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On the Relevance of Credit Market Structure to Monetary Policy

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On the Relevance of Credit Market Structure to Monetary Policy[1]

Sharon Blei[2]

Credit affects the economy via various channels: its price, collateral requirements and the extent of rationing. Would the intensity of monetary transmission be affected by the market structure of the credit industry? Using a spatial competition framework I demonstrate how credit market structure can affect the transmission of monetary policy changes into real activity via the volume of credit. The paper also points that monetary tightening may render lending unprofitable and consequently beget a credit crunch; the extent of credit market robustness to contractive monetary policy is shown to depend on its structural characteristics. (JEL E58, E59, G18, G20)

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1. INTRODUCTION

The literature identifies a number of channels by which the banking system transmits monetary policy changes. Alongside the traditional Keynesian and monetarist bank liabilities channel more recent theories emphasize the role of bank assets, stemming from credit market informational imperfections and banks' informational advantages as credit providers (see Allan S. Blinder and Joseph E. Stiglitz (1983), Ben S. Bernanke and Cara Lown (1991), Bernanke and Blinder (1992), Costas Azariadis and Bruce D. Smith (1993), Mark Gertler and Simon Gilchrist (1994), Bernanke and Gertler (1995), Allan H. Meltzer (1995), Javier Suarez and Oren Sussman (1997, 1999) and Anil K. Kashyap and Jeremy C. Stein (2000)). Bank loans affect the economy via their price, collateral requirements, borrowers' net worth and the extent of rationing – all of which are shown in the banking system structure-performance literature to be affected by the extent of competition between banks (see Marco Pagano (1993), Mitchell A. Petersen and Raghuram M. Rajan (1995) and Nicola Cetorelli (1997, 2001)). Combining the arguments raised by the credit channel literature with the ones broached by the banking system structure-performance literature leads to the hypothesis that banking system structure may, via its effects on credit accessibility, affect the intensity of the credit channel.

The idea that bank market structure can affect the effectiveness of monetary policy was initially developed by Florin Aftalion and Lawrence J. White (1977) and subsequently by David D. Vanhoose (1983). Both studies derive and contrast the effects of

two polar banking system structures - monopoly and competition - on the pass-through of changes in various monetary policy tools to deposit and loan rates. In both studies banking system structure figures as an exogenous parameter. Vanhoose (1985) examines the effect of a change in the number of banks on the Central Bank's ability to control a monetary aggregate, focusing on the market for bank deposits, where banks are engaged in Cournot competition. These works suggest that the competitive configuration of the banking system can affect monetary transmission and the choice of the monetary policy tool.

The creation of the European Monetary Union stirred anew the interest in the implications of financial system structure in general, and banking system structure in particular, on the pass-through of monetary policy changes. Since EMU member countries differ dramatically with respect to banking system structure (Kashyap & Stein (1997) find considerable heterogeneity in the characteristics of banking systems across European countries), the prospective effects of bank market configuration on monetary transmission may entail important policy implications for the ECB. Stephen G. Cecchetti (1999) argues that the differences in financial system structure between EMU countries are the primary cause for the asymmetries that these countries exhibit with respect to monetary policy transmission. In his empirical study, Mojon (2000) shows that the deregulation of European banking system enhanced the transmission of monetary policy changes to bank credit and deposit rates and that greater competition in the banking system reduces the "interest rate cycle asymmetry" of the pass-through.

Some authors have examined the causality running from monetary stance to banking

system structure. Fabio C. Bagliano, Alberto Dalmazzo and Giancarlo Marini (2000) and Linda A. Toolesma (2003) suggest that the choice of a monetary policy rule by the Central Bank affects the extent of competition in the market for bank loans. Toolsema (2003) shows that tight monetary policy impedes banks' ability to charge a lending rate above the Central Bank's policy rate; in Bagliano et al. (2000) monetary contraction favors collusion.

This paper's aim is to examine the way by which credit market structure (henceforth CMS) affects the short run transmission of monetary policy changes into real economic activity[3]. The analytical framework used for this purpose is a one period model of the market for credit, based on Steven C. Salop's (1979) circular model for spatial competition. Salop's model is a standard tool for modeling imperfect competition, and its application to the banking system is by no means a new one. David Besanko and Anjan Thakor (1992) use it to model the implications of banking deregulation; Carmen Matutes and Jorge A. Padilla (1994) apply it for analyzing bank network compatibility; Pierre-Andre Chiappori, David Perez-Castrillo and Thierry Verdier (1995) make use of it in their investigation of the effects of deposit rates regulation on the size and structure of the banking system; Jan Boukaert and Hans Degryse (1995) and Degryse (1996) use it to examine the banking competition consequences of providing bank customers with remote access to banking services and Toolsema (2003) applies it for analyzing the effects of

[3] Banks provide both deposit and credit services, yet the structural-competitive characteristics of the markets for these two types of services are not necessarily identical. In view of this paper's focus on the market for credit, I favor the term "credit market structure" over "bank market structure".

different monetary policy rules on the banking system's Lerner index.

