Contents

1 Introduction

In response to the excessive build-up of risk leverage and the insufficient holdings of liquidity buffer of the banking sector prior to the Global Financial Crisis, the Basel Committee on Banking Supervision (BCBS) had designed a package of reforms under the amendment Basel III. Based on the three-pillar approach of Basel II[1], Basel III includes tighter rules on capital and liquidity as "the Basel III reforms are central to promoting financial stability" (Walter, 2011). Among this set of rules, the Basel Committee strengthens the quantity and quality of the capital base, complements risk-sensitive measures implemented under Basel I and Basel II with a leverage ratio (LR) and introduces two liquidity standards, namely the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR). While the effectiveness of Basel III in achieving its primary goal of financial stability remains a debate of on-going research, we question the fundamental role of this new regulatory regime in promoting bank lending and strengthening the funding structure of the bank. The objective of this paper is twofold: First, we examine the effects of implementing capital and liquidity rules on bank lending in order to raise the key implications of a regulatory environment both capital and liquidity driven such a Basel III on bank lending behaviour. Second, we analyse the impact of this new regulatory environment on the composition of the liabilities of the bank as one objective of Basel III is to promote the adequate funding structure of the banking sector.

Analysing the impact of International Regulatory Standards on bank lending is not new. A large stream of literature supporting the effectiveness of the 1988 Basel Capital Accord shows that banks adopted different strategies to comply with the so-called "Cooke ratio"[2]. The tightening of capital requirements as implemented under Basel III suggests similar strategies[3]. Cohen & Scatigna (2016) show that banks from advanced economies

[1] Basel II, fully effective in 2008, adopted a three-pillar approach to promote financial stability. These three pillars were "Capital Requirements", "Supervisory Review" and "Market Discipline".

[2] The Cooke-ratio, named after one of the past Chairs of the Basel Committee Peter Cooke, defines the first international capital-adequacy standard. Banks were required to hold a minimum capital-to-risk-weighted-asset ratio of 8%. For a complete review on bank strategies, see Jackson et al. (1999) and BCBS (2016)

[3] Note that we do not mention the literature on the effects of the Basel II regulatory regime on bank lending as the main body of research on this topic focuses on the procyclical character of this regulation.

comply with the Basel III capital requirements through the accumulation of retained earnings and to a lesser extent, shifting to assets with lower risk weights. Cosimano & Hakura (2011) examine the impact of the Basel III capital standards on lending rates and growth. They find that a tightening of capital requirements gives incentives to banks to increase lending rates causing a slowdown in credit supply. This stream of literature remains focused on the effects of capital requirements on bank lending behaviour. However, as documented in BCBS (2016) : "Liquidity requirements can affect banks through several channels". For example, King (2013) disentangles the different banks' strategies to meet the NSFR. Among these strategies, the bank is able to shrink the size of the portfolio of loans (downsizing) or substitute them for more liquid assets (portfolio-shift) modifying thus the composition of their assets and bank lending. Gobat et al. (2014) examine the impact and issues raised by the implementation of such a ratio for a large panel of banking systems. They also highlight the potential adverse effect of the NSFR on bank lending especially for large Domestic Systemically Important Banks D-SIBS. Using banks' balance-sheet data, Banerjee & Mio (2017) study the impact of the Individual Liquidity Guidance– a liquidity ratio close to the LCR– on the UK banking sector. They find that banks did not shrink the size of their balance-sheet but rather modify its composition without causing deleterious effects on bank lending. These types of adjustments were already performed under Basel I when no liquidity standard were set-up suggesting that capital and liquidity requirements may produce similar bank balance-sheet adjustments and thus, have common implications for bank lending behaviour.

To our knowledge, the literature examining the effects of liquidity standards on bank behaviour remains relatively sparse due to the fact that liquidity standards set at international level has been mainly motivated since the implementation of Basel III[4]. We contribute to this emerging literature by developing a theoretical model of bank behaviour subject to capital and liquidity regulatory constraints. Our objective is to examine the key implications of a regulatory framework *à la* Basel III, i.e. a regulatory framework

Analysing such aspect of banking regulation is beyond the scope of this paper.

