimum CAR requirement. I now turn to the LR. Basel Committee on Banking Supervision (2014a) defines LR as follows:

$$\frac{Capital\ measure}{Exposure\ measure} \geq lr, \tag{30}$$

where the exposure measure is the sum of bank assets, including all on-balance sheet items; and lr is the minimum LR requirement.

From the balance sheet of banks presented in **Table 1**, the CAR can be expressed as

$$\frac{V_b}{\gamma \cdot L} \geq car, \tag{31}$$

where γ is the risk weight for loans; the definition of the LR becomes

$$\frac{V_b}{L} \geq lr. \tag{32}$$

The LR can be considered a special CAR case as mentioned in the introduction. The form of equation (31) reduces to that of equation (32), if $\gamma = 1$; the LR constraint is merely an instance of the CAR constraint. Moreover, the current model relies on the ability of banks to create credit and money. As this capability implies, banks do not need to hold reserves. In addition, the model does not address the effects of reserve changes; reserves are assumed to be 0 without loss of generality. In sum, I only need to examine the impact of the CAR. Define θ as $car \cdot \gamma$. Then, equation (31) can be rewritten as

$$\theta \cdot L \leq V_b. \tag{33}$$

I divide both sides of equation (33) by PK to obtain

$$\theta \cdot l \leq v_b. \tag{34}$$

Then, I assume that banks lend up to capacity:

$$\theta \cdot l = v_b. \tag{35}$$

Equation (35) indicates that the CAR is binding and subsequently influences banks.[4] The equilibrium condition imposed by the CAR constraint is given by Equation (35). Meanwhile, a combination of equation (35) and the equilibrium conditions listed in

Section 4.2 determines the equilibrium under the CAR.

Secondly, the NSFR mandates that banks maintain a balance between the stability of their liabilities and the liquidity of their assets to withstand adverse liquidity shocks. In particular, based on Basel Committee on Banking Supervision (2014b), the NSFR is defined as

$$\frac{\textit{Available amount of stable funding}}{\textit{Required amount of stable funding}} \geq nsfr, \tag{36}$$

where the available amount of stable funding is the sum of liabilities and capital weighted by their available stable funding (ASF) factors, the required amount of stable funding is the sum of assets weighted by their required stable funding (RSF) factors, and $nsfr$ denotes the minimum NSFR requirement. Let τ be the ASF factor for deposits, and let φ be the RSF factor for loans. Additionally, the ASF factor for bank capital takes the value of 1, as required by the NSFR.

Then, from the bank balance sheet presented in **Table 1**, the formula for the NSFR can be written as

$$\frac{V_b + \tau \cdot M}{\varphi \cdot L} \geq nsfr. \tag{37}$$

Define $nsfr \cdot \varphi$ as η; the preceding expression becomes

$$\eta \cdot L \leq V_b + \tau \cdot M. \tag{38}$$

Divide both sides of equation (38) by PK to obtain

$$\eta \cdot l \leq v_b + \tau \cdot m. \tag{39}$$

I assume that banks lend up to capacity:

$$\eta \cdot l = v_b + \tau \cdot m. \tag{40}$$

As in the CAR discussion, equation (40) is the equilibrium condition given by the NSFR constraint. Combining equation (40) and the equilibrium conditions listed in Section 4.2 yields the equilibrium under the NSFR.

6. Equilibrium solutions and effects of regulations

The capital regulatory equilibrium (CRE) is the equilibrium in which banks comply with the CAR. In contrast, the regulatory liquidity equilibrium (LRE) is the equilibrium in which banks comply with the NSFR. In both the CRE and the LRE, I focus on two key variables. One is the growth rate of the economy, $g = \Delta(PK)/(PK)$; it is equal to the ratio of investment to physical capital $g = i = I/(PK)$. The other is the financial stability of the economy, represented by the firm's debt ratio $l = L/(PK)$.

In Appendix A, I present the equilibrium solutions for the other variables, consisting of the ratios of total income to PK, y; consumption to PK, c; the quantity of money to PK, m; the net worth of banks to PK, v_b; and the equities of firms to PK, e_f.