In this study, CMS is captured by two parameters which, due to the focus on short-run analysis, are treated as exogenous: the number of banks in the economy (whose inverse is the index for banking system concentration), and borrowers' per unit "transportation cost", which is an index for the extent of differentiation between banks as credit providers. The latter parameter can be seen as summarizing various differentiating factors such as banks' deliberate long-run product differentiation strategies (specialization in lending to particular industries, market niches, etc.), credit market frictions, actual transportation costs, the technological state-of-the-art of the banking industry, banking system regulation, etc. Assuming that the so-called transportation costs are incurred by borrowers, the existence of such differentiating factors casts differentiation between borrowers with respect to credit accessibility.

The Central Bank's monetary policy tool is the discount window rate, and as a simplifying assumption, the discount window is always open[4]. Commercial banks procure liquidity from the Central Bank (there is no interbank market[5]) and offer loan contracts to entrepreneurs, who seek external funding for their projects and are assumed to have no alternative source of funding. The credit market is subjected to asymmetric information regarding entrepreneurs' credit worthiness.

The model yields either a separating equilibrium – in which unproductive

[4] This can be thought of as analogous to a monetary regime where the Central Bank conducts open market operations designed to achieve a pre-announced funds' rate target.

[5] In reality, the Central Bank lends funds to commercial banks only in the margin. This simplifying assumption would therefore not affect the model's qualitative results.

entrepreneurs are screened out – or a pooling equilibrium. Within each equilibrium, banks are endogenously configured as either monopolistic competitors or local monopolists, depending not only on the structural parameters - the number of banks and the extent of differentiation between them as credit providers – but also on the Central Bank's discount window rate. It is shown that when the banks assume the behavior of local monopolists, monetary policy changes affect the economy via a CMS-driven lending channel. Another result is that the more concentrated and differentiated the market for credit, the larger the decline in the discount window rate required for the achievement of a given expansionary effect. The model also shows that in the case of pooling loan contracts, monetary tightening may render credit extension unprofitable, thus inducing banks to withhold lending - so that the economy undergoes a credit crunch. The Central Bank therefore has an active role in assuring the viability and proper functioning of the credit market. Since it is plausible to assume that monetary policymakers would refrain from policy actions that are bound to generate a credit crunch, it can be cautiously argued that the vulnerability of the credit market to monetary tightening casts a constraint on monetary policy. CMS is shown to affect the extent to which the credit market is robust to contractive monetary policy (although the direction of the effect varies), which provides yet additional grounds for the relevance of CMS to monetary policy.

The paper is organized as follows: section I presents the theoretical framework; section II present and analyses the case where banks can offer separating loan contracts;

section III present and analyses the case where banks can offer only pooling loan contracts and section IV concludes.

2. THE MODEL

I consider a one period economy, represented by the unit circumference circle. The economy is populated by entrepreneurs whose consumption takes place in the end of the period. A single good serves as both consumption and capital good. n profit maximizing banks are located symmetrically around the circle. The banks borrow funds from the Central Bank and offer loans to entrepreneurs.

Entrepreneurs

A continuum of entrepreneurs is located around the circle, each endowed with illiquid wealth that can be liquidized in the end of the period into w units of capital. Entrepreneurs differ with respect to entrepreneurial skills: there are productive (type h) and unproductive (type ℓ) entrepreneurs. The proportion of type h entrepreneurs in the population is q.

Technology

Production is carried out through projects. At the beginning of the period, each entrepreneur faces the opportunity to start a project that requires the investment of one unit of capital. If the entrepreneur is of type h, the project yields R units of good in the end of the period. If the entrepreneur is of type ℓ, she extracts a private gain of G units of capital from the project, which eventually generates no output.

Assumption 1: $R > 1 > G > 0$.

Assumption 2: *Even if entrepreneurs' wealth had been liquid, they would have not been able to finance their projects, that is,* $w < 1$.

The Credit Market

As entrepreneurs do not possess any liquid assets, an entrepreneur who wishes to start a project has to borrow the required investment of one unit of capital from a bank (commercial banks are the only lenders in the economy). A typical loan contract specifies the loan's interest rate and collateral requirements. If a borrower fails to repay the loan, the bank seizes the collateral. Let $\{r^i , c^i\}$ denote the loan contract offered by bank i where r^i and c^i denote the gross interest rate and collateral requirements, respectively. Loan contracts are not distance-contingent.

Assumption 3: *Entrepreneurial skills are private information.*

Potential borrowers bear a transportation disutility equivalent to α units of capital per unit of length. The parameter α measures the extent of differentiation between banks as perceived by potential borrowers: the higher α, the higher the extent of differentiation. Consider a type $t \in \{h , \ell\}$ entrepreneur located $x \in \{0, 1/n\}$ units of length away from bank i, then αx is the cost that she has to incur in order to access bank i's credit. Hence, the higher α and/or the larger the distance between a potential borrower and a given bank, the higher the cost of credit accessibility that she faces when applying for that particular bank's credit. Since both banks and entrepreneurs are distributed around the

circle, the latter differ with respect to credit accessibility.

