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Angelo Baglioni (\*)

(\*) Istituto di Economia e Finanza, Università Cattolica del Sacro Cuore, Via Necchi 5 –  
20123 Milano, e-mail: [abaglioni@mi.unicatt.it](mailto:abaglioni@mi.unicatt.it)

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Istituto di Economia e Finanza  
Università Cattolica del S. Cuore  
Via Necchi, 5  
20123 Milano  
tel.: 02/7234.2976  
fax: 02/7234.2781  
e-mail: [ecofin@mi.unicatt.it](mailto:ecofin@mi.unicatt.it)

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## THE NEW BASLE ACCORD: WHICH IMPLICATIONS FOR MONETARY POLICY TRANSMISSION?

Angelo Baglioni

**Abstract.** *We address the issue of monetary policy transmission through the banking sector, in presence of bank capital regulation; in particular, we stress the implications of introducing different risk weights for the loans to the private sector, which is a distinctive feature of the New Basle Accord. A model of bank behavior is presented, showing how a monetary policy impulse affects the supply of bank (risky) loans; the model is able to show the difference between the reaction of the banking system to a monetary shock in the short run, when capital is assumed to be fixed, and in the long run, when equity is endogenous. Two main results are the following. First, capital requirements matter (under both current and future regulations) even when the banking system is well capitalized at the time when a monetary policy intervention takes place: the impact of monetary policy increases through time, as long as banks may adjust their equity base to the new level of market interest rates. Second, under the New Basle Accord monetary policy may have perverse effects on the riskier borrowers (those receiving higher risk weights), when the banking system experiences a lack of regulatory capital: an expansionary monetary policy leads to a (short run) contraction of the supply of bank loans to them.*

**JEL Codes:** G21, G28, E51, E52.

**Keywords:** *(New) Basle Accord, Bank equity, Credit risk, Monetary policy transmission.*

# 1 Introduction and summary<sup>1</sup>

## 1.1 From Basle-1 to Basle-2: which implications for monetary policy transmission?

The capital adequacy regulation on the banking sector is undergoing a process of deep reform: the Basle Committee on Banking Supervision has formulated a proposal (BIS, 2001) for a New Basle Accord ("Basle-2"), which is bound to replace the 1988 Basle Accord ("Basle-1"). A lengthy process of consultation with the banking industry will lead, possibly by the end of 2003, to a final version of the new rules, which should be implemented by year-end 2006.<sup>2</sup>

The proposal of the Basle Committee has stimulated a great deal of comments, coming from bank practitioners, academics as well as monetary authorities. In particular, a distinctive feature of Basle-2 has been much debated: bank loans to the (non-bank) private sector<sup>3</sup> will be split into several risk categories, each receiving a different weight in the calculation of the risk-weighted assets. This feature will operate both for those banks relying on external ratings and for those adopting the internal ratings approach, although for the latter the differences among risk weights are going to be much more remarkable. A common criticism is that this feature will induce banks to have a procyclical behavior in the supply of loans. Another concern relates to small-medium size firms, which will be possibly penalized by the fact that they are not usually rated. These drawbacks are currently under the attention of the Basle Committee (see the Agreement of July 10, 2002).

The present study addresses a rather different issue: *which are the implications of the capital adequacy regulation for the transmission of monetary policy through the banking sector?* In trying to answer this question, we will stress the role of the above mentioned feature of Basle-2: as we will see, the introduction of different risk weights into the regulatory framework is likely to have a remarkable impact on the issue at hand.

We will tackle this issue with a microeconomic approach, presenting a model where a bank has to determine the optimal level of loans (together with the other items in its balance sheet), in presence of credit risk and of a capital adequacy regulation. This model will tell us how a bank reacts to a monetary policy shock: in particular, how a change of the monetary policy rate is transmitted to the interest rate applied on bank loans. In this framework, the central bank affects the real sector of the economy as long as the change of the money market rates, induced by its intervention, is passed through by a change of the loan interest rates. The model is able to show the difference between the reaction of the banking system to a monetary shock in the short run, when the regulatory

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<sup>1</sup>I wish to thank, without implicating, Pino Marotta for very usefull comments.

<sup>2</sup>Both the "old" and "new" capital regulations may be found on the web site of the Bank for International Settlements ([www.bis.org](http://www.bis.org)), together with the comments of the banking industry on the consultative document set forth by the Basle Committee.

<sup>3</sup>Actually, not only loans to the non-bank private sector (on which we will focus here), but also those to banks and to sovereign borrowers.

capital is assumed to be fixed, and in the long run, when banks are able to adjust their own equity.

We will present two versions of the model: the first one is designed upon the current regulation (Basle-1), while the second one incorporates the above mentioned distinctive feature of Basel-2 (i.e.: different risk weights). We may summarize our main results as follows.

## 1.2 Main results

1. Under both Basel-1 and Basel-2 regulatory frameworks, the presence of a capital requirement is relevant for the transmission of monetary policy, even when the banking system is well-capitalized at the time when a monetary intervention takes place, so that the capital requirement constraint is not binding; in particular, the impact of monetary policy on the loan market increases through time, as long as banks may adjust their equity base to the new level of market interest rates.

The intuition behind this result is the following. Suppose the central bank makes an expansionary intervention, inducing a reduction of the market level of interest rates. Banks will expand their loan supply, because the yield on the alternative (marketable) assets has decreased: in the short run, when the equity base of banks is supposed to be fixed, this is the only incentive they have to expand their loans. In the long run, when they may adjust their equity, they have an additional incentive: the "marginal cost of equity" - defined as the increase of the opportunity cost of equity funding due to an additional unit of loans - has been reduced by the monetary shock (by lowering the market level of interest rates); therefore, banks are willing to raise new equity and to expand further their loan supply.<sup>4</sup>

2. There is a remarkable difference between Basel-1 and Basel-2, with regard to the short run impact of monetary policy on banks' behavior, when the capital requirement constraint is binding (and their equity base is supposed to be fixed). Under Basel-1, when a bank is in a constrained position, it has no room to respond to a monetary policy impulse: thus, monetary policy is unable to significantly alter the loan market equilibrium, when the whole banking system is affected by a lack of regulatory capital. To the contrary, under Basel-2 a constrained bank has more freedom to adjust its loan portfolio, following a monetary policy shock: indeed, it is optimal to react by altering the composition of its loans. If the whole banking system experiences a lack of capital, this adjustment process turns out having perverse effects on the riskier borrowers (those

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<sup>4</sup>In the short run equilibrium the "marginal cost of equity" is by definition equal to zero: banks increase their loan supply by making use of the "buffer capital" previously build up, so an additional unit of loans does not require an increase of equity funding.

receiving higher risk weights in the calculation of the capital-to-asset ratio): for example, an expansionary monetary policy leads to a contraction of the supply of bank loans to them.<sup>5</sup>

The reason behind this possible "perverse effect" of monetary policy under Basle-2 is clear. Following an expansionary monetary policy intervention, a bank wants to expand the volume of its loans (for the reason outlined above). How can it do that, if it is constrained by the capital requirement? The only way is to shift the composition of its loan portfolio towards the less risky borrowers (those receiving lower risk weights in the calculation of the capital-to-asset ratio): this enables the bank to "soften" the capital requirement constraint. The outcome is an expansion of the total loan supply, but with opposite effects on borrowers of different risk categories: an expansion of the loans supplied to less risky borrowers, together with a contraction of the loans supplied to more risky ones.<sup>6</sup>

### 1.3 Related literature

There is a wide literature covering the issue of the transmission of monetary policy through the banking sector.<sup>7</sup> Following the seminal work by Bernanke - Blinder (1988) on the "bank lending channel", several theoretical and empirical studies have stressed the role of the banking system in transmitting monetary policy impulses to the real sector of the economy. Among them, we wish to mention here a few articles, dealing in particular with the role of bank capital in conditioning the way monetary policy impulses are transmitted through the banking sector: Thakor (1996), Holmstrom - Tirole (1997), Repullo - Suarez (2000), Van den Heuvel (2001), Tanaka (2001), Chami - Cosimano (2001). From these models, it is possible to draw the following general conclusions: i) the presence of a capital requirement may reduce the effectiveness of monetary policy; ii) a reduction of the level of equity of the banking system lowers the volume of bank credit available to the economy (so-called "credit crunch").

Among those articles, the only one dealing with the implications of Basle-2 is Tanaka (2001). As far as monetary policy is concerned, his basic result is the following: during a cyclical downturn, an expansionary monetary policy

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<sup>5</sup>We also argue below that the contingency where the capital requirement constraint "bites" on some banks - preventing them from expanding their risk-weighted loans - is more likely to occur under Basle-2 than under Basle-1: this because Basle-2 introduces a volatility of the requirement, which is absent in Basle-1.

<sup>6</sup>Of course, under Basle-1 this adjustment of the bank loan portfolio cannot occur, as all loans receive the same risk weight.

<sup>7</sup>See the reviews of this literature in the articles by Kashyap - Stein (1994, 1997), Bernanke - Gertler - Gilchrist (1996), Mojon - Smets - Vermeulen (2000), Altunbas - Fazylov - Molyneux (2000). Empirical evidence on the transmission of monetary policy in the euro area is provided by Angeloni - Kashyap - Mojon - Terlizzese (2002) (see also the other papers presented at the ECB Conference on Monetary Policy Transmission in the Euro Area, Frankfurt, December 2001). Mojon (2000) provides evidence on how the interest rate channel works through the banking system in Europe.

becomes less effective, because the increase of credit risk makes the capital requirement constraint become more stringent. This result is consistent with the argument we make below, relative to the volatility of the capital requirement introduced by Basle-2. Our model provides an additional insight: this volatility, in turn, makes more likely a situation where an expansionary monetary policy leads (in the short run) to a contraction of the loan supply for high risk borrowers, because the banking system is constrained by the capital regulation (result 2 above).

Strictly related to this paper is also the stream of literature focussing on the impact of bank capital regulation on the supply of bank credit, trying to assess the macroeconomic implications of such regulation. The empirical evidence provided by these studies is surveyed in BIS (1999), pointing to a significant effect of Basle-1 in some circumstances<sup>8</sup>. As far as Basle-2 is concerned, the debate has concentrated on the likely procyclical effects of the new regulation, due to the changes of the capital requirement across the business cycle (see ECB, 2001)<sup>9</sup>.

#### 1.4 Plan of the paper

The paper is organized as follows. In Section 2, we present a model of bank behavior, where the capital regulation is modelled upon Basle-1: therefore, there is only one category of risky loans, all receiving the same weight in the calculation of the capital-to-asset ratio. In Section 3, the model is extended to the case where there are two categories of bank loans, differing with respect to their credit risk and to the risk weight they are assigned: this is the simplest way to capture an essential feature of Basle-2, namely the introduction of different risk weights into the capital regulatory framework. In both sections, the impact of monetary policy on the supply of bank loans will be analyzed under two different time horizons: i) short run, where banks take the level of regulatory capital as given, as they are unable to raise new equity; ii) long run, where they are able to do so: here the equity base of the banking system becomes endogenous. Finally, Appendix 1 shows that all the results obtained in the paper, under the assumption that banks have some market power, hold under the alternative assumption of perfect competition; Appendix 2 considers what happens when we remove from our model the capital requirement regulation; Appendix 3 provides a graphical illustration of some of the propositions stated in the text.