6.1 Capital regulatory equilibrium

In the CRE, the CAR restricts credit and money creation by banks. The equilibrium conditions consist of equations (23), (24), (25), (26), (27), and (28) and the CAR constraint in equation (35). These conditions provide the solution for the CRE.

Denote the growth rate of the economy in the CRE by g^C. I obtain

$$g^C = r_d + \frac{r_l - r_d}{\theta}. \tag{41}$$

Equation (41) suggests that credit and money creation by banks affects economic growth. The first term of equation (41) results from the payment of interest on deposits, which creates money. The second term results from lending that is subject to the CAR. As equation (35) indicates, the second term equals the quantity of credit or money created when a bank receives a net interest income from lending one unit. These findings demonstrate that the CRE can be referred to as the credit-creation-driven equilibrium. Next, the debt ratio reveals the financial stability of the economy. Denote the debt ratio in the CRE by l^C. Then, I obtain

$$l^C = \frac{\beta_0 \cdot \theta}{r_l - (1 - \theta) r_d}. \tag{42}$$

There is a relationship between the equilibrium debt ratio and growth rate: $l^C = \beta_0 / g^C$. The relationship arises from firms' use of debt, driven by their animal spirits.

The relationship $l^C = \beta_0 / g^C$ specifies the leverage behaviour of firms. In particular, I give the conditions for firms using debt and going bankrupt. If firms do not borrow and finance their investment only through retained earnings, then $l^C = 0$:

$$\beta_0 = 0. \tag{43}$$

By contrast, if firms use leverage or debt to finance their investment, then $l^C > 0$:

$$\beta_0 > 0. \tag{44}$$

According to the equation (44), firms will borrow money from banks when their animal spirits are positive. Suppose firms use more debt; their leverage rises. When firms' debt ratios are greater than 1, they go bankrupt. Using $l^C = \beta_0/g^C$, I obtain the condition for $l^C > 1$ as

$$\beta_0 > g^C. \tag{45}$$

As equation (45) presents, firms' animal spirits and the economy's growth rate are the determinants of bankruptcy. When animal spirits exceed growth rates, firms end up with more debt than assets and eventually go bankrupt. In other words, animal spirits must satisfy $0 < \beta_0 \leq g^C$. Then, firms demand loans, and thus, banks create credit and money. This condition is necessary for the existence of credit-creation-driven equilibrium.

Policy implications. Firstly, I discuss the growth rate and debt ratio responses to interest rate shocks. From equation (41), due to $1/\theta > 1$, the lending under the CAR (the second term) is the dominant determinant of economic growth. Suppose that the risk weight for loans, γ, is constant (or insensitive to loan rates). The responses of θ ($car \cdot \gamma$) to changes in loan rates are ignored. Therefore, bank spreads or profitability changes are the only factors that can affect lending. The amount of lending subject to the CAR constraint increases if bank spreads widen by raising loan rates or lowering deposit rates. This yields a higher growth rate. That is, the derivative of g^C with respect to r_l is greater than 0, and the derivative of g^C with respect to r_d is less than 0:

$$\frac{\partial g^C}{\partial r_l} = \frac{1}{\theta} > 0, \tag{46}$$

$$\frac{\partial g^C}{\partial r_d} = -\left(\frac{1}{\theta} - 1\right) < 0. \tag{47}$$

Meanwhile, the growth rate in loan rates may decline if the risk weight for loans is dependent on loan rates. The justification is provided at the end of Section 6.1.

Let us now examine the debt ratio. Differentiate the equation (42) with respect to r_l and r_d to obtain

$$\frac{\partial l^C}{\partial r_l} = -\frac{\beta_0 \cdot \theta}{(r_l - (1-\theta) r_d)^2} < 0, \tag{48}$$

$$\frac{\partial l^C}{\partial r_d} = \frac{\beta_0 \cdot \theta(1-\theta)}{(r_l - (1-\theta) r_d)^2} > 0. \tag{49}$$

The responses of the debt ratio to interest rate shocks are opposite to the growth rate's. Suppose that the loan rate rises or the deposit rate decreases. The rate of economic growth increases. As demonstrated by equations (48) and (49), an increase in economic growth reduces the debt burden of firms. Equations (46), (47), (48), and (49) demonstrate that by raising loan rates or lowering deposit rates, policymakers can increase economic growth while also lowering the firm's debt ratio.