The cost of accessing credit can be thought of as reflecting the cumulative effects of various factors such as banks' deliberate medium/long run strategic choices (specialization in lending to particular industries[6] local credit markets or market-niches), the supply of services other than loans such as thrift, auditing and consultancy, the degree of potential borrowers' informational opaqueness, the technological state-of-the-art of the banking industry (the use of sophisticated technological tools by financial institutions is likely to diminish the extent of differentiation between banks), the effects of banking supervision – and last but not least - actual geographical distance and transportation costs.

Empirical studies indicate that the actual distance between firms and banks is highly relevant to the price and availability of bank commercial credit. Timothy H. Hannan (1991) presents evidence pointing at the local nature of the market for bank loans. Kenneth P. Brevoort & Hannan (2004) find that distance negatively affects the likelihood of a local commercial loan being made and that this effect consistently increases the smaller the size of the bank; the bulk of their findings indicate that the importance of distance is increasing in U.S local market lending. Degryse & Steven Ongena (2005) present empirical results showing that geographical distance between firms, the lending bank and other banks in the vicinity affect loan conditions. Moreover, from a variety of

[6] The unit circumference circle can be thought of as a spectrum of industries where each bank specializes in lending to a specific industry. In this sense, the farther the location of an entrepreneur from a given bank, the higher the cost that the bank incurs when evaluating that entrepreneur's loan application. Assuming that banks charge loan applicants for the cost of evaluating their applications, a potential borrower's cost of accessing a given bank's credit will be higher the longer the distance between them.

exercises they infer that transportation costs are the primary cause for spatial price discrimination they observe. They also find that distance remained an important factor in determining the price and availability of credit over their sample period (1975 – 1997) – a finding indicating that technological developments in communication and travel have not yet diminished the relevance of distance in the Belgian credit market.

Let $V_t^i(x)$ denote the surplus that a type t entrepreneur located $x \in \{0, 1/n\}$ units of length away from bank i can attain by accepting the bank's loan contract, then:

$$V_t^i(x) = \begin{cases} R - r^i - \alpha x & for \quad t = h \\ G - c^i - \alpha x & for \quad t = \ell \end{cases} \tag{1}$$

Let bank i's closest neighbor be denoted bank $\circ$; then, the entrepreneur is interested in borrowing from bank i if she considers the loan contract it offers to be both beneficial and preferable to the one offered by bank $\circ$, that is, if $V_t^i(x) \geq \max\{0\ ,\ V_t^o(\frac{1}{n} - x)\}$.

Let $\bar{x}_t^i$ denote the location of a type t entrepreneur that is indifferent between starting her project using bank i's funding to giving it up, then $\bar{x}_t^i$ marks the border of bank i's potential monopoly market (to the right and to the left). By definition, $V_t^i(\bar{x}_t^i) = 0$. Therefore:

$$\bar{x}_t^i = \begin{cases} \dfrac{R - r^i}{\alpha} & for \quad t = h \\ \dfrac{G - c^i}{\alpha} & for \quad t = \ell \end{cases}$$

(2)

Let $\hat{x}_t^i$ denote the location of a type *t* entrepreneur that is indifferent between the loan contracts offered by bank *i* and bank ∘, then $\hat{x}_t^i$ marks the border of bank *i*'s potential monopolistic competition market (to the right and to the left). By definition, $V_t^i(\hat{x}_t^i) = V_t^o(\frac{1}{n} - \hat{x}_t^i)$. Therefore:

$$\hat{x}_t^i = \begin{cases} \dfrac{r^o - r^i + \frac{\alpha}{n}}{2\alpha} & for \quad t = h \\ \dfrac{c^o - c^i + \frac{\alpha}{n}}{2\alpha} & for \quad t = \ell \end{cases} \tag{3}$$

Let $x_t^i \in \{0, 1/n\}$ denote the distance between bank *i* and its marginal type *t* borrower, then:

$$x_t^i = \min\{\bar{x}_t^i, \hat{x}_t^i\} \tag{4}$$

Thus, when $\bar{x}_t^i \le \hat{x}_t^i$ bank *i* faces an actual monopoly market, whereas when $\hat{x}_t^i \le \bar{x}_t^i$ it faces an actual monopolistic competition market. Substituting equations (2) and (3) into equation (4) for each type of entrepreneur obtains

$$x_h^i = \begin{cases} \bar{x}_h^i & if \quad r^i \ge 2R - \dfrac{\alpha}{n} - r^o \\ \hat{x}_h^i & otherwise \end{cases} \tag{5a}$$

$$x_\ell^i = \begin{cases} \bar{x}_\ell^i & if \quad c^i \geq 2G - \dfrac{\alpha}{n} - c^o \\ \hat{x}_\ell^i & otherwise \end{cases} \tag{5b}$$