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<sup>8</sup>While the evidence collected in BIS (1999) deals with G-10 countries, other studies have shown the relevance of capital regulation for bank credit supply in developing countries (see, for example, Chiuri - Ferri - Majnoni, 2001).

<sup>9</sup>See also Ayuso - Perez - Saurina (2002), pointing to a procyclical impact of the capital buffers held by banks. Procyclicality is also addressed by Estrella (2001), in a model where the optimal level of bank capital is determined through a value-at-risk (VAR) approach.



## 2 Bank behavior and monetary policy transmission under "Basle-1"

### 2.1 Basic assumptions

Consider a bank, holding loans (denoted by  $L$ ) and bonds ( $B$ ) on the asset side, and funding through deposits ( $D$ ) and own equity ( $E$ ). Let's make the following assumptions.

**Loans.** Our representative bank has some market power in the loan market: as the literature<sup>10</sup> in the banking field has shown, even when the market structure is competitive, banks are able to segment the loan market by keeping private the information on borrowers and by building up customer relationships with them; therefore, borrowers face significant costs if they wish to switch from an existing lending relationship to a new one. Then, our bank is price setter in the loan market; she faces a negatively sloped demand for loans  $L(r_L)$  (with  $L'(r_L) < 0$ ), with finite elasticity defined as  $\eta_L = -\frac{L' \cdot r_L}{L}$ .

The same assumption that loans are "information intensive" assets implies that firms (at least part of them) cannot easily substitute bank loans with alternative sources of funding, like issuing securities in the open market. This makes firms "bank dependent", enabling banks to apply on their loans an interest rate possibly higher than the one prevailing in the securities market.

The other essential feature of bank loans is credit risk, which is modelled in the simplest way as follows. Given the amount ( $L$ ) of loans granted at the beginning of the period, the return to the bank at the end of the period is:  $(1 + r_L)L$  with probability  $p$ , or zero. Therefore,  $(1 - p)$  is the probability of borrowers' insolvency, which in turn makes the bank go bankrupt.

**Deposits.** The bank has some market power also in the market for deposits. The source of monopoly power in this market is different than in the loan market, and it may be found in the ability of banks to segment the deposit market through spatial differentiation. Then, the bank faces a positively sloped supply of deposits  $D(r_D)$  (with  $D'(r_D) > 0$ ), having finite elasticity defined as  $\eta_D = \frac{D' \cdot r_D}{D}$ .

We assume further that the presence of deposit insurance makes deposits be a riskless asset: that's why we may simply write the supply of deposits as a function of the posted rate ( $r_D$ ). Banks pay a flat premium for this insurance.<sup>11</sup>

**Bonds.** In addition to loans, the bank holds a marketable financial asset (Government bonds): the interest rate on these bonds ( $i$ ) is determined in a competitive financial market, where the bank is price taker.

**Capital requirement regulation.** The banking sector is subject to a capital requirement, which in this section is modelled upon the 1988 Basle Accord (Basle-1). As it is well known, under this regulation the loans to the (non-

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<sup>10</sup>See, among others, Sharpe (1990) and Rajan (1992).

<sup>11</sup>For simplicity, we will not explicitly introduce this premium into the model: given the (realistic) assumption that it is not risk-related, its explicit inclusion into the model would not alter any result relative to the bank behavior.

bank) private sector are all subject to the same requirement (all receiving a 100% weight in the weighting scheme for calculating the risk weighted assets, used as denominator in the capital-to-assets ratio),<sup>12</sup> while Government bonds are exempted (as they receive a zero-weight). Thus, we may write the capital requirement as follows:  $E \geq kL$ , meaning that the bank cannot have an equity level lower than  $k$  times the volume of loans.<sup>13</sup> While this is a quite stylized description of Basle-1, it captures two essential features of it: 1) all loans are treated the same way; 2) there is a zero-weight asset (Government bonds), which is "costless" as far as the capital requirement is concerned.

**Monetary policy.** We model monetary policy interventions as modifications of the interest rate ( $i$ ) prevailing in the market for bonds. While traditionally monetary policy has been modelled as modifying the quantity of money, modern macroeconomic theory recognizes the fact that central banks nowadays target directly the level of interest rates.<sup>14</sup> Of course, the picture is actually much more complex than it is in our stylized model: central banks set the level of short term (overnight) interest rates, so an interesting problem is how this impulse is then transmitted through the whole yield curve. We do not tackle this problem here, as we have only one interest rate on bonds, without making any distinction as far as the maturity of assets is concerned.

## 2.2 Bank objective function

The objective of bank management is to maximize the expected end-of-period net value of the bank ( $V$ ), given by:

$$V = p[(1 + r_L)L + (1 + i)B - (1 + r_D)D] - (1 + i)E \quad (1)$$

where the term in square brackets is the return to the bank equity holders, given bank solvency; with probability  $(1 - p)$  the bank is insolvent and their equity holders receive nothing.<sup>15</sup> The last term is the opportunity cost of equity: assuming risk neutrality, this is given by the riskless rate (namely, the return  $i$  on Government bonds).

The budget constraint is:

$$E + D = L + B \quad (2)$$

from which the amount of bonds held by the bank may be derived as a residual item:  $B = E + D - L$ , which in turn may be substituted into the objective function (1) to get:

$$V = p[(r_L - i)L + (i - r_D)D] - (1 - p)(1 + i)E \quad (3)$$

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<sup>12</sup>With the exception of mortgages on residential property, receiving a 50% risk weight.

<sup>13</sup>Under the present regulation  $k = 0.08$ . Alternatively, if  $E$  is interpreted as Tier 1 capital, then  $k$  is actually equal to 0.04.

<sup>14</sup>See Romer (2000).

<sup>15</sup>We are implicitly assuming that  $(1 + r_L)L + (1 + i)B > (1 + r_D)D > (1 + i)B$ .

where the last term is the expected opportunity cost of equity, which is proportional to the probability of bank failure: only in this case the amount  $(1 + i)E$  is actually forgone. To the contrary, with probability  $p$  the bank is solvent and bank assets give back a return at least equal to  $i$ ; in addition, the bank may enjoy some profit margins in the loan and deposit markets, as shown by the term in square brackets.

## 2.3 Short run bank equilibrium and monetary policy transmission

### 2.3.1 Loan and deposit equilibrium rates with exogenous capital

Our final goal is to determine how a monetary policy impulse is transmitted through the banking system to the real sector of the economy, by affecting the level of the interest rates in the loan market. In doing that, we distinguish between a short run and a long run reaction.

A short run equilibrium is defined by the fact that the level of equity is fixed: following a change of  $i$ , the bank may react by changing its own interest rates  $r_L$  and  $r_D$ , but it cannot modify its level of equity  $E$ . Let us consider the immediate reaction of a bank to a modification of the monetary policy rate: this is typically a short run decision problem, where the time horizon of the decision makers (bank managers) is not longer than a few months. It is realistic to assume that in such a short time horizon bank managers find it difficult to modify the equity level of the bank: raising new capital is costly and it may take some time.

To the contrary, in the long run the bank may adjust the level of its own equity - together with its own interest rates - to the new level of the policy rate  $i$ : so the long run equilibrium is defined by the fact that  $E$  is endogenous (we will address this long run reaction in Subsection 2.4).<sup>16</sup>

The short run optimization problem of the bank is the following:

$$\begin{aligned} & \text{P1} \\ & \max_{r_L, r_D} V \\ & \text{s.to } E \geq kL \end{aligned}$$

where  $V$  is the objective function (3) above and where the level  $E$  of equity is exogenous.

The FOC<sup>17</sup> for this problem may be written as follows:

<sup>16</sup>A deeper understanding of the difference between the short and long run effects of monetary policy would probably require the use of a dynamic model. We believe that the one-period model presented here, despite its simplicity, is able to capture the essential elements of such an issue, as it allows to characterize two different equilibria: one with exogenous equity (short run) and one with endogenous equity (long run).

<sup>17</sup>Let's make the following technical assumptions:  $L''(r_L) > 0$ ,  $(r_L - i)L''(r_L) < -2L'(r_L)$ ,  $D''(r_D) < 0$ ; then P1 is a concave programming problem, so that conditions (4-5) below are necessary and sufficient for a maximum.

$$pr_L\left(1 - \frac{1}{\eta_L}\right) = pi + k\lambda \quad (4)$$

$$r_D^*\left(1 + \frac{1}{\eta_D}\right) = i \quad (5)$$

where  $\lambda$  is the Lagrangian multiplier for the capital requirement constraint.

These conditions lead to the well-known dichotomy of the Klein - Monti model of bank behavior:<sup>18</sup> the equilibrium deposit and loan rates are set independently of each other; the balance sheet constraint is met thanks to the presence of the bond portfolio, acting as a "buffer asset".

In particular, the interest rate on deposits is set at a level ( $r_D^*$ ) such that the marginal cost of deposits (LHS in 5) is equal to the marginal return on bank assets ( $i$ ). The bank is able to earn a profit margin on its deposit taking activity, which is proportional to its market power, being higher the lower is the elasticity of the deposit supply schedule; indeed, from equation (5) we have:

$$r_D^* = i \left(1 - \frac{1}{1+\eta_D}\right) \quad (5.i)$$

where  $\frac{1}{1+\eta_D}$  is the "mark-down" on deposits.

On the loan side, we have to distinguish between two cases: (i) the bank is not constrained by the capital regulation; (ii) the bank is constrained by the capital regulation.

**Unconstrained bank.** With  $\lambda = 0$ , condition (4) reads:

$$r_L^*\left(1 - \frac{1}{\eta_L}\right) = i \quad (4.i)$$

where  $r_L^*$  is the optimal unconstrained level of the loan interest rate. Condition (4.i) tells us that the bank makes loans up to the point where the marginal revenue on this asset (LHS) equals its marginal cost, given by the return ( $i$ ) on the alternative asset (bonds). In order to satisfy the assumption that the capital requirement constraint is slack, it must be  $L(r_L^*) < \frac{E}{k}$ . Also the profit margin on loans is proportional to the market power enjoyed by the bank; from equation (4.i):

$$r_L^* = i \left(1 + \frac{1}{\eta_L - 1}\right) \quad (4.ii)$$

where  $\frac{1}{\eta_L - 1}$  is the "mark-up" on loans.