[4]Note that the Basel Committee published "Sound Practices for Managing Liquidity in Banking Organisations" in 2000. However the unprecedented liquidity crisis experienced by the banking sector in 2008 urged for a better liquidity regulation.

both capital and liquidity driven on bank behaviour. Our model is derived from Ito & Sasaki (1998). These authors investigate the impact of the adoption of the first Basel Capital Accord on Japanese banks' behaviour for the period 1990-1993. In particular, they find that banks tended to issue more subordinated debts and to reduce lending following the decrease in the Nikkei index in order to comply with the Basel Capital ratio. However, as international liquidity requirements were not in place at that time, the model does not provide banks' lending implications when implementing an additional regulatory tool such as liquidity requirements. Nevertheless, the role of these last should not be undermined as an emerging body of literature shows that liquidity requirements modify the composition of banks' balance-sheet and thus have effects on bank behaviour. As a result, further investigation on the impact of a regulation both capital and liquidity driven on bank behaviour is needed.

The remainder of this paper is organised as follows: Section 2 describes the model and Section 3 concludes.

2 The Model

We develop a theoretical model of banks' behaviour drawn upon Ito & Sasaki (1998). Their model is suitable to depict and understand banks' behaviour under Basel I and Basel II as the microprudential structure of these two regulatory regimes is capital driven. However, the introduction of liquidity requirements under Basel III questions the implications of a micro-prudential regulatory structure both capital and liquidity driven on bank behaviour. Our contribution is adding liquidity requirements to the model of Ito & Sasaki (1998) in order to assess the effects of such a new regulatory structure on bank behaviour plus modelling the Risk-Weighted-Asset (RWA) metrics designed under Basel II and Basel III.

2.1 The Bank Business Model

We assume the bank buys credits to households and firms whether retail, commercial, wholesale or universal banks[5]. Investment banks are not considered as they do not distribute credits and are involved in financial activities such as trading and mergers and acquisitions (M&As). We depict these credits as mortgage, credit cards or commercial loans which are defined through a unique loan portfolio held by the bank. The credit risk related to these loans plays a central role in the model as we focus on the credit activity of the bank. For the sake of simplicity, we consider the bank is government-bond buyer on capital market. Thus, the market risk is nil because government bonds are risk-free assets in the model. We propose this simple bank investment decision problem for two reasons. First, as one of our objective is to study the impact of capital and liquidity rules on the asset composition of the bank, we reduce the bank investment decision problem to two dual assets, one risky asset (loans) for which the bank has to provide sufficient capital and liquidity coverages and one risk-free asset (government bonds) requiring neither capital nor liquidity coverage. Second, defining a risky market portfolio induces introducing additional hypotheses in the model while our research question remains the same. We choose to keep the simplified version following somewhat Ockham's razor spirit even if a more general specification including market risky securities could be developed.

We assume Capital K, Subordinated Debts R and Customer Deposits D funds Loans L and Government Bonds B, where K represents the shareholder's equity issued by the bank. The maturity of capital is infinite and thus greater than the subordinated debt maturity which consists of long to medium term bonds issued by the bank. Finally customer deposits is a resource comprising both *non-maturity deposit and term deposit*. In sum, the activity of the bank consists of buying a portfolio of loans L and government bonds B, selling capital K, subordinated debt R and customer deposits D.

[5]Following Freixas & Rochet (2008), we define the bank as a financial intermediary buying and selling financial claims. In particular, we consider the bank funds its lending and market activities through the selling of financial liabilities.