Other things being equal, the loan contract offered by a bank determines the location of its marginal borrower, and thereby the demand for its loans. Let $L_h^i(x_h^i) = 2qx_h^i$ and $L_\ell^i(x_\ell^i) = 2(1-q)x_\ell^i$ denote the demand for loans addressed to bank *i* by type *h* and type ℓ entrepreneurs, respectively, then:

$$L_h^i(x_h^i) = \begin{cases} \dfrac{2q(R-r^i)}{\alpha} & if \quad r^i \geq 2R - \dfrac{\alpha}{n} - r^o \\ \dfrac{q(r^o - r^i + \frac{\alpha}{n})}{\alpha} & otherwise \end{cases} \tag{6}$$

$$L_\ell^i(x_\ell^i) = \begin{cases} \dfrac{2(1-q)(G-c^i)}{\alpha} & if \quad c^i \geq 2G - \dfrac{\alpha}{n} - c^o \\ \dfrac{(1-q)(c^o - c^i + \frac{\alpha}{n})}{\alpha} & otherwise \end{cases} \tag{7}$$

Since type *h* entrepreneurs always repay their loans, they are indifferent to collateral requirements and are concerned only by debitory rates; type ℓ entrepreneurs, who never repay their loans, are concerned only by collateral requirements[7].

[7] The assumption that type *h* borrowers always repay their loans while type ℓ borrowers always default is a workable approximation to a more realistic yet cumbersome structure, in which type *h* entrepreneurs are characterized by a high probability to succeed and therefore, to repay their loans, whereas type ℓ entrepreneurs have a low probability to succeed and therefore, are more likely to default. Assuming entrepreneurs are conscious of their chances to succeed, type *h* entrepreneurs' borrowing decisions will be more sensitive to interest rates than to collateral requirements, whereas type ℓ entrepreneurs' borrowing

Equilibrium Collateral Levels

As entrepreneurial talent is private information and type ℓ entrepreneurs never repay their loans, the credit market suffers from adverse selection on the part of type ℓ entrepreneurs. As in Helmut Bester (1985) and Besanko and Thakor (1987), collateral can be used as a screening and loss-minimizing device.

Proposition 1: *Equilibrium loan contracts are either separating or pooling, depending on the comparative values of the parameters G and w.* (*i*) *If* $G \leq w$*, banks offer separating loan contracts stipulating an equilibrium collateral level* $c^s = G$ *(the superscript s stands for "separating").* (*ii*) *If* $G > w$*, banks offer pooling loan contracts (if any) stipulating an equilibrium collateral requirement* $c^p = w$ *(the superscript p stands for "pooling").*

Proof: Since type ℓ entrepreneurs always default on their loans, banks would rather screen away such borrowers. To discourage all type ℓ entrepreneurs from applying for its loans, a bank has to set a collateral level that exceeds the private gain that a type ℓ entrepreneur extracts from her project. Such a policy is feasible only if $G \leq w$ and its corresponding optimal collateral level is $c^s = G$[8]. If, alternatively, $w < G$, collateral

decisions will be affected to a greater extent by collateral requirements than by interest rates.

[8] Although the bank can require borrowers to pledge any collateral between G and w, there is no point in requiring collateral higher than G. Given that any collateral level higher than G will be as good as G in terms of screening out type ℓ borrowers, it is assumed that the equilibrium level of collateral is G.

cannot serve as a means of screening borrowers; it can nevertheless be used to minimize losses. To discourage as many type ℓ entrepreneurs as possible from borrowing and to minimize the losses inflicted by lending to those who remain undiscouraged, the banks will require borrowers to pledge the highest feasible collateral - their entire wealth. The equilibrium collateral level under pooling loan contracts will therefore be $c^p = w$[9]. As will be shown later in section III, banks may rather withhold credit altogether than offer pooling loan contracts: if banks' potential losses from lending to type ℓ entrepreneurs outweigh their potential gains from lending to type h ones they will refrain from providing credit to borrowers.

3. EQUILIBRIUM IN THE CASE OF SEPARATING LOAN CONTRACTS

Credit market equilibrium

Banks can borrow any amount of funds from the Central Bank at a gross discount window rate ϕ. The process by which the Central Bank sets ϕ is beyond the scope of this paper; ϕ is therefore treated as a parameter. Let bank i's profit under separating loan contracts be denoted by $\Pi^i\big|_{c^s=G} = L_h^i(x_h^i)(r^i - \phi)$ and let $\bar{r}^i$, $\hat{r}^i$ and $\tilde{r}^i$ denote bank i's debitory rates for which $\bar{x}_h^i < \hat{x}_h^i$, $\hat{x}_h^i < \bar{x}_h^i$ and $\bar{x}_h^i = \hat{x}_h^i$, respectively. By definition, $\bar{r}^i > 2R - \alpha / n - r^o$, $\tilde{r}^i = 2R - \alpha / n - r^o$ and $\hat{r}^i < 2R - \alpha / n - r^o$. Bank i's profit maximization

[9] As will be shown in section III, banks may rather withhold credit altogether than offer pooling loan contracts: if banks' potential losses from lending to type ℓ entrepreneurs outweigh their potential gains from lending to type h ones, they will refrain from providing credit to borrowers.