**Constrained bank.** If the optimal (unconstrained) level of loans  $L(r_L^*)$  is larger than  $\frac{E}{k}$ , then the bank cannot actually grant such a volume of loans, as it lacks the necessary amount of own equity. In this case, the loan volume and interest rate are determined by the capital requirement constraint, namely:  $L(\bar{r}_L) = \frac{E}{k}$ . Condition (4) then determines the value of the Lagrangian multiplier:

$$\lambda = \frac{p\left[\bar{r}_L\left(1 - \frac{1}{\eta_L}\right) - i\right]}{k} > 0 \quad (4.iii)$$

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<sup>18</sup>See Klein (1971) and Monti (1972). See also Dermine (1986) for an extension of such model to the presence of bankruptcy risk and deposit insurance.

The effect of the constraint is to force the bank to set its loan volume at a level lower than optimal:  $L(\bar{r}_L) < L(r_L^*)$ ; or equivalently to set the interest rates on its loans at a higher level than optimal:  $\bar{r}_L > r_L^*$ . In other words, the bank is forced to work with a marginal revenue on its loans higher than their marginal cost. The value of  $\lambda$  - given by eq. (4.iii) - provides a measure of this inefficiency, namely the marginal cost of the capital requirement constraint.

### 2.3.2 Monetary policy effectiveness

We now come to our main goal, which is to analyze the impact of a monetary policy intervention on the market for loans, as this represents an important channel of monetary policy transmission, particularly for those borrowers which are more "bank-dependent" for their funding. In doing that, we exploit the usual shortcut of the representative agent approach: we assume that the whole banking system is adequately represented by a "representative bank"; this is equivalent to assuming that the whole system is either well-capitalized (unconstrained) or under-capitalized (constrained). While this approach is obviously extremely useful in simplifying the analysis, it overlooks an interesting issue: the interaction in the loan market between well-capitalized and under-capitalized banks; in other words, it is not able to capture the heterogeneity possibly present in the banking system.<sup>19</sup>

In addition, we make the technical assumption that both the loan demand and deposit supply schedules exhibit constant elasticities ( $\eta_L$  and  $\eta_D$  respectively).<sup>20</sup>

The impact of a monetary policy intervention, namely of a change in the policy rate  $i$ , is described in the following proposition (the interested reader may find a graphical illustration of the proposition in Appendix 3: Figure 1).

**Proposition 1** *i) If  $r_L^*$  is such that  $L(r_L^*) < \frac{E}{k}$ , the short run impact of a change in the policy rate  $i$  on the loan rate is given by:  $\frac{dr_L^*}{di} > 0$ .*

*ii) If  $r_L^*$  is such that  $L(r_L^*) > \frac{E}{k}$ , a change in the policy rate  $i$  has no short run impact on the loan rate ( $\frac{dr_L^*}{di} = 0$ ).*

**Proof.** i) This part of the proposition relies on the assumption that the bank is *unconstrained* by the capital requirement, both before and after the monetary policy shock. In this case, the impact of the change in  $i$  on  $r_L^*$  is immediately derived from eq.(4.ii):

$$\frac{dr_L^*}{di} = \frac{\eta_L}{\eta_L - 1} > 0 \quad (6)$$

ii) Here the underlying assumption is that the bank is *constrained* by the capital requirement, both before and after the monetary policy shock. In this case, the equilibrium level of the loan interest rate, given by the condition  $L(\bar{r}_L) = \frac{E}{k}$ , is unaffected by the change in  $i$ . ■

<sup>19</sup>The issue of heterogeneity among banks is taken up in Baglioni (2002).

<sup>20</sup>This is only a simplifying assumption, not able to significantly alter the following results.

**Remark 1.** Notice that in part ii) a change in  $i$  does have an effect: it alters the marginal cost of the capital requirement constraint, measured by  $\lambda$  (see eq.4.iii). For example, a reduction of  $i$  leads to an increase of  $\lambda$ .

**Remark 2.** For simplicity, Proposition 1 rules out those cases where the bank is unconstrained before the monetary policy shock and it becomes constrained after such a shock has taken place (or viceversa). It is easy to extend the proposition to those cases, obtaining mixed results. For example, let's start with  $L(r_L^*) < \frac{E}{k}$  and apply to  $i$  a reduction large enough as to make the new optimal loan rate - say  $r_L^{**}$  - such that  $L(r_L^{**}) > \frac{E}{k}$ : in this case, the impact of the monetary policy shock is a reduction of the loan rate, leading to an expansion of the loan volume up to the point where  $L(\bar{r}_L) = \frac{E}{k}$ : from this point on, the reduction of  $i$  has no further effect on the loan rate, which remains equal to the constrained level  $\bar{r}_L$ .

Proposition 1 points to a simple conclusion. *In the short run,<sup>21</sup> monetary policy is effective, provided the banking system has enough own equity:* only in this case banks are able to adjust their loan rates and volumes to the new level of market interest rates. To the contrary, if the banking system is poorly capitalized, so that its loan supply is constrained by the capital regulation, then a monetary policy shock has no (or only a limited) impact on the loan market.

An important issue is whether the situation described by part ii) of Proposition 1 is empirically relevant. Of course, given the theoretical nature of this study, we can give here only a tentative answer. Our guess is that, under normal circumstances, the banking system is in a condition like the one described by part i) of the proposition. Banks normally keep the ratio between regulatory capital and risk-weighted assets at a level above the minimum required by the regulation: they do so precisely in order to avoid finding themselves in a constrained position.<sup>22</sup> As we have seen, the constrained equilibrium implies a cost for the bank, measured by  $\lambda$ : a bank having a sufficient level of "buffer capital" (i.e. capital in excess of the minimum required by the regulation) is able to react to any shock to its balance sheet, without incurring in such a cost.

However, there are circumstances in which part ii) of the proposition becomes empirically relevant. The evidence provided by BIS (1999) shows at least three historical episodes, where banks have been forced to cut back the volume of their lending in order to comply with the regulation: i) in USA between 1989 and 1991; ii) in Japan between 1991 and 1994; in Sweden between 1992 and 1996.

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<sup>21</sup>Remember that we have defined the short run horizon as one where banks are unable to modify their level of own equity  $E$ .

<sup>22</sup>BIS (1999), for example, reports that the average ratio of capital to risk-weighted assets of major banks in the G10 countries was at 11.2% in 1996. ECB (2001) reports that the average capital ratio across euro area countries was at 10.6% in 1999. Bank of Italy (2001) reports that only a negligible number of Italian banks had a capital-to-asset ratio below 8% in 2000.

## 2.4 Monetary policy transmission in the long run

### 2.4.1 Bank equilibrium with endogenous capital

The preceding subsection was devoted to the analysis of the reaction to a monetary policy shock by the banking system, under the assumption that its own equity endowment was fixed. Let us now remove this assumption: banks are now able to adjust their equity level, together with their interest rates, following a change of  $i$ . This process leads the banking system to what we have called a long run equilibrium, with  $E$  endogenous.

Before proceeding with the long run analysis, we have to make the following additional assumption. We assume that our representative bank wants to keep its long run capital-to-asset ratio at a level (weakly) above the one required by the regulation; in other words, the bank has an internal target for the long run equilibrium level of the ratio  $\frac{E}{L}$ , say  $\hat{k} \geq k$ . This assumption seems quite reasonable and realistic,<sup>23</sup> since the bank has to incur a cost, should she experience a lack of capital (as we saw in the preceding subsection, where such a cost was quantified by  $\lambda$ ). The level of  $\hat{k}$  is determined by the bank, balancing the estimated cost of possibly being in a constrained situation with the expected opportunity cost of equity (which, as we have shown above, is equal to  $(1-p)(1+i)E$ ). This policy enables the bank to have some "buffer capital":  $E - kL \geq 0$ ; as long as it is endowed with a sufficient level of buffer capital, the bank may react in the short run to any shock, without incurring in the cost of being constrained by the capital regulation. Of course, this implies that the bank is willing to let its capital-to-asset ratio fall below  $\hat{k}$  in the short run; to the contrary, she wants to keep  $\frac{E}{L}$  at such a level in the long run.

The long run optimization problem of the bank is the following:

$$\begin{aligned} & \text{P2} \\ & \max_{r_L, r_D} V \\ & \text{s.to } E = \hat{k}L \end{aligned}$$

where  $V$  is the objective function (3) above and where the level  $E$  of equity is endogenous.

While the FOC<sup>24</sup> for deposits is still given by eq.5, on the loan side the FOC is now different from the one obtained in problem P1 (eq.4), and it may be written as:

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<sup>23</sup>See the evidence mentioned in the preceding footnote. Berger - Herring - Szego (1995) point to the need of a "buffer above the regulatory capital minimum to allow the bank to exploit unexpected profitable investment opportunities and to cushion the effects of unexpected negative shocks". Chami - Cosimano (2001) formalize this intuition in a dynamic model, where banks balance the cost of equity with the expected cost of being constrained by the capital requirement in the future. Ayuso - Perez - Saurina (2002) provide a simple model, where the determinants of the capital buffer are: i) the cost of remunerating capital, ii) the cost of failure and/or the penalties for not complying with the regulatory minimum, iii) the adjustment cost. Such factors determine the optimal amount of bank equity also in the model by Estrella (2001).

<sup>24</sup>If we maintain the same technical assumptions introduced in problem P1, then problem P2 is a concave programming problem as well.

$$p\widehat{r}_L(1 - \frac{1}{\eta_L}) = pi + \widehat{k}(1 - p)(1 + i) \quad (7)$$

where we denote by  $\widehat{r}_L$  the long run equilibrium level of the loan interest rate, in order to avoid confusion with the short run equilibrium level, denoted by  $r_L^*$  (unconstrained) or  $\bar{r}_L$  (constrained).

This equation shows the long run equilibrium condition for loans. Their expected marginal revenue (LHS) has to be equal to their expected marginal cost (RHS), which is now given by two components: the expected<sup>25</sup> return ( $pi$ ) on the alternative asset (bonds), and the cost of adjusting the level of own equity (making an additional unit of loans induces the bank to increase its equity base by  $\widehat{k}$ , increasing proportionally the expected opportunity cost of equity). We call this second term -  $\widehat{k}(1 - p)(1 + i)$  - "marginal cost of equity", meaning the increase of the expected opportunity cost of equity, due to an additional unit of loans. As we shall see shortly, this term is going to make the difference between the short run and the long run impact of a monetary policy shock: this because in the short run, when the bank takes the level of  $E$  as fixed, such a term is equal to zero by definition.

#### 2.4.2 Monetary policy impact

We are now able to assess the long run effectiveness of monetary policy, defined as the impact of a change in  $i$  on the equilibrium loan rate and volume, given that banks are able to adjust their equity level (in addition to their own interest rates) to the monetary shock. The following proposition summarizes our results on this point (see Appendix 3 - Figure 2 for a graphical illustration).