Secondly, I present the response to changes in the stringency of the CAR. The response of the growth rate to the regulatory changes is

$$\frac{\partial g^C}{\partial \theta} = -\frac{r_l - r_d}{\theta^2} < 0, \tag{50}$$

which indicates that the growth rate is decreasing in θ. Strengthening the CAR by increasing the minimum CAR requirement or risk weight for loans reduces banks' ability to create credit and money, lowering the economic growth rate. This result confirms that the credit and money supply are the primary determinants of economic growth.

For the debt ratio, I show the derivative of the debt ratio in equation (42) with respect to θ as

$$\frac{\partial l^C}{\partial \theta} = \frac{\beta_0(r_l - r_d)}{(r_l - (1-\theta)r_d)^2} > 0. \tag{51}$$

Firms' indebtedness rises as the CAR is strengthened. The debt ratio responds to changes in the stringency of the CAR in the opposite sign to the growth rate. The rise in θ decreases the economic growth rate. Meanwhile, the decrease in the growth rate increases the debt burden of firms. Such a finding reveals that strengthening the CAR increases bank resilience while increasing firm bankruptcy risk. When policymakers adjust the CAR, it is critical to strike a balance between decreasing bank insolvency risk and increasing firm bankruptcy risk.

Considering the relationship between loan risk weight and loan rates may yield results that contradict equation (46). The reason for this is that a higher loan rate frequently implies a higher risk weight for loans and then a larger θ. Consequently, according to equation (50), a higher loan rate can result in a lower growth rate. I leave this extension for future work.

6.2 Liquidity regulatory equilibrium

In the LRE, the NSFR restricts banks' ability to create credit and money. The equilibrium conditions for the LRE are the same as those for the CRE, except that in equation (40), the CAR constraint is replaced with the NSFR constraint. These conditions provide the economy's growth rate and the debt ratio of firms in the LRE.

Before showing the main results, I provide the parameter ranges for τ and η. The ranges are calculated using loans and deposits greater than 0. From equation (40) and the balance sheet identity of banks, the relationship between loans l^L and the net worth of banks v_b^L is

$$l^L = \frac{1-\tau}{\eta-\tau} v_b^L. \tag{52}$$

Similarly, the relationship between deposits m^L and the net worth of banks is

$$m^L = \frac{1-\eta}{\eta-\tau} v_b^L. \tag{53}$$

Equations (52) and (53) yielding greater than 0 suggest that $\tau < 1$ and $\eta < 1$ if $\tau < \eta$; or $\tau > 1$ and $\eta > 1$ if $\tau > \eta$. However, if $\tau > \eta$, then $\tau > 1$ suggests that the liabilities of banks are more stable than the net worth or capital. So far, this is not realistic in practice. Appendix B briefly discusses the growth rate and debt ratio solutions under $\tau > \eta$. Here, I focus on the growth rate and debt ratio under $\tau < 1$, $\eta < 1$, and $\tau < \eta$.

The growth rate of the economy is

$$g^L = r_d + \frac{(1-\tau)(r_l - r_d)}{\eta-\tau} \tag{54}$$

The condition $\tau < 1$, $\eta < 1$, and $\tau < \eta$ yields $(1-\eta)/(1-\tau) < 1$. Together with $r_l/r_d > 1$, I obtain $g^L > 0$ because

$$\frac{r_l}{r_d} > \frac{1-\eta}{1-\tau} \tag{55}$$

implies that equation (54) is greater than 0. Next, I link the growth rate in the LRE to money creation. The first term in equation (54) results from the creation of money through interest payments on deposits. The second term is the result of money creation through lending subject to the NSFR. As shown in equation (52), the second term equals the amount of credit or money created when banks earn net interest income from issuing one unit of loans. In line with these findings, the LRE is referred to as the credit-creation-driven equilibrium. The second key variable is the debt ratio of firms given by

$$l^L = \frac{\beta_0(\eta - \tau)}{(1-\tau)r_l - (1-\eta)r_d}. \tag{56}$$

As in the CRE, I obtain $l^L = \beta_0/g^L$ in the LRE. This relationship arises from firms' use of debt motivated by their animal spirits.