problem is given by:

$$\begin{bmatrix} \bar{r}^{is} \\ \hat{r}^{is} \end{bmatrix} \equiv \arg\max \begin{bmatrix} \frac{2q}{\alpha}\left(R-\bar{r}^{i}\right)\left(\bar{r}^{i}-\phi\right) \\ \frac{q}{\alpha}\left[r^{o}-\hat{r}^{i}+\frac{\alpha}{n}\right]\left(\hat{r}^{i}-\phi\right) \end{bmatrix} \tag{8}$$

$$s.t. \quad \bar{r}^{i} > 2R-\frac{\alpha}{n}-r^{o} \quad , \quad \hat{r}^{i} < 2R-\frac{\alpha}{n}-r^{o}$$

Solving (8) and using the symmetry between banks yields the following equilibrium interest rates:

$$r^{s} = \begin{cases} \bar{r}^{s} = \dfrac{\phi+R}{2} & for \quad \dfrac{\alpha}{n} \geq R-\phi \\ \tilde{r}^{s} = R-\dfrac{\alpha}{2n} & for \quad \dfrac{2}{3}(R-\phi) < \dfrac{\alpha}{n} < R-\phi \\ \hat{r}^{s} = \phi+\dfrac{a}{n} & for \quad \dfrac{\alpha}{n} \leq \dfrac{2}{3}(R-\phi) \end{cases} \tag{9}$$

Lemma 1: *The comparative values of the compound structural parameter α/n, projects' output, R, and the discount window rate, ϕ, determine the competitive configuration of the credit market: $\alpha/n \leq 2/3(R-\phi)$ generates a monopolistic competition configuration; $\alpha/n \geq R-\phi$ yields a local monopolies configuration and $2/3(R-\phi) < \alpha/n < R-\phi$ produces a hybrid configuration - a convergence of the monopolistic competition and the local monopolies configurations.*

Substituting for $\bar{r}^{s}$, $\tilde{r}^{s}$ and $\hat{r}^{s}$ in equation (6) and using the symmetry between banks obtains:

$$x_h^s = \begin{cases} \bar{x}_h^s = \dfrac{R-\phi}{2\alpha} & for \quad \dfrac{\alpha}{n} \geq R-\phi \\ \tilde{x}_h^s = \dfrac{1}{2n} & for \quad \dfrac{2}{3}(R-\phi) < \dfrac{\alpha}{n} < R-\phi \\ \hat{x}_h^S = \dfrac{1}{2n} & for \quad \dfrac{\alpha}{n} \leq \dfrac{2}{3}(R-\phi) \end{cases} \tag{10}$$

Where $\tilde{x}_h^s$ denotes the distance between a bank and its marginal type *h* borrower in the hybrid case, in which $\hat{x}_h^s$ and $\bar{x}_h^s$ converge. Equation (10) can be rewritten as:

$$x_h^s = \min\left\{\frac{1}{2n} \quad , \quad \frac{R-\phi}{2\alpha}\right\} \tag{10'}$$

A bank's market region occupies $2x_h^s$ units of length. Thus, the amplitude of a bank's market under the hybrid and the monopolistic competition configurations depends solely on the number of banks in the system, *n*, whereas under local monopolies it is invariant to *n*. Furthermore, the amplitude of a bank's market under local monopolies is smaller than 1/*n*. Given banks' symmetric distribution around the circle, it follows that every two neighboring local monopolies are separated from one another by a buffer zone of $(1/n)-(R-\phi)/\alpha$ units of length. As the number of banks in the system increases, individual markets remain unchanged, yet the buffer zones narrow. When the number of banks reaches $\alpha/(R-\phi)$ the buffer zones disappear. Figure 1 provides a mapping of credit market equilibrium configurations under separating loan contracts.

