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The versatility of money multiplier under Basel III regulations[☆]

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ABSTRACT

The fractional reserve theory of money creation only considers the reserve requirement but ignores prudential regulations. We study the impacts of four prudential regulations under the Basel III framework on the commercial bank's ability to create money. Using a balance sheet approach, we formulate the corresponding maximum money multiplier under each regulation. We find that in addition to the concerned minimum required ratio, the banking system's liquidity and default risk portfolios also play key roles in determining the maximum money supply.

1. Introduction

Recent financial crises have reignited heated discussions about the role of banks in money creation (Werner, 2014; Ábel et al., 2016; Keen, 2010). The textbook model of money creation is the fractional reserve theory (FRT). In this theory, individual banks are financial intermediaries between depositors and debtors and their lending ability is constrained by their deposits and the reserve requirement. Because the required quantity of reserves is a fraction of the total deposits, the banking system as whole can magnify the monetary base by a constant money multiplier, which is usually expressed as the inverse of the required reserve ratio in its simplest form.

Despite the wide acceptance of the FRT, there is growing consensus that commercial banks are not simply intermediators of money, but are creators of credit (Werner, 2014). According to the official bulletin of the Bank of England (McLeay et al., 2014), commercial banks making loans is the principal means of creating money in the modern economy. Whenever a bank makes a loan, it simultaneously creates a matching deposit in the borrower's bank account. Each individual bank does not pass on deposits or reserves into its lending but creates loans out of nothing. Thus bank lending is not determined by pre-existing amount of deposits or reserves, but depends on the profitability of this loan and the banking regulations to which the bank is subject (Goodhart, 2010).

Among the concerned regulations faced by commercial banks, we argue that the reserve requirement has become a less important constraint while prudential regulations affect bank's credit supply in a much more targeted fashion. Many advanced economies do not have reserve requirement, such as the UK, Canada and Australia. Regardless, for countries that do retain this policy, banks can always

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Table 1
Balance sheet for a representative commercial bank.

Asset	Liability
Reserves (R)	Deposits (D)
Loans (L)	Equities (E)

make loans first and fulfill the reserve requirement later by borrowing from the interbank market or directly from the central bank (Fullwiler, 2012). On the other hand, prudential regulations became much more rigid after recent financial crises. Unlike the reserve requirement which focuses only on the reserve holdings, prudential regulations limit bank lending and the money supply based on the sufficiency of banks' liquidity and capital positions against maturity mismatch and default loss (Li et al., 2017). Despite the extensiveness of the literature on the macroeconomic impacts of prudential regulations, there are few studies on their roles in the money creation process.

To fill in this knowledge gap, we take the Basel III accord as the representative framework for prudential regulations and examine its impact on commercial banks' ability to create money.

2. The balance sheet approach

A bank's balance sheet reflects its current financial condition. Banking regulations are usually based on the minimum ratios related to the items of bank balance sheet. To elaborate the roles of commercial banks in the money creation process and their behaviors under different regulations, we propose here a simple balance sheet approach.

We consider a representative commercial bank with a simplified balance sheet as shown in Table 1.

There are two types of assets: reserves (R) with high liquidity and zero risk, and loans (L) with low liquidity and a risk weight of γ. On the liability side, there are deposits (D) and equities (E).[1] To make the balance sheet even,

$$R + L = D + E. \tag{1}$$

Assuming no cash is held by the public, we have the monetary base equal to the amount of reserves, i.e., $MB = R$ and the broad money supply equal to the amount of deposits, i.e., $M = D$. Thus the corresponding money multiplier is

$$m = \frac{D}{R}. \tag{2}$$

When a loan is made (repaid), there is an identical and simultaneous increase (decrease) in the stocks of loans and deposits. Driven by profits, the banking system is inclined to increase lending regardless of the underlying risks. Unlike the fast and easy expansion of loans and deposits, increases in reserves and equities are much slower and more dependent on external forces.[2] For simplicity, we assume R and E are exogenously given and

$$E = e^{*}R, \tag{3}$$

where e is the equity-to-reserve ratio and $e > 0$.