Moreover, $l^L = \beta_0/g^L$ suggests the firms' leverage behaviour. I show the conditions for firms' use of debt and bankruptcy. The condition that firms do not use debt (i.e. $l^L = 0$) is expressed as:

$$\beta_0 = 0. \tag{57}$$

When firms use leverage or debt, firms borrow from banks to finance their investment (i.e. $l^L > 0$):

$$\beta_0 > 0. \tag{58}$$

When firms have a positive animal spirit, they finance their investments with retained earnings and bank loans. Suppose that firms continue to increase their leverage. The upper limit on the leverage is the debt ratio of 1. Above the limit, a firm's net worth is less than 0; thus, the firm goes bankrupt. From $l^L = \beta_0/g^L$, the condition for $l^L > 1$ is

$$\beta_0 > g^L. \tag{59}$$

The preceding conditions show that animal spirits must satisfy $0 < \beta_0 \leq g^L$, the same as in the CRE. Similarly, this condition ensures firms' demand for credit and banks' credit and money creation, and it is necessary for the existence of the credit-creation-driven equilibrium.

Policy implications. Firstly, I show the growth rate and debt ratio responses to interest rate shocks. From equation (54), the lending under the NSFR (the second term) plays a major role in determining economic growth because of $(1-\tau)/(\eta-\tau)>1$. Suppose that the ASF factor for deposits, τ, and RSF factor for loans, φ, are constant (or insensitive to interest rates). I abstract from the changes in τ and η $(nsfr \cdot \varphi)$ in response to interest rate shocks. The lending can then only be altered by changing bank spreads or profitability. When an increase in loan rates or a decrease in deposit rates increases bank spreads, lending under the NSFR increases, and the growth rate rises:

$$\frac{\partial g^L}{\partial r_l}=\frac{1-\tau}{\eta-\tau}>0, \tag{60}$$

$$\frac{\partial g^L}{\partial r_d}=-\frac{1-\eta}{\eta-\tau}<0. \tag{61}$$

Considering the relationship between η (τ) and loan rates (deposit rates) may give opposite results, which will be explained at the end of Section 6.2.

Let us discuss the responses of the debt ratio. The debt ratio of firms in equation (56) gives

$$\frac{\partial l^L}{\partial r_l}=-\frac{\beta_0(\eta-\tau)(1-\tau)}{\big((1-\tau)r_l-(1-\eta)r_d\big)^2}<0, \tag{62}$$

$$\frac{\partial l^L}{\partial r_d}=\frac{\beta_0(\eta-\tau)(1-\eta)}{((1-\tau)r_l-(1-\eta)r_d)^2}>0. \tag{63}$$

As explained in the CRE, if the growth rate rises (falls), the debt ratio will fall (rise) in response to interest rate shocks. Equations (60), (61), (62), and (63) show that policymakers can increase the loan rate or decrease the deposit rate to simultaneously increase the growth rate of the economy and decrease the firm's debt burden.

Secondly, I present the responses to changes in the NSFR's stringency. The growth rate in equation (54) is increasing in the ASF factor for deposits, τ, whereas it is decreasing in the product of the minimum NSFR requirement and RSF factor for loans, η:

$$\frac{\partial g^L}{\partial \tau} = \frac{(r_l - r_d)(1-\eta)}{(\eta - \tau)^2} > 0, \tag{64}$$

$$\frac{\partial g^L}{\partial \eta} = -\frac{(r_l - r_d)(1-\tau)}{(\eta - \tau)^2} < 0. \tag{65}$$

These equations imply that the increase in the stringency of the NSFR by decreasing τ or increasing η lowers the growth rate. From equations (52) and (53), decreasing τ or increasing η reduces the supply of credit and money; then, economic growth falls. This result evidences that credit and money creation govern economic growth.