We depict the balance-sheet of the bank as follows:

Assets			Liabilities
L	Loans	Capital	K
		Subordinated Debts	R
B	Government Bonds	Customer Deposits	D

We consider the loan activity of the bank as the main source of illiquidity. The portfolio of government bonds defines the total amount of liquid assets the bank can buy. Finally, capital, subordinated debts and customer deposits define the sources of available funding the bank disposes for covering the funding risk induced by the credit activity. The loan decision process of the bank is characterised by the parameter $0 < \theta \leq 1$ which is the risk default on loan and the return r_L at which the bank charges the loan. Therefore, the product θL defines the credit risk the bank is willing to bear on the loan activity. Assuming a competitive loan market environment, the bank has to decrease the loan interest rate in order to raise the volume of loans bought by one unit setting $r'_L(L) < 0$[6] .

The introduction of the parameter θ allows us to better account for the aggregate risk related to the bank lending activity. An exogenous shock may indeed increase the overall credit risk as it has been the case in 2008. This risk parameter is necessary to measure the credit risk assessed in the requirement ratios. The market activity of the bank consists of buying a risk-free portfolio of bonds, typically high-graded government bonds excluded from the regulatory risk-asset base given a risk-free rate r_B. Thus, the portfolio of loans defines the total asset risk-exposure of the bank since the market-risk is nil in the model. We suppose the bank takes as given the rate r_K at which it issues capital because investors benefit from perfect information on capital market and thus, are perfectly able to assess the cost of equity r_K of the bank. As a result, the rate r_K is investor-driven, not bank-driven. On the other hand, the bank can increase its capital

[6] Assumptions on the second derivative of the interest rates will be discussed later on.

base by raising R. We assume the bank sells more subordinated debts as it raises its attractiveness via r_R implying $r'_R(R) > 0$.

2.2 Regulatory Requirements

The Basel III measures aim at providing a " global regulatory framework for more resilient banks and banking systems" BCBS (2010). Reforming the Basel II Accords was about " strengthening the global capital framework" and "introducing a global liquidity standard" (*ibid.*). The introduction of liquidity requirements is the most significant change in the regulatory framework and is a direct consequence of the liquidity crisis faced by the banking industry in 2008 when the subprime mortgage crisis triggered. The theoretical approach we use underlines the impact of these new liquidity requirements both on bank lending and liability composition. In view of this, we propose to transpose the Basel III regulatory ratios.

2.2.1 The Capital Requirement Ratio (CRR)

Due to the insufficient build-up of capital coverage during the financial crisis, the Basel Committee proposed to tighten the definition of capital under Basel III. The bank regulatory capital base has been classified into two categories denominated "Tier". We define K as Tier 1, the best-quality capital which includes Common Equity Tier 1 Capital (CET1) and Additional Tier 1 Capital (AT1). The liability R is defined as Tier 2 with a lower Risk Absorbing Capacity (RAC)[7]. The regulatory capital of the bank is thus equal to $(K+R)$. The Basel III Total Capital Ratio (TCR) is the sum of Tier 1 and Tier 2 (Capital plus Subordinated Debts) and complemented regarding the bank asset risk-exposure:

$$\text{TCR} = \frac{\text{Regutatory capital}}{\text{Risk-weighted assets}}$$

RWAs are the sum of the risks incurred by the bank. They consist in credit risk, market risk, and operational risk. Since both market and operational risk are nil in our model, the TCR can be rewritten as follows:

[7]Note that Tier 3 aiming at covering the market risk under Basel II has been removed in Basel III.

$$CRR = \frac{(K+R)}{\theta L} \tag{1}$$

CRR defines the total amount of capital available to the bank to cover the credit risk and corresponds to the Basel III Total Capital Ratio. The CRR we propose differs from the capital ratio standard developed by Ito & Sasaki (1998) to the extent that we introduce the parameter θ. However, the two regulatory ratios are similar for $\theta = 1$[8]. The credit risk θL is a positive linear function of L and is measured in units of currency as it is the case for the Value-at-Risk (VaR) which is used to assess RWAs under Basel II and Basel III. This metric is consistent with the underlying logic of VaR "which is a lower tail percentile for the distribution of profit and loss (P&L)" (Berkowitz & O'Brien, 2002). All things being equal, the higher the aggregate risk related to banks' lending activity, the higher the credit risk. Similarly, the higher the volume of loans bought by the bank, the higher the credit risk[9]. This phenomenon complies with Samuelson's "fallacy of large numbers" (Samuelson, 1963) since the "maximum loss" increases with the size of the portfolio of loans.