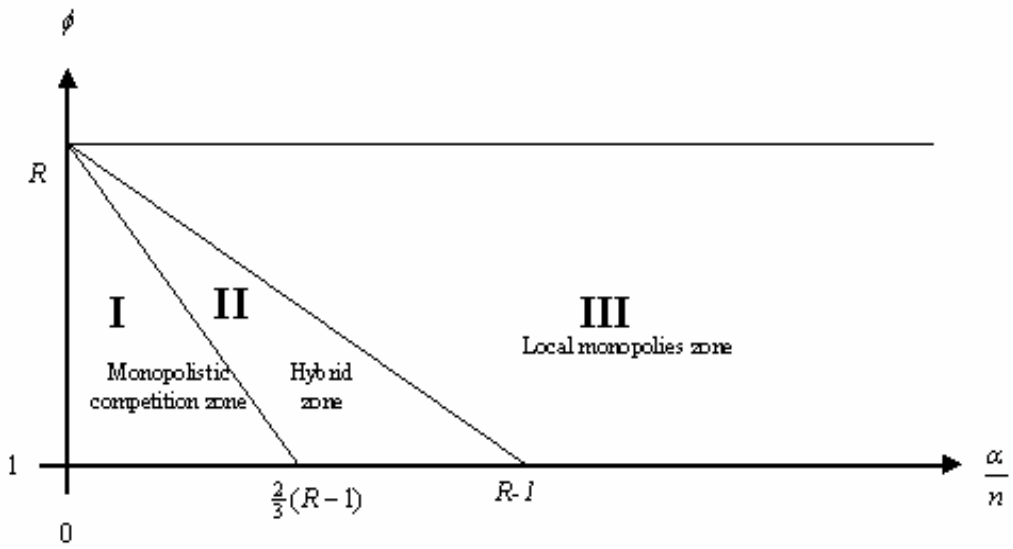

Figure 1. A Mapping of Credit Market Equilibria under Separating Loan Contracts

The real effects of monetary policy under separating loan contracts

Let b_h^s denote the equilibrium proportion of type *h* borrowers in the type *h* population under separating loan contracts, then:

$$b_h^s = \min\left\{1 \quad , \quad \frac{R-\phi}{\alpha / n}\right\} \tag{11}$$

Equation (11) implies that under both the hybrid and the monopolistic competition configurations all type *h* entrepreneurs borrow, whereas under local monopolies only part of them do. The explanation is straightforward: the local monopolies configuration is the only one that introduces buffer zones between the markets of neighboring banks; type *h*

entrepreneurs that are located within these buffer zones do not borrow.

Given that the economy-wide population of type *h* entrepreneurs is *q,* the number of type *h* borrowers, and hence, the number of projects established in the beginning of the period, is qb_h^s. By the end of the period these projects mature and yield *R* units of good each. Let y^s represent the economy's total output, then, using equation (11):

$$y^s = Rq \cdot \min\left\{1 \quad , \quad \frac{R-\phi}{\alpha / n}\right\} \tag{12}$$

Proposition 2: *(i) Under both the monopolistic competition and the hybrid configurations all type h entrepreneurs borrow, so that output reaches its maximal level of Rq units of good. (ii) Under the local monopolies configuration only a proportion (R-ϕ)/(α/n) < 1 of type h entrepreneurs borrow, so that output is inferior to its maximal level and mounts to Rq(R-ϕ)/(α/n) units of good.*

Proposition 3: *(i) Whenever the credit market is segmented into local monopolies, the Central Bank can expand the economy's output by lowering the discount window rate. (ii) The larger the extent of differentiation between banks, α, the larger the decline in the discount window rate that generates a given expansionary effect.*

Proof: Corollary (i): according to proposition 2, under both the hybrid and the monopolistic competition configurations output attains its maximal level of *Rq* units of

good, which is invariant to ϕ. Therefore, monetary policy cannot generate real effects within these configurations. Under local monopolies, however, output is inferior to its maximal level and is negatively related to the discount window rate; thus a reduction (augmentation) of the discount window rate generates economic expansion (contraction). Corollary (ii): let $\bar{y}^s$ denote output under local monopolies, then $\partial\bar{y}^s / \partial\phi = -Rqn/\alpha$. Hence a change in the discount window rate induces a change in the opposite direction in $\bar{y}^s$. Since $\partial\bar{y}^s / \partial\phi\partial(\alpha/n) = Rq/(\alpha/n)^2$, the more differentiated and concentrated the credit market, the milder the negative effect that a given rise in the discount window rate bears on $\bar{y}^s$. The explanation for this outcome is simple. Under local monopolies, a single bank's market range is $(R-\phi)/\alpha$. Hence, the higher α, the milder the negative effect of a given rise in ϕ on a single bank's market region and thereby on the number of type *h* entrepreneurs that borrower from it and the output they produce. The fewer the number of banks in the economy, the weaker the economy-wide manifestation of an increase in ϕ on the overall volume of type *h* borrowers and on output. Thus, the more differentiated and concentrated the credit market, the milder the real effect of a given change in the discount window rate. Alternatively, the more differentiated and concentrated the credit market, the larger the change in the discount window rate required for the achievement of a given real effect.

Figure 2 provides a mapping of output levels under separating loan contracts. The downward slopping lines projecting in a fan-like pattern from the point (*0* , *R*) across the

local monopolies zone are iso-output lines. An iso-output line depicts all the combinations of ϕ and α/n that sustain a given level of output[10]. Higher iso-output lines correspond to lower output levels: the highest iso-output line corresponds to zero output whereas the lowest iso-output line corresponds to the maximal level of output, Rq units of good. Note that the lowest iso-output line traces the border between the hybrid and the local monopolies zones; all combinations of ϕ and α/n that fall below it sustain the maximal level of output. The iso-output line that corresponds to an output of $\bar{y}_0^s$ units of good is given by

$$\phi = R - \frac{\bar{y}_0^s}{Rq} \cdot \frac{\alpha}{n} \tag{13}$$

Equation (13) entails monetary policy implications:

Proposition 4: *(i) When the credit market is segmented into local monopolies, the preservation of a given output level* $\bar{y}_0^s$ *requires that a unit rise in* α/n *be compensated for by a* $\bar{y}_0^s / Rq < 1$ *units drop in the discount window rate. (ii) The higher the level of output to be sustained, the larger the extent by which the discount window rate has to fall in order to compensate for a unit rise in* α/n.