Moreover, the debt ratio in equation (56) is decreasing in τ and increasing in η:

$$\frac{\partial l^L}{\partial \tau} = -\frac{\beta_0 (r_l - r_d)(1-\eta)}{\left((1-\tau) r_l - (1-\eta) r_d\right)^2} < 0, \tag{66}$$

$$\frac{\partial l^L}{\partial \eta} = \frac{\beta_0 (r_l - r_d)(1-\tau)}{\left((1-\tau) r_l - (1-\eta) r_d\right)^2} > 0. \tag{67}$$

As stated in the CRE, a decrease in the growth rate is accompanied by an increase in the debt ratio or indebtedness of firms in response to tightening the regulation. Consider the scenario where the NSFR is strengthened by decreasing τ or increasing η. Then banks' liquidity risk decreases. However, as equations (66) and (67) suggest the bankruptcy risk of firms increases. The NSFR transfers risk from banks to firms. Therefore, policymakers must strike a balance between reducing banks' liquidity risk and increasing firms' bankruptcy risk.

Meanwhile, including the relationship between η and loan rates or between τ and deposit rates may produce opposite results to equations (62) and (63). The following is the rationale: A higher loan rate suggests that loans typically have a longer maturity and, consequently, a larger η. A higher deposit rate indicates that deposits typically have a lower run-off rate, resulting in a larger τ. From equation (65), a higher loan rate can result in a lower growth rate, whereas from equation (64), a higher deposit rate can result in a higher growth rate. I leave this issue for future research.

7. Conclusion

Based on the SFC framework, this study presented a simple MC model. The model incorporates banks that endogenously create credit and money. I employ the model to investigate the macroeconomic implications of the CAR and NSFR. To do so, I analytically solve for the equilibrium subject to the CAR or NSFR.

Under the CAR or NSFR, I obtain the credit-creation-driven equilibrium. In such equilibria, banks creating credit and money play a dominant role in influencing the economy. In either equilibrium, I pay close attention to economic growth and financial stability (the debt ratio of firms). The economic growth rate is broken down into money creation processes: banks paying interest on deposits and lending under the regulation. Lending is determined by bank spreads or profitability. These findings point to a channel through which banks' ability to create credit and money influences equilibria. A firm's debt ratio is related to its animal spirits and the economy's growth rate. Firms borrow money when their animal spirits are greater than 0, and they go bankrupt when their animal spirits exceed the economy's growth rate. The conditions for borrowing and bankruptcy then become the boundary conditions for the equilibrium's existence. Finally, I draw policy implications from the growth rate and debt ratio responses to interest rate shocks and regulatory changes. Interest rate shocks influence the growth rate by influencing bank spreads, which influence lending. Concerning regulatory changes, strengthening the CAR or NSFR to reduce bank insolvency or liquidity risk will increase firm debt ratios and bankruptcy risk.

This paper suggests three promising future research directions. Firstly, firm behaviour can be described in greater depth. The investment functions presented by Nikiforos and Zezza (2017) and Nikolaidi and Stockhammer (2017) can be used to investigate how different investment decisions affect economic growth. Secondly, the model can be enriched by including the relationships between the parameters introduced under the regulations and interest rates. Such a model would then produce more diverse results. Thirdly, I hope my model can be used to assess other government policies, such as capital injections into banks and purchases of bank-held securities. These policies could be viewed as shocks to bank balance sheets. Thus, the policies would be described as changes in bank balance sheets, and the model would examine them.

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Appendix A

In the following, I derive the ratios of total income to PK, y^J; consumption to PK, c^J; the net worth of banks to PK, v_b^J; the quantity of money to PK, m^J; and the equities of firms to PK, e_f^J, in the capital regulatory equilibrium ($J = C$) and liquidity regulatory equilibrium ($J = L$).

The capital regulatory equilibrium. The solution for y^C is given by

$$y^C = \frac{1+\rho}{\rho \cdot \theta \cdot s_f\big((1-\theta)r_d - r_l\big)} [\theta \cdot r_l \cdot s_f((1-\theta)r_d - r_l) \\ -((1-\theta)r_d + \theta \cdot r_l \cdot s_f - r_l)((1-\theta)r_d + \theta \cdot \beta_0 - r_l)]. \tag{A1}$$