**Proposition 2** *The long run impact of a change in the policy rate  $i$  on the loan rate is given by:  $\frac{d\widehat{r}_L}{di} > 0$ , with  $\frac{d\widehat{r}_L}{di} > \frac{dr_L^*}{di}$ .*

**Proof.** From eq.7:

$$\frac{d\widehat{r}_L}{di} = \frac{\eta_L}{\eta_L - 1} \left( 1 + \frac{1-p}{p}\widehat{k} \right) > 0 \quad (8)$$

Then compare eq.8 with eq.6. ■

Proposition 2 tells us that, when the bank is able to adjust its own equity to the new level of the monetary policy interest rate, its reaction will take into account that what we have called "marginal cost of equity" has changed, following a change in  $i$ ; this is not true in the short run, when the bank takes the level of its equity as fixed. Suppose, for example, that the central bank lowers  $i$  (expansionary monetary intervention).<sup>26</sup> In the short run, the bank lowers the interest rate on loans and expand their volume, only as a reaction

<sup>25</sup>Bonds are a riskless asset: however, here their return is multiplied by the probability of bank solvency ( $p$ ).

<sup>26</sup>The following reasoning applies symmetrically to an increase of  $i$  (monetary contraction).



to the reduction of the return on the alternative asset (bonds):<sup>27</sup> the expected opportunity cost of equity<sup>28</sup> is unaffected by the level of  $L$ , because  $E$  is fixed. In the long run, there is an additional effect. The bank may now choose the level of its equity base; this makes the bank take into account the fact that the marginal cost of equity has decreased, following the reduction of  $i$ : therefore, the bank is willing to expand further the volume of loans - by lowering the interest rate applied - beyond the level reached in the short run.<sup>29</sup>

Proposition 2 shows a not trivial point: *even when the banking system is well-capitalized at the time when a monetary policy intervention takes place, so that it is not constrained by the capital requirement, the presence of a capital regulation is relevant for the transmission of monetary policy.* In particular, *the impact of monetary policy on the loan market increases through time, as long as banks may adjust their equity base to the new level of market interest rates.*<sup>30</sup>

### 3 The new regulatory framework ("Basle-2")

#### 3.1 The key assumption: different risk weights

As it is well known, the current capital requirement regulation is undergoing a process of reform, based on a proposal by the Basle Committee on Banking Supervision (BIS, 2001) and on the comments raised by the banking industry. The new regulation is quite complex and it has not yet been defined in full detail. However, there is one key feature, which is going to make a remarkable difference between the New Basle Accord (Basle-2) and the old one (Basle-1): while under Basle-1 all loans to the (non-bank) private sector receive the same weight in the calculation of the risk-weighted assets (used as denominator in the capital-to-asset ratio), under Basle-2 the loans to the private sector will be split into several risk categories, each receiving a different weight.

The aim of this study is not to discuss the reasons behind the introduction of that feature into the new capital adequacy regulation, nor its possible drawbacks. What we want to do here is to examine the implications that such feature is going to have on the transmission of monetary policy through the banking sector. In particular, we will extend the model presented in the previous section to the case where bank loans are grouped into several (actually two, for simplicity) risk categories, each receiving a different weight in the capital requirement regulation: this extension will enable us to assess the impact of a monetary

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<sup>27</sup>That's the effect we read in eq.6. The bank may expand  $L$ , by making use of the available buffer capital (provided she has some) and by lowering the current level of  $\frac{E}{L}$  below the long run target  $\hat{k}$ .

<sup>28</sup>Which, remember, is equal to  $(1-p)(1+i)E$ .

<sup>29</sup>Of course, the long run adjustment to an expansionary monetary policy intervention implies an increase of  $E$ , in order to restore a ratio  $\frac{E}{L}$  equal to the long run target  $\hat{k}$ .

<sup>30</sup>On the other hand, if we start from a situation where the banking system is under-capitalized, we get the following, rather trivial, result: monetary policy is unable to affect the loan market equilibrium in the short run, because the capital requirement constraint "bites"; to the contrary, it works in the long run, when banks are able to build up new equity.

policy intervention (i.e. a change of the policy rate  $i$ ) on the market for bank loans.

In order to do that, we make the following modifications to the assumptions made in the previous section (all other assumptions remain unchanged).

**Loans.** The representative bank groups its loans into two risk categories: so there are two types of loans ( $L_1$  and  $L_2$ ), with  $r_1$  and  $r_2$  being the interest rate applied by the bank respectively to the loans of type 1 and 2. Each loan gives the bank an end-of-period return equal to  $(1 + r_j)L_j$  with probability  $p_j$  (for  $j = 1, 2$ ) or zero, where  $p_1 > p_2$ . Type 2 loans are therefore more risky, as they have a higher insolvency probability. The demand schedules for each type of loans are denoted by  $L_1(r_1)$  and  $L_2(r_2)$ , with  $L'_j(r_j) < 0$  and finite elasticities<sup>31</sup> defined as  $\eta_j = -\frac{L'_j \cdot r_j}{L_j}$ .

**Capital requirement regulation.** Type 2 loans receive a higher weight in the risk-weighting scheme used to calculate the capital-to-assets ratio: then we write the capital requirement as  $E \geq k_1 L_1 + k_2 L_2$ , where  $k_2 > k_1$ .<sup>32</sup>

### 3.2 Loan portfolio return and bank value

The loan portfolio of our representative bank is  $L = L_1 + L_2$ . The end-of-period return on this portfolio is described in Table 1 (under the implicit assumption that the returns on  $L_1$  and  $L_2$  are statistically independent).

Table 1: *end-of-period return on the loan portfolio*

Return on $L$	Probability
$(1 + r_1)L_1 + (1 + r_2)L_2$	$p_1 p_2$
$(1 + r_1)L_1$	$p_1(1 - p_2)$
$(1 + r_2)L_2$	$(1 - p_1)p_2$
<b>0</b>	<b><math>\pi \equiv (1 - p_1)(1 - p_2)</math></b>

We identify the last row of the table as the "default region", assuming that the bank is insolvent if (and only if) both categories of borrowers turn out to be insolvent; formally:  $\min [(1 + r_1)L_1, (1 + r_2)L_2] + (1 + i)B > (1 + r_D)D > (1 + i)B$ . Thus  $\pi$  is the probability of bank default.<sup>33</sup>

The expected end-of-period net value of the bank ( $V$ ) is given by:

$$V = p_1 p_2 [(1 + r_1)L_1 + (1 + r_2)L_2] + p_1(1 - p_2)(1 + r_1)L_1 + (1 - p_1)p_2(1 + r_2)L_2 + (1 - \pi)[(1 + i)B - (1 + r_D)D] - (1 + i)E \quad (9)$$

<sup>31</sup>We keep the technical assumption that the interest rate elasticities of loan demand - as well as of deposit supply - are constant.

<sup>32</sup>The coefficients  $k_j$  may result from the application of external ratings as well as from the use of internal ratings: our formulation applies to both cases. For a risk category receiving a 100% weight,  $k_j = 0.08$  (or 0.04, if  $E$  is interpreted as Tier 1 capital).

<sup>33</sup>Drawing the "default line" somewhere else in Table 1 does not significantly alter the results we are going to show in the following.

where the first line is the expected return on the loan portfolio, while in the second line you may read the expected return on bonds and the expected cost of deposit funding,<sup>34</sup> as well as the opportunity cost of equity.

The amount of bonds held by the bank may be written as a residual item, thanks to the budget constraint:  $B = E + D - L$ , and substituted into the objective function (9) to get:

$$V = p_1 p_2 [(1 + r_1)L_1 + (1 + r_2)L_2] + p_1(1 - p_2)(1 + r_1)L_1 + (1 - p_1)p_2(1 + r_2)L_2 + (1 - \pi)(1 + i)L + (1 - \pi)(i - r_D)D - \pi(1 + i)E \quad (10)$$

where the last term is the expected opportunity cost of equity, which is proportional to the probability of bank failure  $\pi$ .

### 3.3 Short run bank equilibrium and monetary policy transmission

As we did in Section 2, we begin by analyzing the short run reaction of the banking system to a monetary policy shock, where the "short run" is defined as the time horizon where our representative bank takes the level of its own equity capital as given.

The short run optimization problem of the bank is the following:

$$\begin{aligned} & \text{P3} \\ & \max_{r_1, r_2, r_D} V \\ & \text{s.to } E \geq k_1 L_1 + k_2 L_2 \end{aligned}$$

where  $V$  is the objective function (10) above and where the level  $E$  of equity is exogenous.

The FOC<sup>35</sup> for this problem may be written as follows:

$$p_1 r_1 \left(1 - \frac{1}{\eta_1}\right) = i(1 - \pi) + p_2(1 - p_1) + k_1 \lambda \quad (11)$$

$$p_2 r_2 \left(1 - \frac{1}{\eta_2}\right) = i(1 - \pi) + p_1(1 - p_2) + k_2 \lambda \quad (12)$$

$$r_D^* \left(1 + \frac{1}{\eta_D}\right) = i \quad (5)$$

where  $\lambda$  is the Lagrangian multiplier for the capital requirement constraint.

On the deposit side, the equilibrium condition is the same we found with the current regulation (Basle-1). Things are quite different on the loan side, where equations (11-12) now replace eq.4. These two conditions give us some interesting insights about the short run impact of a monetary policy intervention

<sup>34</sup>Remember that with probability  $\pi$  the bank is worth nothing to its shareholders: in this case (bank default) their deposit liability vanishes and bonds are worthless.

<sup>35</sup>The technical assumptions introduced in problem P1 are modified here as follows:  $L_j''(r_j) > 0$  and  $(1 + r_j)L_j''(r_j) < -2L_j'(r_j)$  (for  $j = 1, 2$ ),  $D''(r_D) < 0$ ; then P3 is a concave programming problem, so that conditions (11-12-5) below are necessary and sufficient for a maximum.

under the new regulation (Basle-2), which we may summarize in the following proposition<sup>36</sup> (for a graphical illustration, see Appendix 3: Figures 3-4).