2.2.2 The Liquidity Requirement Ratio (LRR)

In addition to strengthening the global capital framework, the Basel Committee designed a new liquidity framework as the banking sector failed to enter the financial crisis with adequate liquidity buffers. More specifically, the Basel Committee emphasised on the need for a better liquidity risk management and published in 2008 "Principles for Sound Liquidity Risk Management and Supervision" which has been complemented by the introduction of two minimum liquidity regulatory standards under "Basel III: International framework for liquidity risk measurement, standards and monitoring" in 2010. While the LCR is designed to improve the short-term resilience of the banking sector to meeting liquidity obligations for 30 days, the NSFR requires to meet funding obligations under a time horizon of one year. This last is designed to promote sustainable sources of funding

[8] Ito & Sasaki (1998) add the term *fukumi* to the book value of shareholders' equity which is equivalent to mark-to-market valuation.

[9] If the aggregate risk for loans was nil, the VaR would equal zero and thus $\theta = 0$. The market risk is nil in the model as the bank buys risk-free bonds which is equivalent to a zero VaR within the Basel framework.

when banks perform maturity transformation activities such as credit origination. As a result, we choose to model a liquidity ratio close to the NSFR because "Maturity transformation performed by banks is a crucial part of financial intermediation that contributes to efficient resource allocation and credit creation." (BCBS, 2014). Moreover, we choose to characterise the liquidity aspect of our regulatory environment with the quality of the funding stability the banking sector might produce because as referenced in EBA (2015), the NSFR " is needed in addition to the solvency requirements (capital and leverage ratio) and the LCR, because these existing requirements miss important aspects of structural funding stability." Finally, it is more convenient to distinguish stock measures from flow measures. Therefore, we characterise the regulatory environment with stock measures only. We contribute to the emerging literature by modeling a funding requirement ratio close to the NSFR in order to assess to what extent the adoption of this ratio modifies the funding risk structure of the bank and thus ensures the primary goal of financial stability as set under Basel III. As defined by (BCBS (2014), p.2): "The NSFR is defined as the amount of available stable funding relative [AASF] to the amount of required stable funding [RASF]. This ratio should be equal to at least 100 % on an on-going basis. "Available stable funding" is defined as the portion of capital and liabilities expected to be reliable over the time horizon considered by the NSFR, which extends to one year. The amount of stable funding required is function of the liquidity characteristics and residual maturities of the various assets held by the bank as well as those of its off-balance sheet (OBS) exposures".

The liabilities taken into account to assess the available stable funding (ASF) are weighted using an ASF factor which is between 100 % (e.g. for Tier 1 liabilities and Tier 2 liabilities with a maturity above one year) and 0 %. Symmetrically, the assets taken into account to assess the required stable funding (RSF) are weighted using an RSF factor which is between 0 % (e.g. for central bank reserves and risk free securities) and 100 % e.g. for "all assets that are encumbered for a period of one year or more" (BCBS (2014), p.11). The NSFR can thus be defined as follows:

$$NSFR = \sum_i \frac{L_i \times ASF_i}{A_i \times RSF_i}$$

Where: L_i is the total amount of liabilities which belongs to the category i defining an ASF factor of ASF_i, and A_i is the total amount of assets belonging to the category i defining an ASF factor of RSF_i. Based on this definition, we can write the equivalent of the NSFR ratio in our model. Both K (Tier 1) and R (Tier 2) receive an ASF factor of 100 %. Deposits which are composed of term and non-maturity customer deposits define and ASF factor of 95 % or 90 % under the Basel III framework. For the sake of simplicity we also consider an ASF factor of 100 % for D. As a consequence, $AASF$ equals $(K + R + D)$ in the model. RASF induced by the banking activity are related to each asset held by the bank. Since the market risk is nil for the government bonds B, they define a 0% RSF-factor. Loans have a credit risk parameter equals to θ. Following the Basel III principle that the higher the risk, the higher the RSF factor we assume that loans L receive a RSF factor of θ. The assets with the highest VAR also have a high level of required stable funding: such as the unencumbered residential mortgages (65 % RSF factor) and the other unencumbered performing loans (85 % RSF factor)[10]. This symmetry is respected in our model where the credit risk is set equal to the requirement amount of stable funding for loans.