Recall that i^c is given by equation (41). Substitute equations (41) and (A1) into equation (23) to obtain the solution for consumption, c^C. The solution for v_b^C is

$$v_b^C = \frac{\theta^2 \cdot \beta_0}{r_l - (1-\beta_0)r_d}. \tag{A2}$$

Using equation (35) and the balance sheet identity of banks, $m = l - v_b$, one can obtain the solution for $m^C = ((1/\theta) - 1)v_b^C$. Finally, to obtain e_f^C, rearranging equation (28), I have

$$e_f = \frac{c - \alpha_1 \cdot \left(\frac{1}{1+\rho}\big(1 + (1-s_f)\rho\big) \cdot y - (1-s_f)r_l l + r_d m\right)}{\alpha_2} - m. \tag{A3}$$

Plugging the solutions for c^C, y^C, l^C, and m^C into equation (A3) yields e_f^C straightforwardly.

The liquidity regulatory equilibrium. The solution for y^L is

$$y^L = \frac{1+\rho}{s_f \cdot \rho(\eta-\tau)\big((1-\tau)r_l-(1-\eta)r_d\big)}[r_d(1-\eta)$$
$$\times\Big(r_d(1-\eta)-r_l\big(2(1-\tau)\big)+\beta_0(\eta-\tau)\Big)+r_l^2(1-\tau)(1-\tau) \tag{A4}$$
$$+r_l \cdot \beta_0(\eta-\tau)(s_f(\eta-\tau)+\tau-1)].$$

Using equation (54) and going through the same steps as when deriving c^C, I obtain c^L. The net worth of banks, v_b^L, is given by

$$v_b^L = \frac{\beta_0(\eta-\tau)^2}{(1-\tau)\big((1-\tau)r_l-(1-\eta)r_d\big).} \tag{A5}$$

Substituting the solution for v_b^L into equation (53) yields m^L. Finally, I obtain e_f^L by plugging the solutions for c^L, y^L, l^L, and m^L into equation (A3).

Appendix B

Here I discuss the equilibrium subject to the condition $\tau > \eta$. This condition indicates that the ASF factor for deposits is larger than the product of the minimum NSFR requirement and RSF factor for loans. Moreover, it implies that the ASF and RSF factors are larger than 1, $\tau > 1$ and $\eta > 1$. The equilibrium subject to $\tau > \eta$ is the mirror-symmetric counterpart of that subject to $\tau < \eta$. The insights obtained from the two equilibria are the same.

The growth rate of the economy is

$$g^L = r_d + \frac{(\tau-1)(r_l-r_d)}{\tau-\eta}. \tag{B1}$$

Because $r_l/r_d > 1$ and $(\eta-1)/(\tau-1) < 1$, I obtain

$$\frac{r_l}{r_d} > \frac{\eta-1}{\tau-1}. \tag{B2}$$

Then, $g^L > 0$. Meanwhile, the debt ratio of firms is

$$l^L = \frac{\beta_0(\tau - \eta)}{(\tau - 1)r_l - (\eta - 1)r_d.} \quad \text{(B3)}$$

There exists $l^L = \beta_0 / g^L$. These are the same as in the equilibrium subject to $\tau < \eta$.

Policy implications. Rearranging equations (60), (61), (62), and (63) yields the following:

$$\frac{\partial g^L}{\partial r_l} = \frac{\tau - 1}{\tau - \eta} > 0, \quad \text{(B4)}$$

$$\frac{\partial g^L}{\partial r_d} = -\frac{\eta - 1}{\tau - \eta} < 0, \quad \text{(B5)}$$

$$\frac{\partial l^L}{\partial r_l} = -\frac{\beta_0(\tau - \eta)(\tau - 1)}{\big((\tau - 1)r_l - (\eta - 1)r_d\big)^2} < 0, \quad \text{(B6)}$$

$$\frac{\partial l^L}{\partial r_d} = \frac{\beta_0(\tau - \eta)(\eta - 1)}{((\tau - 1)r_l - (\eta - 1)r_d)^2} > 0. \quad \text{(B7)}$$

As equations (B4), (B5), (B6), and (B7) show, under the condition $\tau > \eta$, the effects of interest rate shocks are the same as those subject to $\tau < \eta$.