As an example for the balance sheet approach, we demonstrate here how the reserve requirement limits money creation. Denoting the actual reserve ratio as r and the required reserve ratio as $r_{\min}$, then the central bank requires that

$$r = \frac{R}{D} \geq r_{\min}. \tag{4}$$

We force (4) to take equality and combine it with (2) to derive at the maximum money multiplier under reserve requirement,

$$m_{RR} = \frac{1}{r_{\min}}. \tag{5}$$

Note that m_{RR} is obtained when the banking system reaches its maximum capacity of credit creation given the required reserve ratio $r_{\min}$. The maximum money multiplier is a regulation specific concept which is equal to the actual money multiplier only when the concerned regulation is the most rigid constraint. We next use this approach to derive at the corresponding formulas of maximum money multiplier for the following three Basel III regulations.

3. Money multiplier under Basel III regulations

The purpose of the Basel III accord is to reduce banks' risk exposure and improve financial stability (BCBS, 2010). It introduces minimum requirements for the liquidity coverage ratio and the net stable funding ratio to enhance the liquidity position of the bank, requires an increase in the risk-based capital adequacy ratio to ensure adequate holdings of bank equities against solvency risk, and

[1] We assume all equities qualify Tier 1 capital defined in Basel III.

[2] Total reserves are ultimately determined by the central bank while the increase of bank equities requires issuing more shares or keeping more retained earning.

imposes a minimum requirement for the leverage ratio to restrict the build-up of excessive leverage.

3.1. Liquidity coverage ratio (LCR)

The LCR regulation requires banks to hold sufficient unencumbered high liquid assets (*HQLA*) that can cover the expected net cash outflows (*NCOF*) during a 30-calendar-day liquidity stress scenario (BCBS, 2013). We compute the actual LCR from the bank's balance sheet and denote the minimum requirement as $LCR_{\min}$ and the actual ratio as *LCR*.

Because the only qualified high quality liquid asset in our model is reserves, we have

$$HQLA = R. \tag{6}$$

On the other hand, Basel III defines

$$NCOF = OF - min\{IF, 0.75OF\}, \tag{7}$$

where *OF* is the total expected cash outflows and *IF* is the total expected cash inflows. In our case, *OF* is equal to the deposit loss with an expected run-off ratio of μ ($\mu \in (0, 1]$) during a 30-day horizon, i.e.,

$$OF = \mu D. \tag{8}$$

On the other hand, *IF* is computed as the total amount of repayments (*RP*) that are performing and contractually maturing for the given time period with a discount of 50% due to the stressed scenario hypothesis, as given by

$$IF = 0.5RP. \tag{9}$$

Suppose *RP* is proportional to the outstanding loans with a rate of λ ($\lambda \in (0, 1]$), we can rewrite (9) as

$$IF = 0.5\lambda L. \tag{10}$$

To comply with LCR regulation, the actual LCR of the bank should be no less than the minimum requirement, i.e.

$$LCR = \frac{HQLA}{NCOF} = \frac{R}{OF - min\{IF, 0.75OF\}} \geq LCR_{\min}. \tag{11}$$

With a few manipulations,[3] we can obtain the maximum money multiplier under the LCR regulation as follows:

$$m_{LCR} = \begin{cases} \frac{4}{\mu LCR_{\min}}, & \lambda \leq 1.5\mu,\ e > A,\ \ or\ \lambda > 1.5\mu,\ e \geq 1; \\ \frac{\lambda(1-e)}{\lambda - 1.5\mu}, & \lambda < 1.5\mu,\ 1 < e < A,\ \ or\ \lambda > 1.5\mu,\ A \leq e < 1; \\ \frac{\lambda(1-e)LCR_{min} + 2}{(2\mu - \lambda)LCR_{min}}, & \lambda \leq 1.5\mu,\ B < e \leq 1,\ \ or\ 1.5\mu < \lambda < 2\mu,\ B < e < A, \end{cases} \tag{12}$$

where $A = 1 - \frac{4\lambda - 6\mu}{\mu\lambda LCR_{\min}}$, $B = 1 - \frac{2}{\lambda LCR_{\min}}$.