[10] Note that at the point $\phi = R$ the level of output is undetermined.

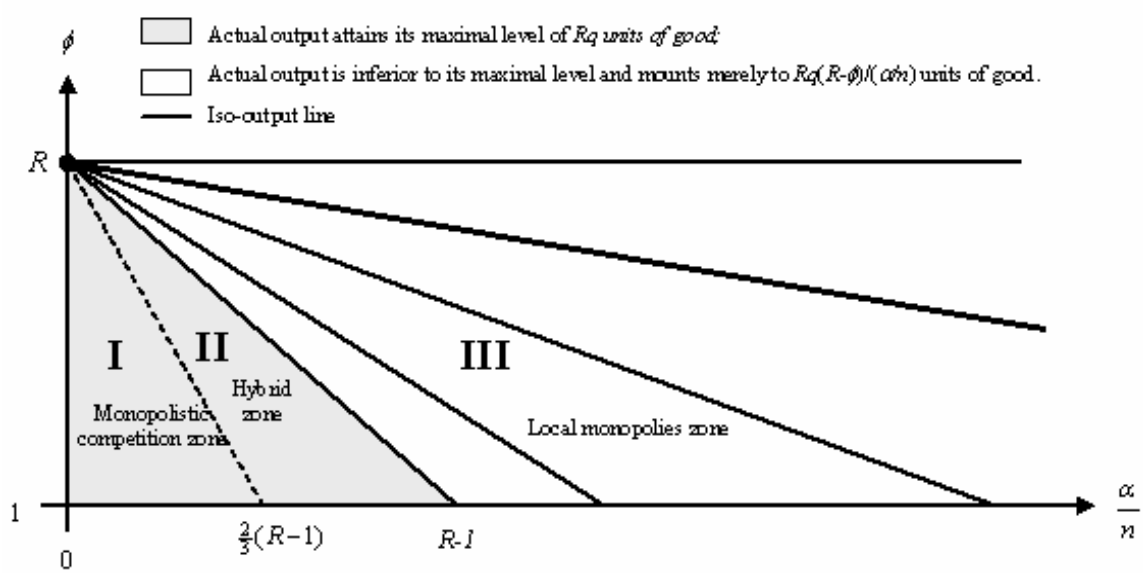

Figure 2: A Mapping of Output Levels under Separating Loan Contracts

4. EQUILIBRIUM IN THE CASE OF POOLING LOAN CONTRACTS

Pooling loan contracts introduce the possibility of a credit crunch – an overall collapse of the market for bank loans. The inevitable presence of type ℓ borrowers may render lending unprofitable, thus inducing banks to withhold loans. As shall be shown in section III subsection B, monetary policy can play an active role both in the prevention and in the eventuality of a credit crunch.

Credit market equilibrium

Substituting $c^i = w$ in equation (7) obtains type ℓ entrepreneurs' equilibrium demand

for the loans of a single bank under pooling loan contracts[11]:

$$L_\ell^p(x_\ell^p) = \begin{cases} \dfrac{2(1-q)(G-w)}{\alpha} & if \quad \dfrac{\alpha}{n} \geq 2(G-w) \\ \\ \dfrac{1-q}{n} & otherwise \end{cases} \tag{14}$$

Credit market Nash equilibrium under pooling loan contracts is obtained in two stages. First, each bank sets a profit-maximizing debitory rate, taking as given the behavior of its neighbors. Then, if the maximized profit is non-negative, the bank chooses to provide loans; if the maximized profit is negative, it will refrain from lending.

Bank *i*'s profit under pooling loan contracts is obtained by deducing the loss inflicted by loans extended to type ℓ borrowers from the gain on loans extended to type *h* borrowers:

$$\Pi^i\Big|_{c^p=w} = L_h^i(x_h^i)(r^i - \phi) - L_\ell^p(x_\ell^p)(\phi - w) \tag{15}$$

Due to the separability in solving for debitory rates and collateral requirements, the optimal debitory rates under pooling loan contracts are identical to the ones obtained under separating loan contracts:

$$r^p = r^s \tag{16}$$

The equilibrium distance between a bank and its marginal type *h* borrower under pooling

[11] Equation (14) indicates that under pooling loan contracts type ℓ entrepreneurs' demand for the loans of a single bank depends on the comparative values of α/n and G-w. The explanation for this is the following. The transportation disutility incurred by a type ℓ borrower that is located in the midway between a bank and its closest neighbor is equivalent to a cost of $\alpha/2n$ units of capital, while the surplus she extracts is G-w units of capital. Hence, as long as $\alpha/n \leq 2(G\text{-}w)$, all type ℓ entrepreneurs that lie within $1/2n$ units of length from a bank would like to borrow from it, so that the demand for loans faced by each bank is $(1\text{-}q)/n$.