Rearrange equations (64), (65), (66), and (67) to obtain

$$\frac{\partial g^L}{\partial \tau} = -\frac{(r_l - r_d)(\eta - 1)}{(\tau - \eta)^2} < 0, \quad \text{(B8)}$$

$$\frac{\partial g^L}{\partial \eta} = \frac{(r_l - r_d)(\tau - 1)}{(\tau - \eta)^2} > 0, \quad \text{(B9)}$$

$$\frac{\partial \epsilon^L}{\partial \tau} = \frac{\beta_0(r_l - r_d)(\eta - 1)}{\big((\tau - 1)r_l - (\eta - 1)r_d\big)^2} > 0, \quad \text{(B10)}$$

$$\frac{\partial \epsilon^L}{\partial \eta} = -\frac{\beta_0(r_l - r_d)(\tau - 1)}{\big((\tau - 1)r_l - (\eta - 1)r_d\big)^2} < 0. \quad \text{(B11)}$$

The preceding equations demonstrate that the effects of changes in the ASF factor for deposits, τ, and the product of the minimum NSFR requirement and RSF factor for loans, η, are sign-opposite to those subject to $\tau < \eta$. However, if $\tau < \eta$, from equations (52) and (53), increasing τ or decreasing η reduces the supply of credit and money. Thus, an increase in τ or decrease in η does in fact increase the stringency of the NSFR in terms of the effects on the supply of credit and money. As a result, strengthening the NSFR by increasing τ or decreasing η lowers the growth rate and raises the debt ratio. These findings are consistent with those subject to $\tau < \eta$.

Notes

1. For an exception, see Jakab and Kumhof (2015).
2. By raising loan rates or lowering deposit rates, banks can become more profitable. In this way, an increase in loan rates or a decrease in deposit rates boosts economic growth. As explained in Section 6, if the regulatory parameters are based on loan or deposit rates, an increase in loan rates or a decrease in deposit rates could result in slower growth rates.
3. The stringency of the regulations depends on the regulatory parameters. Increasing the minimum CAR requirement or risk-weight for loans increases the stringency of the CAR. Increasing the minimum NSFR requirement, raising the RSF factor for loans, or lowering the ASF factor for deposits increases the stringency of the NSFR.
4. My model abstracts from the effects of the regulations on bank behaviour when banks hold capital in excess of the regulatory minimums (e.g. for the CAR, $\theta \cdot l < v_b$). Beyond the bounds of this fundamental model are the analyses of these effects. To understand this issue, Borio and Zhu (2012) provide the key notions.

Table 1. *Balance-sheet matrix.*

		1	2	3	4
		Households	Firms	Banks	Sum
A	Physical capital		$+PK$		$+PK$
B	Deposits	$+M$		$-M$	0
C	Loans		$-L$	$+L$	0
D	Equities	$+E_f$	$-E_f$		0
E	Net worth	$-V_h$	$-V_f$	$-V_b$	$-PK$
F	Sum	0	0	0	0

Note: A positive sign $(+)$ before a magnitude denotes an asset, and a negative sign $(-)$ before a magnitude denotes a liability on rows A, B, and C or equities on row D.

Table 2. *Transaction-flow matrix.*

		1	2	3	4	5
			Firms		Banks	Sum
		Households	Current	Capital		
A	Consumption	$-C$	$+C$			0
B	Investment		$+I$	$-I$		0
C	Wages	$+W$	$-W$			0
D	Profits	$+F_d$	$-F$	$+F_r$		0
E	Interest on loans		$-r_l L$		$-(-r_l L)$	0
F	Interest on deposits	$+r_d M$			$-(+r_d M)$	0
G	Changes in loans			$+\Delta L$	$-(+\Delta L)$	0
H	Changes in deposits	$-\Delta M$			$+\Delta M$	0
I	Sum	0	0	0	0	0

Note: A positive sign (+) before a magnitude denotes a receipt or source of funds, and a negative sign (−) before a magnitude denotes a payment or use of funds. Moreover, on column 4, the negative signs (−) before the parentheses indicate the flows linked to the liability (deposits) of banks. In the parentheses, a positive sign indicates that banks create the money received by households or firms, whereas a negative sign demonstrates that banks destroy the money repaid by firms.