Correspondingly, the dependence of the maximum money multiplier on corresponding parameters can be analysed, the results of which are listed in Table 2.

3.2. Net stable funding ratio (NSFR)

While both the LCR and the NSFR regulation focus on liquidity risks, the latter aims to reduce funding risk within a longer time horizon. The NSFR is the ratio of the amount of available stable funding (ASF) to the required amount of stable funding (RSF). The ASF is measured as the weighted sum of the bank's sources of funds which differ in terms of stability during stressed times. In principle, higher weight is assigned to more stable funding source. Therefore, assuming that the ASF weights for bank equity and deposits are respectively 100% and β ($\beta \in (0, 1]$), we have

$$ASF = E + \beta D. \tag{13}$$

Similarly, the RSF is measured as the weighted sum of the bank's uses of funds, which reflects the expected exposure of asset loss.[4] Each type of assets is assigned with an RSF weight, while higher weights are given to assets with higher liquidity risk. Suppose the RSF weight is $\epsilon(\epsilon \in (0, 1])$ for loans and 0% for reserves. The expression for RSF is then given by

$$RSF = 0{*}R + \epsilon{*}L = \epsilon L. \tag{14}$$

Denoting $NSFR_{\min}$ as the minimum regulatory requirement and *NSFR* as the actual ratio of the bank, it is required by the NSFR regulation that

$$NSFR = \frac{ASF}{RSF} = \frac{E + \beta D}{\epsilon L} \geq NSFR_{min}. \tag{15}$$

Likewise, the maximum money multiplier under the NSFR regulation can be obtained as follows:

[3] Proof details are shown in the appendix.

[4] Here we do not consider off-balance sheet risk exposures.

Table 2
Dependence of the maximum money multiplier on corresponding parameters .

Expression of m_{LCR}	$LCR_{\min}$	λ	e	μ
$\frac{4}{\mu LCR_{\min}}$	−	NA	NA	−
$\frac{\lambda(1-e)}{\lambda-1.5\mu}$, if $\lambda < 1.5\mu$, $1 < e < A$	NA	+	+	+
$\frac{\lambda(1-e)}{\lambda-1.5\mu}$, if $\lambda > 1.5\mu$, $A \le e < 1$	NA	−	−	−
$\frac{\lambda(1-e)LCR_{\min}+2}{(2\mu-\lambda)LCR_{\min}}$	−	+	−	−

"+" denotes positive dependence of m_{LCR} on the corresponding parameter. "−" denotes negative dependence of m_{LCR} on the corresponding parameter. "NA" means not applicable.

$$m_{NSFR} = \frac{e + \epsilon NSFR_{min}(1-e)}{\epsilon NSFR_{min} - \beta}, \tag{16}$$

where $\beta < \epsilon NSFR_{\min}$.[5]

As indicated by (16), m_{NSFR} depends positively on e and β while being negatively dependent on $NSFR_{\min}$ and ϵ.

3.3. Risk-based capital adequacy ratio (CAR)

The CAR is defined as the ratio of the bank's equity holdings to the total risk-weighted assets, denoted as RWA. Suppose that the risk weight of reserves is zero and that of loans is γ ($\gamma \in (0, 1]$). The mathematical expression for RWA can be given by

$$RWA = \gamma^* L + 0^* R = \gamma L. \tag{17}$$

Thus banks in conformity with the CAR regulation must satisfy

$$CAR = \frac{E}{RWA} = \frac{E}{\gamma L} \ge CAR_{\min}, \tag{18}$$

where CAR and $CAR_{\min}$ respectively denote the actual CAR and the minimum requirement.