**Proposition 3** *i) If  $r_j^*$  are such that  $k_1L(r_1^*) + k_2L(r_2^*) < E$ , the short run impact of a change in the policy rate  $i$  on the loan rates is given by:  $\frac{dr_j^*}{di} > 0$ , for  $j = 1, 2$ .*

*ii) If  $r_j^*$  are such that  $k_1L(r_1^*) + k_2L(r_2^*) > E$ , the short run impact of a change in the policy rate  $i$  on the loan rates is given by:  $\frac{d\bar{r}_1}{di} > 0$ ,  $\frac{d\bar{r}_2}{di} < 0$ .*

**Proof.** i) This part of the proposition relies on the assumption that the bank is *unconstrained* by the capital requirement, both before and after the monetary policy shock. In this case, the (short run) equilibrium levels of the loan rates are determined by equations (11-12), with  $\lambda = 0$ :

$$p_1r_1^*(1 - \frac{1}{\eta_1}) = i(1 - \pi) + p_2(1 - p_1) \quad (11.i)$$

$$p_2r_2^*(1 - \frac{1}{\eta_2}) = i(1 - \pi) + p_1(1 - p_2) \quad (12.i)$$

from which:

$$\frac{dr_j^*}{di} = \frac{\eta_j}{(\eta_j - 1)} \frac{(1 - \pi)}{p_j} > 0, \quad \text{for } j = 1, 2 \quad (13)$$

ii) Here the underlying assumption is that the bank is *constrained* by the capital requirement, both before and after the monetary policy shock. In this case, the level of the (constrained) equilibrium loan rates  $\bar{r}_j$  - together with the value of  $\lambda$  - are jointly determined by equations (11-12) and the capital constraint (holding with equality), as a function of the policy rate  $i$  and of the equity level  $E$ . By solving equations (11) and (12) for  $\lambda$ , we get:

$$\frac{p_1\bar{r}_1(1 - \frac{1}{\eta_1}) - i(1 - \pi) - p_2(1 - p_1)}{k_1} - \frac{p_2\bar{r}_2(1 - \frac{1}{\eta_2}) - i(1 - \pi) - p_1(1 - p_2)}{k_2} = 0 \quad (14)$$

which we may write in a compact way as  $g(\bar{r}_1, \bar{r}_2; i) = 0$ , implicitly defining  $\bar{r}_1$  and  $\bar{r}_2$  as a function of  $i$ . Then, by application of the Implicit Function Theorem, we have:

$$\frac{d\bar{r}_1}{di} = \frac{(1 - \pi)(\frac{1}{k_1} - \frac{1}{k_2})}{\frac{p_1}{k_1}(1 - \frac{1}{\eta_1})} > 0 \text{ and } \frac{d\bar{r}_2}{di} = \frac{(1 - \pi)(\frac{1}{k_1} - \frac{1}{k_2})}{-\frac{p_2}{k_2}(1 - \frac{1}{\eta_2})} < 0 \quad (15-16) \quad \blacksquare$$

**Remark 1.** In Part ii), a change of  $i$  leads to a change of opposite sign of the marginal cost of the capital requirement constraint ( $\lambda$ ): for example, a reduction of  $i$  implies an increase of  $\lambda$ . This may be seen by solving eq.12 for  $\lambda$  (and taking into account the fact that  $\frac{d\bar{r}_2}{di} < 0$ ).<sup>37</sup>

**Remark 2.** Derivatives (15-16) may also be written as follows, after substituting (13) into them:

$$\frac{d\bar{r}_1}{di} = \frac{dr_1^*}{di} (1 - \frac{k_1}{k_2}) \text{ and } \frac{d\bar{r}_2}{di} = \frac{dr_2^*}{di} (1 - \frac{k_2}{k_1}) \quad (15.i - 16.i)$$

<sup>36</sup>The notation used here is consistent with the one of the preceding section. In particular:  $r_j^*$  are the optimal unconstrained levels of the loan interest rates, prevailing in the short run equilibrium;  $\bar{r}_j$  are the constrained levels.

<sup>37</sup>Under this regard, we obtain here a result similar to the one obtained with Basle-1 (see Remark 1 to Proposition 1).

In particular, from (15.i) we can see that  $\frac{d\bar{r}_1}{di} < \frac{d\bar{r}_1^*}{di}$ : the impact of monetary policy on type 1 borrowers is lower in the constrained case than in the unconstrained one.

The result stated in Part i) of this proposition is qualitatively similar to the one obtained under Basle-1 (see Proposition 1); this is not surprising, as this part refers to the *unconstrained* bank, for which the capital requirement does not play any role (in the short run). Thus, the reaction of the banking system to a change in the monetary policy rate is to move in the same direction the interest rates applied to *both* types of borrowers: *the transmission of the monetary policy impulse through the banking sector works here in the usual way.*

Things are much different in Part ii), where the *binding* capital constraint does play a role in shaping banks' reaction to monetary policy. In particular, here we have a remarkable result: *our representative bank reacts to a change in  $i$  by moving the interest rate ( $\bar{r}_2$ ) on the riskier borrower in the opposite direction.* So, for example, an expansionary monetary policy intervention (a reduction of  $i$ ) leads the bank to increase - in the short run - the rate applied to type 2 borrowers (those having a higher risk weigh).

How can we explain such a striking result? Before we do that, it is worth defining the "average capital requirement coefficient" as follows:

$$K = k_1 \frac{L_1}{L} + k_2 \frac{L_2}{L} \quad (17)$$

so that the capital constraint  $E \geq k_1 L_1 + k_2 L_2$  may be rewritten (by dividing and multiplying the RHS by  $L$ ) as:

$$E \geq KL \quad (18)$$

This formulation stresses the fact that the average requirement ( $K$ ) depends on the composition of the loan portfolio: so for example, a shift towards the less risky borrower (increase of  $L_1$  and reduction of  $L_2$ ) implies a reduction of  $K$ , enabling the bank to expand the (unweighted) total loan portfolio  $L = L_1 + L_2$  for a given equity endowment  $E$ .

Now, suppose the central bank lowers  $i$ . This means a reduction of the return on bonds, which are the alternative asset to bank loans: therefore, the bank wants to expand its loan supply. But because of the capital constraint, she is not allowed to do so: as a consequence, the marginal cost of the constraint ( $\lambda$ ) gets larger. What is the optimal way to manage this situation? The best reaction is to shift the composition of the loan portfolio towards the less risky borrowers, in order to obtain a reduction of the average coefficient  $K$ : this enables the bank to soften the "average" capital requirement constraint (as written in eq.18). The outcome is an expansion of the total loan supply ( $L$ ), but with opposite effects on the two types of borrowers: an expansion of the loans supplied to type 1 borrowers (a reduction of  $\bar{r}_1$ , leading to an expansion of  $L_1$ ) together with a contraction of the loans supplied to type 2 borrowers (by increasing  $\bar{r}_2$  and reducing  $L_2$ ).

Such a shift from type 2 to type 1 loans may also be justified on the following grounds. Equilibrium conditions (11-12) imply, as it shown in equation (14), that the bank wants to equalize the marginal cost of the capital constraint ( $\lambda$ ) across the two types of loans. Now suppose that, starting from an initial situation where such condition is met, a monetary policy shock lowers  $i$ . As a consequence, the marginal cost of the constraint increases for both type of loans, but its change is larger for type 1 than for type 2 borrowers (being proportional to  $\frac{1}{k_j}$ , for  $j = 1, 2$ ). Therefore, the bank has an incentive to shift the allocation of its equity capital in favor of type 1 loans, in order to re-establish the equilibrium condition on the marginal cost ("shadow price") of the constraint across the two types of borrowers.

The result stated in Proposition 3 (Part ii) points to a significant difference between the new regulation and the existing one. Under Basle-1, when a bank is in a constrained position, it has no room to respond to a monetary policy impulse (in the short run, as long as  $E$  is fixed): the volume of its loans is determined by the capital constraint,<sup>38</sup> as a consequence, monetary policy is unable to alter the loan market equilibrium, when the whole banking system is affected by a lack of regulatory capital. To the contrary, under Basle-2 a constrained bank has more freedom to adjust its loan portfolio, following a monetary policy shock: indeed, it is optimal to react by altering the composition of its loans. If the whole banking system experiences a lack of capital, this adjustment process turns out having perverse effects on the riskier borrowers (those receiving higher risk weights in the calculation of the capital-to-asset ratio): an expansionary monetary policy leads to a contraction of the supply of bank loans to them (in the short run).<sup>39</sup>

In the comments to Proposition 1, we said that the empirical relevance of the constrained representative bank may be limited to rather exceptional circumstances, where the whole banking system is suffering from a lack of regulatory capital. However, there are good reasons to believe that under Basle-2 banks may more often find themselves in a constrained position, giving empirical significance to the result stated in Part ii) of Proposition 3. The basic reason for that relies in the volatility of the capital requirement, introduced by the new regulation: a cyclical downturn, for example, may induce banks to assign higher risk weights to many borrowers, leading to an increase of the "average" capital requirement ( $K$ );<sup>40</sup> this, in turn, might exhaust the "buffer capital" previously build up by a number of banks. The regulator himself implicitly recognizes that the need to maintain a buffer capital will become more stringent under the new regulation, due to the variability of risk weights.<sup>41</sup>

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<sup>38</sup>See Proposition 1 (Part ii).

<sup>39</sup>The reverse is also true: a contractionary monetary policy leads to an increase of the bank loan supply for them.

<sup>40</sup>This may be particularly relevant for those banks relying on the internal ratings approach: see the simulations reported in ECB (2001), pointing to the potential pro-cyclical impact of the new regulation. This argument confirms the result obtained by Tanaka (2001): an expansionary monetary policy becomes less effective when it is more needed, i.e. during a downturn.

<sup>41</sup>Following Principle 3 of the Second Pillar, "Supervisors should expect banks to operate above the minimum regulatory capital ratios and should have the ability to require banks to

Proposition 3 leaves open a couple of issues: i) which type of borrower is applied a higher interest rate? ii) in the unconstrained equilibrium, which type of borrower is more affected by a monetary policy impulse?<sup>42</sup> These issues are addressed in the following proposition:

**Proposition 4** *If  $\eta_1 = \eta_2$ :*

- i)  $r_2^* > r_1^*$
- ii)  $\bar{r}_2 > \bar{r}_1$
- iii)  $\frac{dr_2^*}{di} > \frac{dr_1^*}{di}$

**Proof.** i) Trivial, by comparison of eq.11 with eq.12 (with  $\lambda = 0$ )

ii) Trivial, by comparison of eq.11 with eq.12 (with  $\lambda > 0$ )

iii) Trivial, from eq.13. ■

Proposition 4 tells us that, if we are willing to make the assumption that the interest rate elasticity of loan demand is the same for the two types of borrowers<sup>43</sup> (equivalently: the market power enjoyed by the bank is the same), then we may easily prove that: a) a riskier (type 2) borrower is applied a higher interest rate than a borrower belonging to the other type, in both the unconstrained and the constrained equilibria; b) type 2 borrowers are more affected by a change of the monetary policy rate, in the unconstrained equilibrium.

### 3.4 Monetary policy transmission in the long run

Coming to the long run impact of monetary policy, we let the amount of own equity  $E$  be endogenous, so that it may be adjusted to the new value of the market interest rates, following a change of  $i$ . We keep the assumption introduced in Section 2: banks want to set the long run equilibrium level of  $E$  in such a way that they are endowed with a "buffer capital", possibly enabling them to react in the short run to a shock, without incurring in the cost of being constrained (this cost is measured by  $\lambda$  in our model). Formally, the long run equilibrium level of  $E$  is determined by:  $E = \hat{k}_1 L_1 + \hat{k}_2 L_2$ , where  $\hat{k}_1 \geq k_1$ ,  $\hat{k}_2 \geq k_2$  and  $\hat{k}_2 > \hat{k}_1$ : the "internal targets"  $\hat{k}_1$  and  $\hat{k}_2$  reflect the fact that type 2 loans are more risky, implying a higher requirement of regulatory capital ( $k_2 > k_1$ ).<sup>44</sup> Therefore, banks are endowed with a buffer capital equal to

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hold capital in excess of the minimum". Among the reasons for that, it is recognized that "In the normal course of business, the type and volume of activities will change, as will the different risk requirements, causing fluctuations in the overall capital ratio". See BIS (2001), page 110.