Applying the former NSFR formula to the model, we obtain the following liquidity requirement ratio:

$$LRR = \frac{(K \times 1) + (R \times 1) + (D \times 1)}{(L \times \theta) + (B \times 0)}$$

LRR measures the total amount of available funding (total capital plus deposits) the bank disposes of to cover the funding risk induced by the credit activity and can be rewritten as follows:

$$LRR = \frac{(K + R + D)}{\theta L} = CRR + \frac{D}{\theta L} \tag{2}$$

Note that CRR and LRR are not orthogonal by construction and modify the funding

[10] BCBS (2014), p.11

choice structure of the bank: a rise in CRR implies a rise in LRR while a rise in LRR does not necessarily entail a rise in CRR. More specifically, raising R increases both CRR and LRR while increasing D only improves LRR. Even though Regulatory Authorities introduce an incentive to raise deposits via the funding requirement, the liability structure of the bank remains capital driven under a regulatory environment *à la* Basel III because the bank has an incentive to raise R at the expense of D. As a result, we question the efficacy with which such a type of regulatory environment strengthens the liability structure of the bank.

2.3 Bank Behaviour under a Regulatory Regime *à la* Basel III

To analyse the behaviour of the banking firm under Basel III, we consider a representative bank seeking to maximise its profits under a capital and liquidity constrained environment. The constraints the regulatory authorities implement take the form of incentives and specifically ratios the bank is expected to comply with. These ratios are central to the bank decision process since the bank use them as indicators of profitability. Ito & Sasaki (1998) assume that "the cost of the [regulatory capital] ratio is reduced as the ratio increases while its rate of change is diminished or constant; ($C' < 0$, $C'' \geq 0$). It means that banks with a low [regulatory capital] ratio can improve profit more by raising the ratio than banks with a high [regulatory capital] ratio" (Ito & Sasaki (1998), p.15). We define L and R among the bank decision variables of the profit maximisation problem as in Ito & Sasaki (1998). However, deposits D becomes central within our bank decision problem because the NSFR is designed to give incentives to the bank to fund its business activities with stable sources of funding such as customer deposits: " The second objective is to promote resilience over a longer time horizon by creating additional incentives for a bank to fund its activities with more stable sources of funding on an ongoing structural basis. The Net Stable Funding Ratio (NSFR) has a time horizon of one year and has been developed to provide a sustainable maturity structure of assets and liabilities " (BCBS (2010), p.9). As a result, we define the deposit endogeneization of our bank decision problem as regulatory-induced. To picture the importance of collecting deposits, we set the following assumption on customer deposits: $r'_D(D) > 0$, meaning the bank raises more customer deposits when increasing its return.

We define the profits of the bank, denoted Π as the sum of its revenues on credit and market activity net of the costs on capital, subordinated debts, deposits and net of the costs induced by the regulation. Increasing the volume of loans bought is costly $C'_L > 0$ as the regulatory ratios of the bank are lower reducing thus its ability to cover capital and liquidity losses ceteris paribus. On the other hand, rising the volume of subordinated debts and deposits decreases the costs $C'_R < 0$ and $C'_D < 0$ as the ratios of the bank are higher increasing thus its RACs:

$$\Pi = r_L(L).L + r_B.B - r_K.K - r_R(R).R - r_D(D).D - C(L, R, D)$$

2.3.1 Properties of the Cost Function

The cost function $C(L, R, D)$ measures the restriction and opportunity costs a bank may incur for its activity[11]. We consider that a bank with low capital and liquidity ratios incurs an opportunity cost not expanding its business activities as a strong capital base is necessary to support lending[12] and "Deposits are used to fund loans and other earning assets" (Spierdijk et al. (2017), p.2) . On the other hand, high ratios are a signal for good bank business opportunities and the bank is thus able to improve its profitability. The cost function $C(L, R, D)$ also measures the management costs related to the intermediation activity of the bank. In particular, the bank incurs a structural funding liquidity risk when funding illiquid assets with liquid liabilities as the banking sector experienced during the 2008 financial crisis[13]. The quality of the management of the liquidity funding risk can be assessed through the banking Asset and Liability Management (ALM) activity which plays a prominent role under Basel III as the NSFR is designed to limit the over-