When (18) takes identity and is combined with (1) and (2), the maximum money multiplier under CAR requirement can be obtained,

$$m_{CAR} = 1 + e\left(\frac{1}{\gamma CAR_{\min}} - 1\right). \tag{19}$$

From (19), it can be inferred that m_{CAR} is an increasing function of e and a decreasing function of $CAR_{\min}$ and γ.

3.4. Leverage ratio (LR)

The leverage ratio (LR) is the ratio between bank equity and total assets (TA). The actual leverage ratio LR should be no less than the required ratio $LR_{\min}$, i.e.,

$$LR = \frac{E}{TA} \ge LR_{min}, \tag{20}$$

where $TA = L + R$.

Likewise, the corresponding maximum money multiplier under the LR regulation is

$$m_{LR} = e\left(\frac{1}{LR_{\min}} - 1\right). \tag{21}$$

From (21), we conclude that m_{LR} decreases as $LR_{\min}$ increases, and increases as e increases.

4. Conclusion

We have shown that both the reserve requirement and prudential regulations affect money creation. By expressing the maximum money multiplier as a function of the minimum required ratio of each regulation and the parameters related to banks' liquidity and equity positions, we find that the commercial bank can create more money when the binding regulation is loose, or when the bank maintains a robust balance sheet structure with less maturity mismatch, high equity position and low risks of funding and asset loss. The versatility of the maximum money multipliers under different regulations provides an explanation alternative to the FRT for the

[5] Note that the NSFR regulation poses no constraint on money creation when $\beta \ge \epsilon NSFR_{\min}$, because the stability of deposits is higher than that of loans under this condition.

unexpected empirical facts that increases in total reserves did not "multiple up" to bigger changes in the broad money supply but may result in the decrease of the actual money multiplier, as exemplified by what happened in the U.S. and Europe after the implementation of the quantitative easing policy during recent crises (Carpenter and Demiralp, 2012).

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Appendix A

We derive at the expression for the maximum money multiplier under the LCR regulation by taking three steps: 1) rewrite Inequation (11) as a function of the money multiplier m; 2) derive at the range of m under the corresponding condition; 3) summarize the expression for the maximum money multiplier m_{LCR}.

Step 1

Inequation (11) can be expanded to two sets of conditions:

$$\begin{cases} IF > 0.75OF; \\ \frac{R}{0.25OF} \geq LCR_{min}, \end{cases} \tag{A.1}$$

or

$$\begin{cases} IF \leq 0.75OF; \\ \frac{R}{OF - IF} \geq LCR_{min}. \end{cases} \tag{A.2}$$

Substituting IF and OF with their corresponding expressions in (8) and (10), replacing L with $D + E - R$, dividing both sides by D and replacing $\frac{R}{D}$ with m, we can rewrite the above two conditions as follows:

$$\begin{cases} (\lambda - 1.5\mu)m > \lambda(1 - e); \\ m \leq \frac{4}{\mu LCR_{min}}, \end{cases} \tag{A.3}$$

or

$$\begin{cases} (\lambda - 1.5\mu)m \leq \lambda(1 - e); \\ (\lambda - 2\mu)m \geq \frac{\lambda(1 - e)LCR_{min} - 2}{LCR_{min}}. \end{cases} \tag{A.4}$$

Step 2

From (A.3), we can obtain the corresponding value range for the money multiplier as follows:

$$\begin{cases} m \leq m_1, & \lambda \leq 1.5\mu,\ e > A; \\ m < m_2, & \lambda \leq 1.5\mu,\ e \leq A; \\ m_2 < m \leq m_1, & \lambda > 1.5\mu,\ e > A; \\ m \in \varnothing, & \lambda > 1.5\mu,\ e \leq A, \end{cases} \tag{A.5}$$

where $m_1 = \frac{4}{\mu LCR_{\min}}$, $m_2 = \frac{\lambda(1 - e)}{\lambda - 1.5\mu}$, $A = 1 - \frac{4\lambda - 6\mu}{\mu\lambda LCR_{\min}}$.