<sup>42</sup>This question makes sense only in the unconstrained equilibrium: in the constrained case, the interest rates applied to the two types of borrowers move in opposite directions, following a monetary policy shock (as we have shown in Part ii) of Proposition 3).

<sup>43</sup>Notice that this condition is sufficient, but not necessary, to get the results stated in Proposition 4.

<sup>44</sup>Remember that  $\hat{k}_1$  and  $\hat{k}_2$  are *long run* internal targets: in the short run (as long as  $E$  is fixed) a bank is willing to set its loans at a level such that  $E < \hat{k}_1 L_1 + \hat{k}_2 L_2$ .

$E - k_1 L_1 - k_2 L_2 \geq 0$ . The level of  $\hat{k}_1$  and  $\hat{k}_2$  is determined by balancing the estimated cost of possibly being constrained with the expected opportunity cost of equity (equal to  $\pi(1+i)E$ ).

The long run optimization problem of our representative bank is the following:

$$\begin{aligned} & \text{P4} \\ & \max_{r_1, r_2, r_D} V \\ & \text{s.to } E = \hat{k}_1 L_1 + \hat{k}_2 L_2 \end{aligned}$$

where  $V$  is the objective function (10) above and where the level  $E$  of equity is endogenous.

On the deposit side, the FOC<sup>45</sup> is still given by eq.5. On the loan side, to the contrary, equations (11-12) are now replaced by:<sup>46</sup>

$$p_1 \hat{r}_1 \left(1 - \frac{1}{\eta_1}\right) = i(1 - \pi) + p_2(1 - p_1) + \hat{k}_1 \pi(1 + i) \quad (19)$$

$$p_2 \hat{r}_2 \left(1 - \frac{1}{\eta_2}\right) = i(1 - \pi) + p_1(1 - p_2) + \hat{k}_2 \pi(1 + i) \quad (20)$$

where you will notice that the last term gives, for each type of borrower, the "marginal cost of equity", meaning the increase of the expected opportunity cost of equity, due to an additional unit of loans (making an additional unit of loans to a type  $j$  borrower induces the bank to increase its equity base by  $\hat{k}_j$ , increasing proportionally the opportunity cost of equity). Conditions (19-20) lead us to state the following proposition, regarding the long run impact of monetary policy:

**Proposition 5** *The long run impact of a change in the policy rate  $i$  on the loan rates is given by:  $\frac{d\hat{r}_j}{di} > 0$ , with  $\frac{d\hat{r}_j}{di} > \frac{dr_j^*}{di}$ , for  $j = 1, 2$ .*

**Proof.** From equations (19-20):

$$\frac{d\hat{r}_j}{di} = \frac{\eta_j}{(\eta_j - 1)} \frac{(1 - \pi + \hat{k}_j \pi)}{p_j} > 0, \quad \text{for } j = 1, 2 \quad (21)$$

Then compare eq.21 with eq.13. ■

**Remark.** The comparison between the long run impact of monetary policy and its effects on the short run *constrained* equilibrium gives the following results.

For a type 1 borrower, the impact of monetary policy is stronger in the long run than in the short run; this may be seen by combining Proposition 5 with Proposition 3 (Remark 2), obtaining:  $\frac{d\hat{r}_1}{di} > \frac{dr_1^*}{di} > \frac{d\bar{r}_1}{di}$ .

For a type 2 borrower, a change of  $i$  leads to a change in the opposite direction of the loan rate applied to him in short run (see Proposition 3, Part

<sup>45</sup>We maintain the same technical assumptions made with regard to problem P3, so that problem P4 is a concave programming problem as well.

<sup>46</sup>As we did in the preceding section, we distinguish between the long run equilibrium levels of the loan rates, denoted by  $\hat{r}_j$  ( $j = 1, 2$ ), and their short run levels, denoted by  $r_j^*$  (unconstrained) or  $\bar{r}_j$  (constrained).



ii), while it leads to a change in the same direction in the long run (Proposition 5).

Proposition 5 highlights two interesting points. First, *in the long run equilibrium such "perverse effects" of monetary policy, as the one affecting type 2 borrowers in the constrained short run equilibrium, are absent.* Therefore, for example, an expansionary monetary policy intervention (lowering  $i$ ) leads unambiguously banks to lower the interest rates applied to *both* types of borrowers. The reason for this difference between the short run and the long run bank reaction should be clear: in the former, the above mentioned perverse effect was due to the bank incentive to alter the composition of its loan portfolio, which in turn was due to the lack of regulatory capital; in the long run this problem is not there, since the bank is able to raise new capital.

Second, *the long run impact of monetary policy on the bank loan rates is stronger than the one prevailing in the short run unconstrained equilibrium.* Thus, the conclusion reached in Proposition 2 (relative to Basle-1) continues to hold under Basle-2: the presence of a capital regulation is relevant for the transmission of monetary policy, even when the banking system is well-capitalized at the time when a monetary intervention takes place (so that the capital requirement constraint is not binding); in particular, the impact of monetary policy on the loan market increases through time, as long as banks may adjust their equity base to the new level of market interest rates.<sup>47</sup>

We conclude by stating the following proposition, which extends to the long run equilibrium the results stated in Proposition 4:

**Proposition 6** *If  $\eta_1 = \eta_2$ :*

- i)  $\hat{r}_2 > \hat{r}_1$
- ii)  $\frac{d\hat{r}_2}{di} > \frac{d\hat{r}_1}{di}$

**Proof.** i) Trivial, by comparison of eq.19 with eq.20.

ii) Trivial, from eq.21. ■

It is interesting to note that, following a monetary expansion, type 2 borrowers might suffer from a contraction of the supply of bank loans in the short run (this was the "perverse effect" obtained in the constrained equilibrium), while benefiting from an expansion of the bank loan supply in the long run, even larger than the one enjoyed by type 1 borrowers. This does not come as a surprise. We have already explained the short run effect. To understand the long run effect, remember that a reduction of  $i$  makes the marginal cost of equity ( $\hat{k}_j \pi(1+i)$ ) decrease: this effect is greater for type 2 loans, since  $\hat{k}_2 > \hat{k}_1$ .

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<sup>47</sup>The reason behind this result is much the same as with Basle-1. In the long run, banks may adjust the level of  $E$ ; therefore they take into account the fact that a change, say a reduction, of  $i$  implies a reduction of what we called the "marginal cost of equity":  $\hat{k}_j \pi(1+i)$  (for  $j = 1, 2$ ). As a consequence, they are willing to raise new equity and to expand their supply of loans beyond the level reached in the short run (when  $E$  was fixed, so that the only incentive to expand loans came from the reduction of the yield on the alternative asset, i.e. bonds).

# Appendix 1

## The model with perfect competition

We consider here a version of the model, where perfect competition is assumed to prevail both in the market for bank loans and in the one for deposits; equivalently, banks are assumed to be price takers in both markets. The only modification we have to make to our model is that the demand for loans and the supply of deposits faced by each bank have infinite elasticities with respect to the interest rate applied by that bank. All the other assumptions remain unchanged. It is easy to see that the analysis carried out in this paper trivially extends to the case where  $\eta_L \rightarrow \infty$  and  $\eta_D \rightarrow \infty$ : in particular, all the results stated in the propositions continue to hold under such assumption. Therefore, in this Appendix we just go through the analysis of Section 2 ("Basle-1") and we show in detail how it can be adapted to perfect competition, leaving to the interested reader to verify that the same adaptation may be done for Section 3 ("Basle-2").

### *Short run equilibrium and monetary policy transmission*

Problem P1 may be rewritten as follows:

$$\begin{aligned} & \text{P1} \\ & \max_{L,D} V \\ & \text{s.to } E \geq kL \end{aligned}$$

where the objective function  $V$  is still given by (3); the difference is that now the bank takes  $r_L$  and  $r_D$  (in addition to  $i$ ) as given, as they are competitively determined in the market, and it maximizes  $V$  with respect to the quantities  $L$  and  $D$ .

The FOC for this problem are the following:

$$pr_L = pi + k\lambda \quad (\text{A.1})$$

$$r_D^* = i \quad (\text{A.2})$$

where  $\lambda$  is the Lagrangian multiplier for the capital requirement constraint. Not surprisingly, these conditions may be directly derived from equations (4) and (5) in the text, by taking the limit for  $\eta_L \rightarrow \infty$  and  $\eta_D \rightarrow \infty$ .

In particular, you will notice that the profit margin on the deposit taking activity is reduced to zero by competition: then (A.2) may be read as a zero-profit condition on the deposit side. The volume of deposits collected by each bank is undetermined here. However, the total volume of deposits collected by the banking system is determined by the aggregate supply of deposits, say  $\mathbf{D}(r_D)$  with  $\mathbf{D}'(r_D) > 0$ , at the level  $\mathbf{D}^* = \mathbf{D}(r_D^*)$ .

On the loan side, we still have to distinguish between an unconstrained equilibrium and a constrained one. In the first case ( $\lambda = 0$ ), condition (A.1) tells us that it must be  $r_L^* = i$ : the equilibrium loan rate is such that the profit margin on loans is nil; at this rate, each bank is willing to supply any quantity of loans, compatible with the capital requirement constraint. Again, the volume

of loans at bank level is undetermined, but the total volume is determined by the aggregate demand for loans - say  $\mathbf{L}(r_L)$  with  $\mathbf{L}'(r_L) < 0$  - at the level  $\mathbf{L}^* = \mathbf{L}(r_L^*)$ , provided  $\mathbf{L}^* < \frac{\mathbf{E}}{k}$ , where  $\mathbf{E}$  is the aggregate endowment of equity capital of the banking system as a whole.

If, to the contrary,  $\mathbf{L}^* > \frac{\mathbf{E}}{k}$ , the rate  $r_L^* = i$  cannot be an equilibrium: at such rate, the market for bank loans exhibits an excess demand equal to  $\mathbf{L}^* - \frac{\mathbf{E}}{k}$ , as the aggregate loan supply cannot be larger than  $\frac{\mathbf{E}}{k}$ . Then the equilibrium value of the loan interest rate is determined by the condition  $\mathbf{L}(\bar{r}_L) = \frac{\mathbf{E}}{k}$ . Obviously, given that  $\frac{\mathbf{E}}{k} < \mathbf{L}(r_L^*)$ , it must be  $\bar{r}_L > r_L^*$ . In this case, condition (A.1) determines the value of the Lagrangian multiplier:

$$\lambda = \frac{p(\bar{r}_L - i)}{k} > 0$$

From the above discussion, we can see that Proposition 1 continues to hold in a competitive setting. This is immediately proved, by noting that: i) in the unconstrained equilibrium:  $\frac{dr_L^*}{di} = 1$ ; ii) in the constrained equilibrium:  $\frac{d\bar{r}_L}{di} = 0$ .