[11] A bank satisfying no regulatory standard incurs restriction costs as regulatory authorities monitor certain credit activities of the bank. If there is no regulation, $C(L, R, D) = 0$ by definition.

[12] For example, see BCBS (2010).

[13] The funding liquidity risk the bank is willing to bear is different from the aggregate credit risk it takes on its loan portfolio. We define the funding liquidity risk as the inability of the bank "to meet its obligations as they fall due" (BCBS, 2014).

reliance on short-term wholesale funding[14]. Thus, we are able to measure the efficacy of the liquidity regulation through the cost function $C(L, R, D)$. In more details, a high qualitative liquidity regulation should promote an efficient banking ALM which minimises the funding liquidity risk the bank bears and limit the incentive to increase the liquidity gap.

2.3.2 The Bank Profit Maximisation Problem

We reduce the optimisation problem of the bank as an ALM problem in order to assess the impact of the banking regulation on bank lending and the structure of bank liabilities:

$$\max_{L,R,D} \Pi = r_L(L).L + r_B.B - r_K.K - r_R(R).R - r_D(D).D - C(L, R, D)$$

s.t. $L + B = K + R + D$

Solving this profit-maximisation problem with the Lagrangian method gives the following first-order economic conditions:

$$(3) \quad r_L(L) - r_R(R) = C'_L + C'_R - (r'_L(L) \cdot L - r'_R(R) \cdot R),$$

$$(4) \quad r_R(R) - r_D(D) = C'_D - C'_R + r'_D(D) \cdot D - r'_R(R) \cdot R,$$

$$(5) \quad K + R + D - (L + B) = 0.$$

Eq.3 means that the difference between the loan and subordinated debt rate - the Net Interest Margin (NIM) - equals the sum of the marginal regulatory costs on loans and subordinated debts $(C'_L + C'_R)$ net of the marginal profit derived from the intermediation activity $(r'_L(L) \cdot L - r'_R(R) \cdot R)$. Rising the portfolio of loans bought L entails an increase in the NIM $(r_L(L) - r_R(R))$ as managing a higher illiquid portfolio of loans is costly. Other things being equal, the bank has to pay a higher price $(C'_L - r'_L)$ for its ALM.

Eq.4 states that the funding arbitrage of the bank – the difference between the subordinated debt and deposit rate – equals the marginal regulatory cost difference between deposits and subordinated debts plus the marginal market funding cost on these same liability components. Assuming the funding arbitrage is positive, the bank has an incen-

[14]The ALM activity covers other types of risk which turned out to be significant during banking crises. For example, the Saving and Loans Crisis (S&Ls) the US banking sector experienced at the end of the 80s was related to the mismanagement of the repricing gap of the banking sector.

tive to raise deposits D at the expense of subordinated debts R. However, selling more deposits is costly at the margin. Thus, the bank issues deposits to the extent that the marginal cost of issuing it equals the marginal cost of issuing subordinated debt. The implementation of the additional liquidity ratio LRR shows that the bank funding arbitrage is both capital and deposit driven while it is only capital driven under a regulatory environment capital constrained such as Basel I and Basel II[15].

Eq.5 simply refers to the balance-sheet equilibrium constraint.