Similarly, the corresponding constraint on the money multiplier inferred from (A.4) is given by

$$\begin{cases} m_2 \leq m \leq m_3, & \lambda < 1.5\mu,\ e < A; \\ m \leq m_2, & 1.5\mu < \lambda \leq 2\mu,\ e \geq A; \\ m \leq m_3, & 1.5\mu \leq \lambda < 2\mu,\ e < A; \\ m_3 \leq m \leq m_2, & \lambda > 2\mu,\ e \geq A; \\ m \in \varnothing, & \lambda < 1.5\mu,\ e \geq A,\ or\ \lambda > 2\mu,\ e < A, \end{cases} \tag{A.6}$$

where $m_3 = \frac{\lambda(1 - e)LCR_{\min} + 2}{(2\mu - \lambda)LCR_{\min}}$.

Step 3

We focus only on the maximum constraint on the money multiplier instead of the minimum, because banks have the incentives to create more credit to gain profits from the interest spreads between loans and deposits, which makes it natural for the overall money creation approaching to the upper limit. Therefore, the expression for the maximum money multiplier under the LCR regulation, m_{LCR}, can be obtained from (A.5) for the condition of $IF > 0.75OF$, as given by

$$\begin{cases} m_{LCR} = m_1, \quad e > A; \\ m_{LCR} = m_2, \quad \lambda \leq 1.5\mu, \quad e \leq A. \end{cases} \tag{A.7}$$

Similarly, when $IF \leq 0.75OF$, the maximum money multiplier under the LCR regulation can be expressed as

$$\begin{cases} m_{LCR} = m_2, \quad \lambda > 1.5\mu, \; e \geq A; \\ m_{LCR} = m_3, \quad \lambda < 2\mu, \quad e < A. \end{cases} \tag{A.8}$$

Considering the fact that the maximum money multiplier should always be positive, the conditions in (A.7) and (A.8) should be further reduced so that the expressions m_{LCR} are rewritten as follows:

$$\begin{cases} m_{LCR} = m_1, \quad e > A; \\ m_{LCR} = m_2, \quad \lambda \leq 1.5\mu, \quad e \leq A. \end{cases} \tag{A.9}$$

Similarly, when $IF \leq 0.75OF$, the maximum money multiplier under the LCR regulation can be expressed as

$$\begin{cases} m_{LCR} = m_2, \quad \lambda > 1.5\mu, \; A \leq e < 1; \\ m_{LCR} = m_3, \quad \lambda < 2\mu, \quad B < e < A, \end{cases} \tag{A.10}$$

where $B = 1 - \frac{2}{\lambda LCR_{\min}}$.

Further, to obtain the final expression for m_{LCR}, we synthesize the conditions in (A.9) and (A.10), and use the expression for m_{LCR} with the minimum value as the final expression if the corresponding conditions overlap with each other. The final results can be shown as follows:

$$m_{LCR} = \begin{cases} \frac{4}{\mu LCR_{\min}}, \quad \lambda \leq 1.5\mu, \; e > A, \quad or \; \lambda > 1.5\mu, \; e \geq 1; \\ \frac{\lambda(1-e)}{\lambda - 1.5\mu}, \quad \lambda < 1.5\mu, \; 1 < e < A, \quad or \; \lambda > 1.5\mu, \; A \leq e < 1; \\ \frac{\lambda(1-e)LCR_{min} + 2}{(2\mu - \lambda)LCR_{min}}, \quad \lambda \leq 1.5\mu, \; B < e \leq 1, \quad or \; 1.5\mu < \lambda < 2\mu, \; B < e < A. \end{cases} \tag{A.11}$$

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