*Monetary policy transmission in the long run*

Coming to the long run equilibrium, where equity is endogenous, problem P2 may be written as follows:

$$\begin{aligned} & \text{P2} \\ & \max_{L, D} V \\ & \text{s.to } E = \widehat{k}L \end{aligned}$$

where the objective function  $V$  is still given by (3) and the bank takes  $r_L$  and  $r_D$  as given.

On the deposit side, the FOC does not change, relative to the short run equilibrium (A.2). On the loan side, the FOC is now the following:

$$p\widehat{r}_L = pi + \widehat{k}(1-p)(1+i) \quad (\text{A.3})$$

where  $\widehat{r}_L$  is the long run equilibrium level of the loan interest rate. Again, this condition may be directly derived from equation (7) in the text, by taking the limit for  $\eta_L \rightarrow \infty$ .

From (A.3) we have:

$$\frac{d\widehat{r}_L}{di} = 1 + \frac{(1-p)\widehat{k}}{p}$$

Therefore, Proposition 2 continues to hold under perfect competition.

## Appendix 2

### The model without capital requirement regulation

The main focus of this paper is the impact of capital regulation, particularly of Basel-2, on the monetary policy transmission through the banking sector. We may compare the model presented in the text with one where banks are not imposed any capital requirement, in order to have a better understanding of the implications of the capital regulation. In this Appendix, we are going to do that in two steps. First, we remove from our model the capital requirement constraint, but we keep the assumption that the banking sector is subsidized by a deposit insurance. Second, we remove also the latter assumption, presenting a model of "unregulated banking".

#### *Deposit insurance without capital regulation*

We refer here to the model presented in Section 2:<sup>48</sup> let us remove the assumption that banks are imposed a capital requirement, while keeping unchanged all the other assumptions. In particular, we keep assuming that the banking sector is subsidized through a deposit insurance with flat premium, which for simplicity we set equal to zero.

Absent capital regulation, the bank optimization problem is the following:

$$\max_{r_L, r_D, E} V$$

where the objective function  $V$  is given by (3). The level of equity funding is now determined by the bank, without any constraint imposed by the regulator.

The FOC of this problem for loans and deposits are still given by equations (4.i) and (5) respectively: loan and deposit rates - and volumes - are determined as in the unconstrained equilibrium of section 2.3.

Moreover the optimal level of equity is  $E^* = 0$ . The intuition behind this results is easy to get. The bank has a clear incentive to make use of deposits as a unique source of funding, because of the subsidy implicit in the deposit insurance scheme. An additional unit of equity funding makes bank's shareholders suffer an opportunity cost equal to  $(1 + i)$ , which has to be contrasted with an expected return equal to  $p(1 + i)$ : the marginal return on bank assets  $(1 + i)$  accrues to shareholders only in case of solvency. Therefore they bear an expected opportunity cost equal to  $(1 - p)(1 + i)$ . On the other hand, adding equity does not reduce the cost of deposits, as the interest rate paid to depositors is independent of bank equity.

The above analysis implies that the impact of a monetary policy shock on the equilibrium loan interest rate is given by equation (6), with no difference between short and long run bank behavior. Not surprisingly, this impact is identical to the one obtained in the short run unconstrained equilibrium of section 2.3, where the capital requirement was not "binding".

Therefore, the capital regulation affects monetary policy transmission either in the short run constrained equilibrium (where banks lack regulatory capital),

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<sup>48</sup>We might equivalently refer to the model of Section 3, with two types of loans differing for their credit risk: this would not alter the following reasoning.

or in the long run equilibrium (where a change of  $i$  changes the cost of keeping the equity-to-loan ratio at the level  $\hat{k}$ ).

*The unregulated banking sector*

We analyze here the behavior of an unregulated banking sector, as we remove from the model of Section 2 both the assumptions that banks are imposed a capital requirement regulation and that depositors are protected through a deposit insurance (all the other assumptions remain unchanged). As a consequence, deposit supply is no longer a function of the posted interest rate ( $r_D$ ), but it is a function of the expected return on deposits, say  $D(\bar{r}_D)$ , where  $\bar{r}_D$  is defined as follows:

$$(1 + \bar{r}_D)D = p(1 + r_D)D + (1 - p)(1 + i)B \quad (\text{A.4})$$

By substituting this expression into the objective function (1) we get:

$$V = p(1 + r_L)L - (1 + \bar{r}_D)D + (1 + i)(B - E) \quad (\text{A.5})$$

and by making use of the budget constraint (2) we have:

$$V = [p(1 + r_L) - (1 + i)]L + (i - \bar{r}_D)D \quad (\text{A.6})$$

which is the objective function to be maximized by bank management.

The FOC for this problem are the following:

$$r_L^* \left(1 - \frac{1}{\eta_L}\right) = \frac{1+i}{p} - 1 \quad (\text{A.7})$$

$$\bar{r}_D^* \left(1 + \frac{1}{\eta_D}\right) = i \quad (\text{A.8})$$

The equilibrium level of equity is undetermined here, as it is the amount of bonds. The reason for that relies in the absence of deposit insurance: the return of an additional unit of equity is fully internalized to shareholders, instead of being partly appropriated by the deposit insurer. Suppose the bank raises an additional unit of equity, for given levels of deposits and loans; such unit is invested in bonds. This action is neutral from shareholders' viewpoint: from equation (A.5) you may see that the value of the bank does not change. In detail, we observe that the opportunity cost of this additional unit of equity is  $(1 + i)$ . Its expected return to shareholders is  $(1 + i)$  as well, which is made up of two components:  $p(1 + i)$  is the return on bonds going to shareholders in case of bank solvency;  $(1 - p)(1 + i)$  is the reduction of the (expected) cost of deposit taking (which for shareholders is equal to  $p(1 + r_D)D$ ): as you may see from equation (A.4), holding an additional unit of bonds allows the bank to reduce  $r_D$ , for a given level of  $\bar{r}_D$ . (The second component vanishes in presence of deposit insurance: an additional unit of bonds reduces the expected liability of the insurer by  $(1 - p)(1 + i)$ , without benefiting shareholders).

From equation (A.7) we can evaluate the impact of a monetary policy shock on the equilibrium level of the loan interest rate:

$$\frac{dr_L^*}{di} = \frac{\eta_L - 1}{\eta_L - 1} \frac{1}{p} \quad (\text{A.9})$$

This effect is greater, relative to what we obtained in presence of deposit insurance and capital requirement. By comparing equations (6) and (8) with (A.9), we see that both the short run and long run reactions of a "regulated bank" are weaker than the one of an "unregulated bank" (actually, this holds for the long run reaction if you are willing to assume that  $\hat{k} < 1$ , which is quite reasonable). Again, the reason behind this difference is to be found in the deposit insurance scheme. In presence of deposit insurance, the bank balances the expected return on loans with the expected return on the alternative asset, i.e. bonds: a monetary policy shock leading to a reduction of  $i$ , say  $\Delta i < 0$ , produces a reduction of the opportunity cost of loans equal to  $p\Delta i$ . Absent deposit insurance, to the contrary, the return on bonds is fully internalized to shareholders, for the reason explained above: therefore the reduction of the opportunity cost of loans, following the monetary policy shock, is equal to  $\Delta i$ .

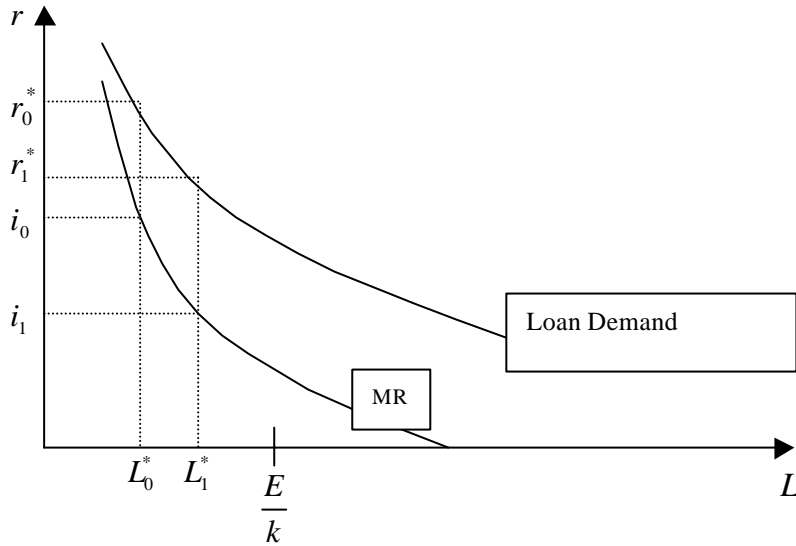
## Appendix 3

### A graphical illustration

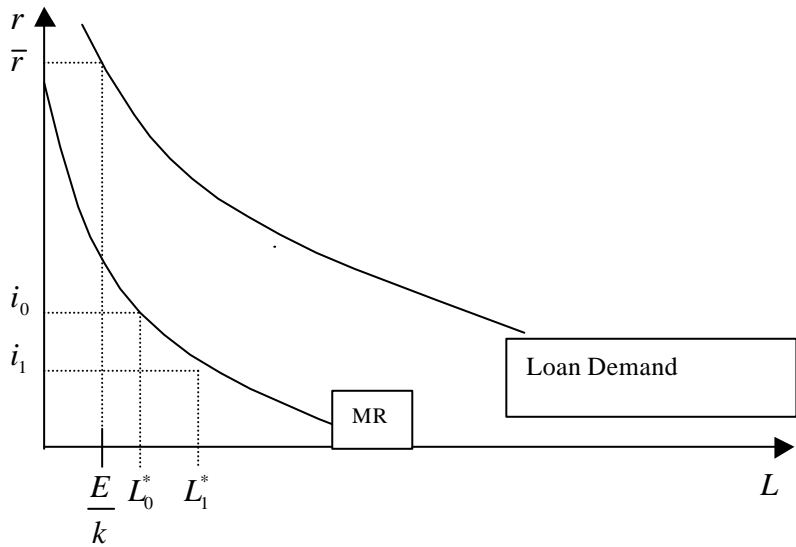
In this Appendix, we provide a graphical illustration of Propositions 1, 2 and 3 stated in the paper. The following Figures show the impact of an expansionary monetary policy intervention – lowering the policy rate from  $i_0$  to  $i_1$  – on the loan interest rate and volume for a representative bank.