We assume $d\theta = 0$ which means that the bank implements the right screening mechanism and is therefore able to perfectly assess the credit risk of the borrower in the short-run. The bank is unable to raise K to the extent that it remains investor-driven and is thus considered exogenous in the model setting $dK = 0$. We obtain the following elasticities by totally differentiating Eq.3 and Eq.4 at the third order[16]:

$$(6) \quad dL = \frac{\delta_2 \cdot dR + \delta_3 \cdot dD}{\delta_1};$$

$$(7) \quad dD = \frac{\delta_4 \cdot dR + \delta_6 \cdot dL}{\delta_5};$$

where the coefficients are given by:

$$\delta_1 = r''_L(L) \cdot L + 2 \cdot r'_L(L) - \left(\frac{\partial^2 C}{\partial L^2} + \frac{\partial^2 C}{\partial L \, \partial R}\right);$$

$$\delta_2 = r''_R(R) \cdot R + 2 \cdot r'_R(R) + \frac{\partial^2 C}{\partial R^2} + \frac{\partial^2 C}{\partial R \, \partial L};$$

$$\delta_3 = \frac{\partial^2 C}{\partial D \, \partial L} + \frac{\partial^2 C}{\partial D \, \partial R};$$

$$\delta_4 = r''_R(R) \cdot R + 2 \cdot r'_R(R) + \frac{\partial^2 C}{\partial R^2} - \frac{\partial^2 C}{\partial R \, \partial D};$$

$$\delta_5 = r''_D(D) \cdot D + 2 \cdot r'_D(D) + \frac{\partial^2 C}{\partial D^2} - \frac{\partial^2 C}{\partial D \, \partial R};$$

$$\delta_6 = \frac{\partial^2 C}{\partial L \, \partial R} - \frac{\partial^2 C}{\partial L \, \partial D};$$

[15] For further details, see Appendix A.

[16] Note that developing the model at further order is possible. However, we do not do so because the economic interpretation would not be straightforward.

$$(8) \quad \frac{dL}{dR} = \frac{\left(\delta_2 + \dfrac{\delta_3 \cdot \delta_4}{\delta_5}\right)}{\left(\delta_1 - \dfrac{\delta_3 \cdot \delta_6}{\delta_5}\right)};$$

$$(9) \quad \frac{dD}{dR} = \frac{\left(\delta_4 + \dfrac{\delta_6 \cdot \delta_2}{\delta_1}\right)}{\left(\delta_5 - \dfrac{\delta_6 \cdot \delta_3}{\delta_1}\right)}.$$

Totally differentiating Eq.3 and Eq.4 stresses three important results. First, we see that the elasticities are market driven via the conduct of the first and second derivatives of the interest rates $r'(.)$ and $r''(.)$ obtained in δ_1, δ_2, δ_4 and δ_5. Second, we note that these elasticities are also regulatory driven. In addition to introducing banking adjustment and marginal regulatory costs as we have seen so far, capital and liquidity requirements adds secondary costs $\left(\dfrac{\partial^2 C}{\partial(.)^2}\right)$ and cross-effects $\left(\dfrac{\partial^2 C}{\partial(.)\,\partial(.)}\right)$ potentially. The nature of these secondary costs and cross-effects may modify the structure of the elasticities of the bank and thus its behaviour. As stated in Freixas & Rochet (2008), if costs are separable, then cross-effects are nil. If cross-effects are not nil then the elasticities are modified and determined depending on the functional form of the cost function. It is crucial to determine the nature of these costs because they may affect the profitability, the NIM, the funding arbitrage and the elasticities of the bank as a whole. Therefore, the regulation may not be neutral. Third, as in (Ito & Sasaki (1998), p.18) the signs of these elasticities "may not be uniquely determined." We find that they depend on the costs that the regulation entails and second, the structure of the competition the bank faces on the market. For small enough C'', the signs of the elasticities depends on the structure of this competition and the regulation has only effects on the profitability, the NIM and the funding arbitrage of the bank:

$$(10) \quad \frac{dL}{dR} \simeq \frac{\delta_2}{\delta_1} \simeq \frac{r''_R(R) \cdot R + 2 \cdot r'_R(R)}{r''_L(L) \cdot L + 2 \cdot r'_L(L)};$$

$$(11) \quad \frac{dD}{dR} \simeq \frac{\delta_4}{\delta_5} \simeq \frac{r''_R(R) \cdot R + 2 \cdot r'_R(R)}{r''_D(D) \cdot D + 2 \cdot r'_D(D)}.$$