**FIGURE 1: Monetary policy impact in the short run (Basel-1)**  
*(Proposition 1)*

**Fig. 1 – A: Unconstrained bank**



**Fig. 1 – B: Constrained bank**



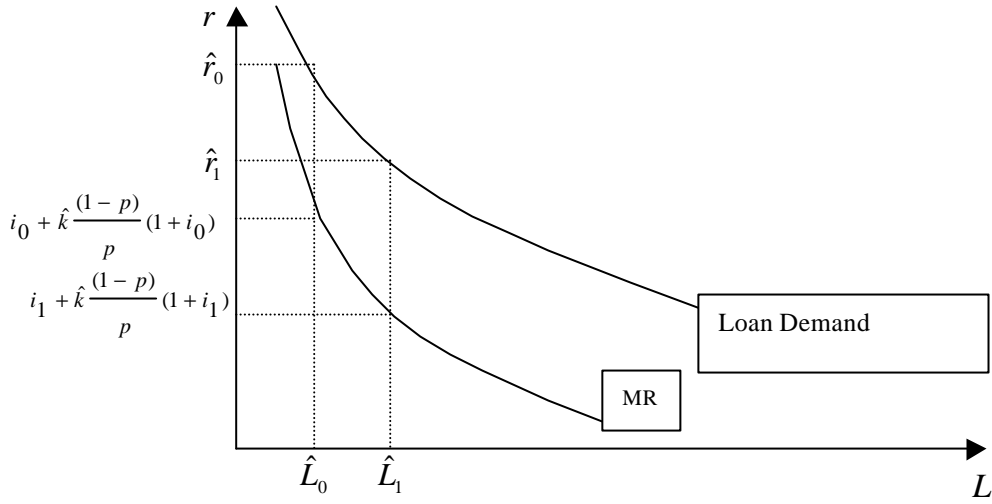
In Figure 1-A the bank has excess own equity, so that the capital requirement is not binding: the loan rate decreases from  $r_0^*$  to  $r_1^*$ , together with a volume expansion from  $L_0^*$  to  $L_1^*$ .

In Figure 1-B, to the contrary, the capital constraint is binding: the loan rate and volume stay at their constrained levels  $\bar{r}$  and  $\frac{E}{k}$  respectively.

(MR stands for Marginal Revenue on loans)

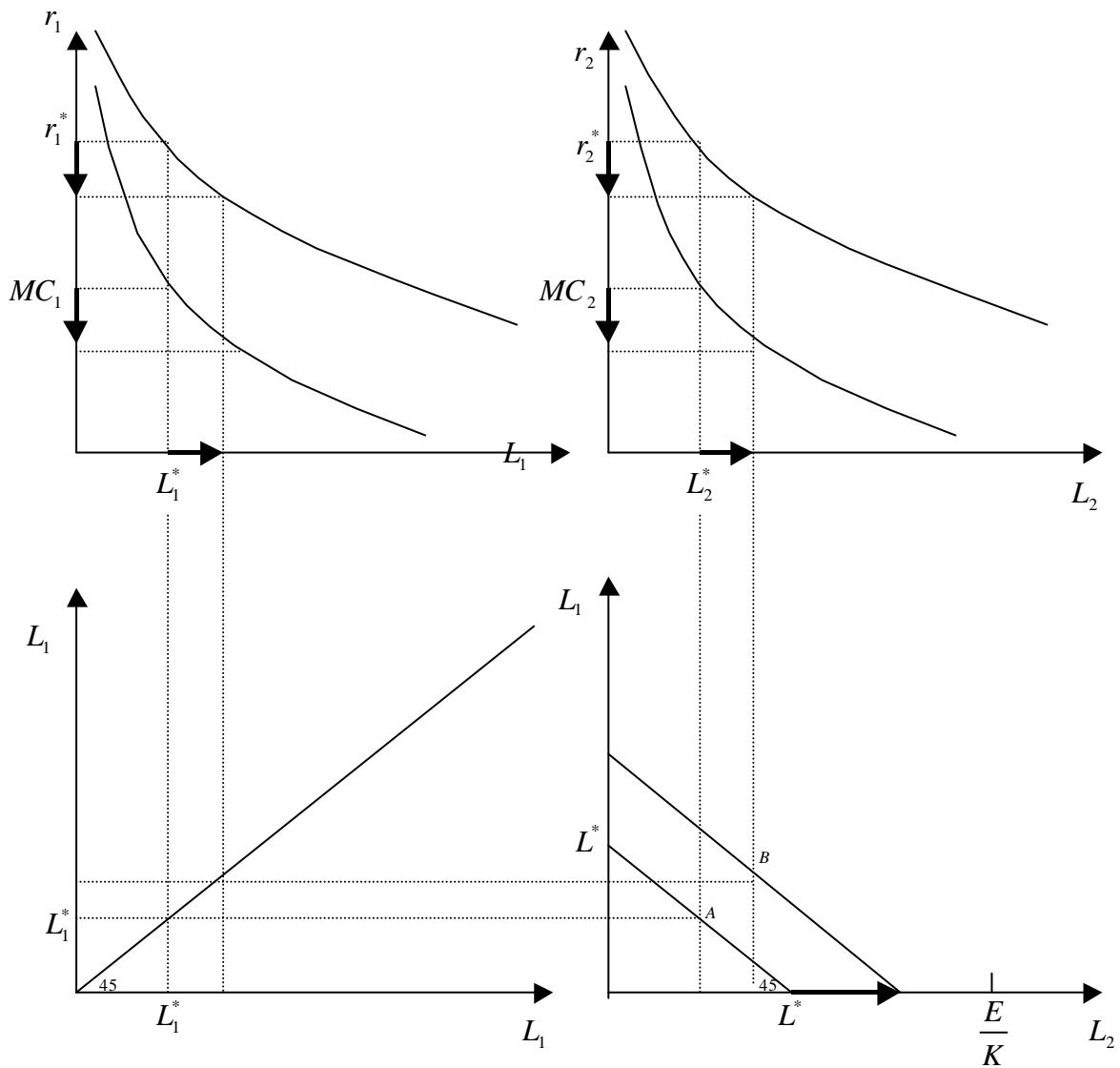


**FIGURE 2: Monetary policy impact in the long run (Basel-1)**  
*(Proposition 2)*



The bank lowers the interest rate applied on loans from  $\hat{r}_0$  to  $\hat{r}_1$ , expanding their volume from  $\hat{L}_0$  to  $\hat{L}_1$ . Notice that, following the reduction of the policy rate, the marginal cost of loans decreases by  $\left[1 + \hat{k} \frac{(1-p)}{p}\right] \Delta i$  (where  $\Delta i = i_1 - i_0$ ), whereas in Figure 1-A its change was just equal to  $\Delta i$ . This implies that  $\Delta \hat{r} > \Delta r^*$ .

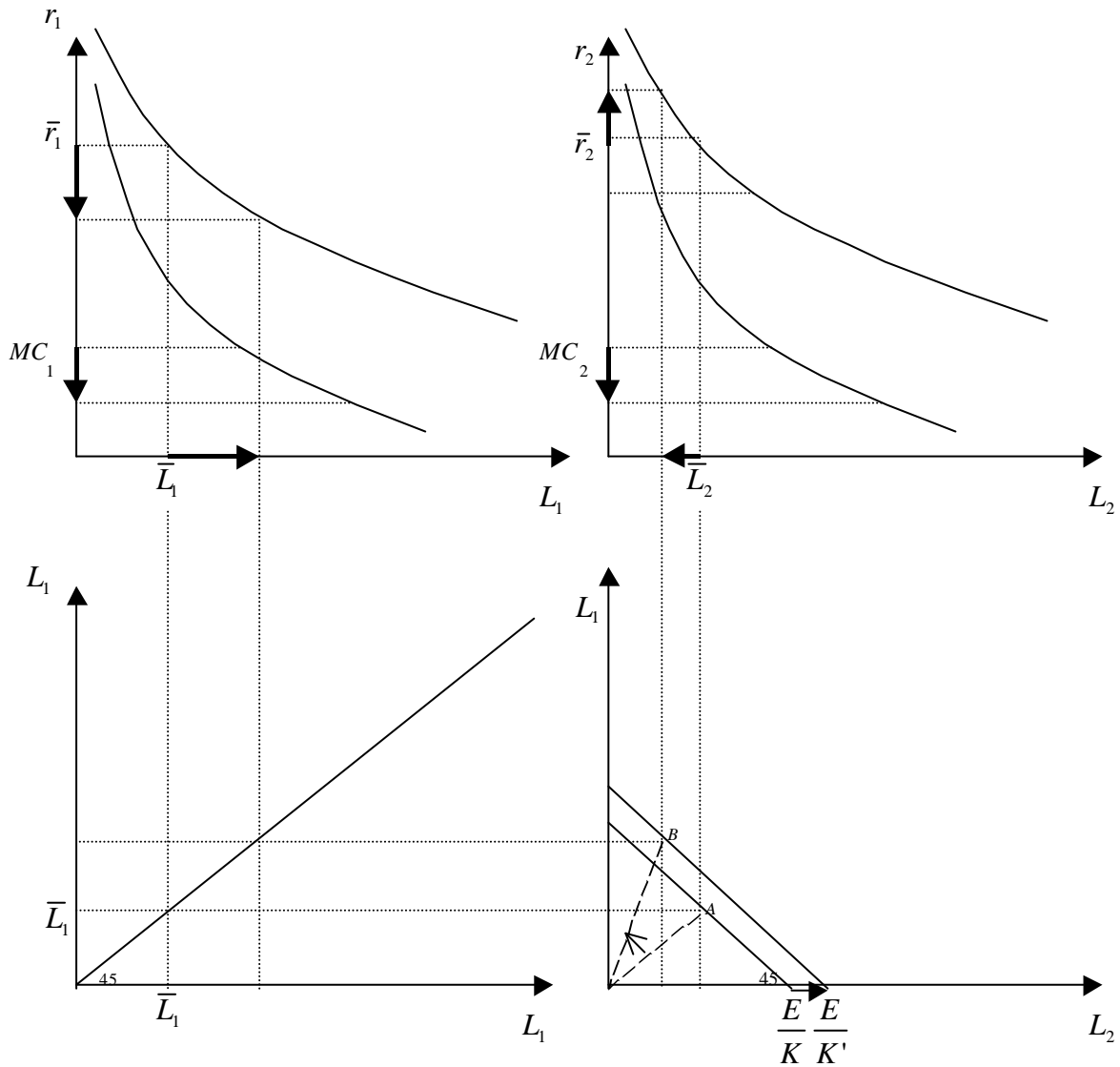
**FIGURE 3: Monetary policy impact in the short run (Basel-2)**  
*(Unconstrained bank: Proposition 3-i)*



The bank lowers the loan interest rates applied to both type 1 and type 2 borrowers ( $r_1^*$  and  $r_2^*$  respectively), expanding their volumes. The lower right-hand side of the picture shows the expansion of the total (unweighted) volume of loans ( $L^* = L_1^* + L_2^*$ ), as the bank moves from point A to point B.

( $MC_j$  (for  $j = 1,2$ ) stands for marginal cost of loans (see equations (11.i – 12.i));  $K$  is the average capital requirement coefficient defined in equation (17) )

FIGURE 4: Monetary policy impact in the short run (Basel-2)  
 (Constrained bank: Proposition 3-ii)



The bank lowers the loan interest rate applied to type 1 borrowers ( $\bar{r}_1$ ), expanding the volume  $\bar{L}_1$ ; the opposite happens for type 2 borrowers. By shifting the composition of loans towards type 1 borrowers, the bank is able to increase its total unweighted loans from  $\frac{E}{K}$  to  $\frac{E}{K'}$  (going from point A to point B).

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