The sign of the loan-to-subordinated-debt elasticity depends on the condition set on δ_1 and δ_2. Assuming the competitive pressure on the loan market increases as the bank buys a greater portion of loans ($r''_L < 0$), " the rate of increase accelerates as more subordinated debts being issued" (Ito & Sasaki, 1998)[17] and the deposit interest rate follows the same pattern than subordinated debts ($r''_D > 0$), it follows:

(12) $\frac{dL}{dR} > 0\,;$

(13) $\frac{dD}{dR} > 0\,\cdot$

3 Conclusion

The insufficient build-up of capital and liquidity buffers of the banking sector prior to the 2008 financial crisis has raised the rationale for implementing the regulatory regime Basel III. The novel aspect of this banking regulation is introducing liquidity requirements aiming at counteracting the massive liquidity disruptions experienced by the banking sector during the 2008 financial crisis. In this paper, we propose to draw a micro-founded analysis of bank behaviour subject to capital and liquidity regulatory constraints in order to raise the key implications of this type of regulation on bank behaviour. To our knowledge, this is the first paper presenting a theoretical approach of bank behaviour under a regulatory regime *à la* Basel III. Based on Ito & Sasaki (1998), we define the liquidity constraint as a ratio the bank is expected to comply with in addition to the capital ratio. We also propose to enhance the definition of the capital ratio the authors introduced in their model by including the credit risk parameter which models the risk-based regulatory capital approaches implemented under Basel II and Basel III. Evidence contained in this paper points to two major results. First, we see that implementing new regulatory rules for a given regulatory structure shed some light on the need to re-consider the design of the micro-prudential architecture. Indeed, introducing an additional rule such as liquidity funding requirement could interfere with the capital requirements and produce

[17]This implies that $r''_R > 0$.

non-desirable effects taking the form of distortions on bank behaviour. These distortions could entail the misachievement of the objectives set by Regulatory Authorities because, following the Tinbergen counting rule and (Fisher (2014), p.2-3): " A necessary condition is that there should be at least as many independent and effective policy instruments as there are independent policy targets.". Thus, the results also question the need to clarify the hierarchy (primary or secondary) of the objectives as well as their nature (complements or substitutes). Second, Regulatory Authorities should identify the nature of the competitive pressure the bank faces for implementing the optimal regulatory regime. The results obtained in this paper show that the sign of the elasticities derived in the model is primarily market-determined and depends on the conditions set on competition. Identifying the costs the bank incurs could be one way to determine this competitive nature.

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Appendix A Bank Behaviour Under Basel II

We reduce the optimisation problem of the bank as follows:

$\max_{L,R,D} \Pi = r_L(L).L + r_B.B - r_K.K - r_R(R).R - r_D.D - C(L,R)$

s.t. $L + B = K + R + D$

Solving this profit-maximisation problem with the Lagrangian method gives the following first-order economic conditions:

(14) $r_L(L) - r_R(R) = C'_L + C'_R - (r'_L(L) \cdot L - r'_R(R) \cdot R),$

(15) $r_R(R) - r_D = -(C'_R + r'_R(R) \cdot R),$

(16) $K + R + D - (L + B) = 0.$

Eq.14 means that the difference between the loan and subordinated debt rate - the Net Interest Margin (NIM) - equals the sum of the marginal regulatory costs on loan and subordinated debt plus the marginal profit derived from the intermediation activity as deduced from the Basel III optimisation problem. Rising the portfolio of loans bought increases the NIM as it is costly to manage a higher loan portfolio. Eq.15 states that the funding arbitrage - the difference between the subordinated debt and deposit rate - equals the marginal regulatory and market cost on subordinated debt. The structure of this funding arbitrage remains capital driven as the bank has no incentive to raise deposits.