loan contracts is, consequently, the same as under separating loan contracts:

$$x_h^p = x_h^s \tag{17}$$

Thus, x_h^p can take one of three forms (denoted $\bar{x}_h^p$, $\tilde{x}_h^p$ and $\hat{x}_h^p$) depending on the comparative values of α/n and R-ϕ, whereas x_ℓ^p can take one of two forms ($\bar{x}_\ell^p$ and $\hat{x}_\ell^p$), depending on the comparative values of α/n and G-w (see equation (14)). In the two-dimensional [α/n , ϕ] space, let

zone I denote all the combinations of α/n and ϕ for which $x_h^p = \hat{x}_h^p$ and $x_\ell^p = \hat{x}_\ell^p$;

zone II denote all the combinations of α/n and ϕ for which $x_h^p = \tilde{x}_h^p$ and $x_\ell^p = \hat{x}_\ell^p$;

zone III denote all the combinations of α/n and ϕ for which $x_h^p = \bar{x}_h^p$ and $x_\ell^p = \hat{x}_\ell^p$;

zone IV denote all the combinations of α/n and ϕ for which $x_h^p = \bar{x}_h^p$ and $x_\ell^p = \bar{x}_\ell^p$;

zone V denote all the combinations of α/n and ϕ for which $x_h^p = \tilde{x}_h^p$ and $x_\ell^p = \bar{x}_\ell^p$;

zone VI denote all the combinations *of* α/n and ϕ for which $x_h^p = \hat{x}_h^p$ and $x_\ell^p = \bar{x}_\ell^p$;

Given that banks value only type h entrepreneurs as desired borrowers, market configurations under pooling loan contracts will be defined by x_h^p. Thus zones I and VI are defined as monopolistic competition zones, zones II and V as intermediate zones, and zones III and IV as monopolistic competition zones.

Lemma 2: *The number of pooling equilibrium zones in the two-dimensional* [α/n , ϕ] *space varies between four and six, depending on the comparative values of R and G-w:*

When 2(G-w) > R-1 *there exist four equilibrium zones (zones I – IV);* *When 2*(*R*-1)/3 < 2(*G-w*) < *R*-1 *there exist five equilibrium zones (zones I – V);* *When G-w* < (*R*-1)/3 *there exist six equilibrium zones (zones I – VI).*

Proof: see the Appendix.

Figures 3 - 5 provide mappings of the equilibrium zones under pooling loan contracts:

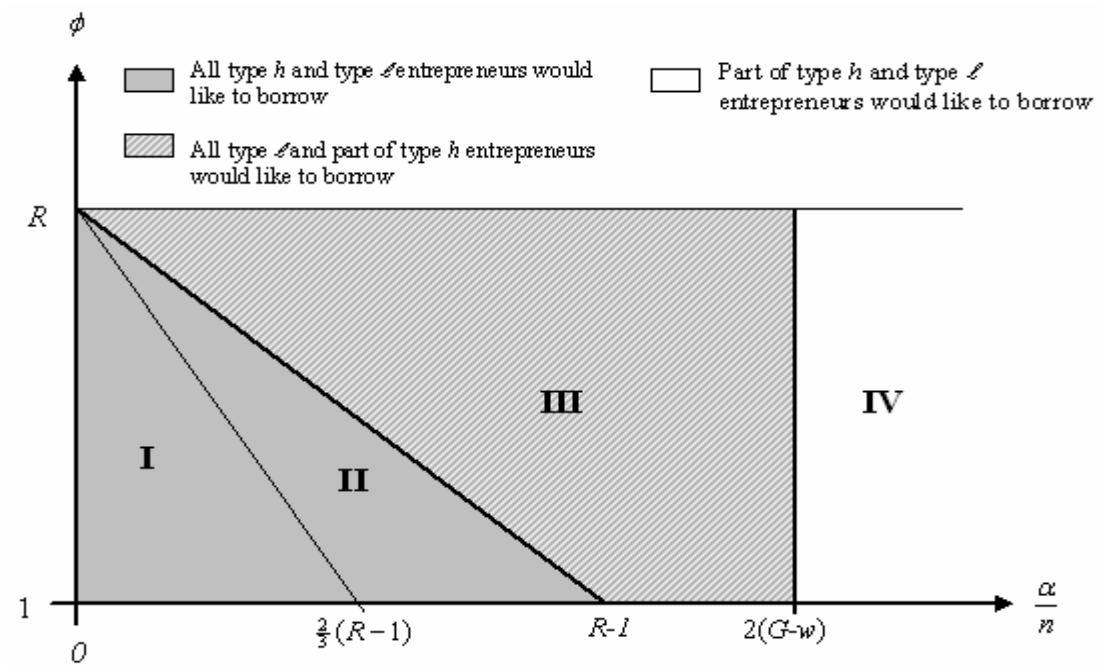

Figure 3: A Mapping of Credit Market Equilibria under Pooling Loan Contracts When 2(*G – w*) > *R-1*

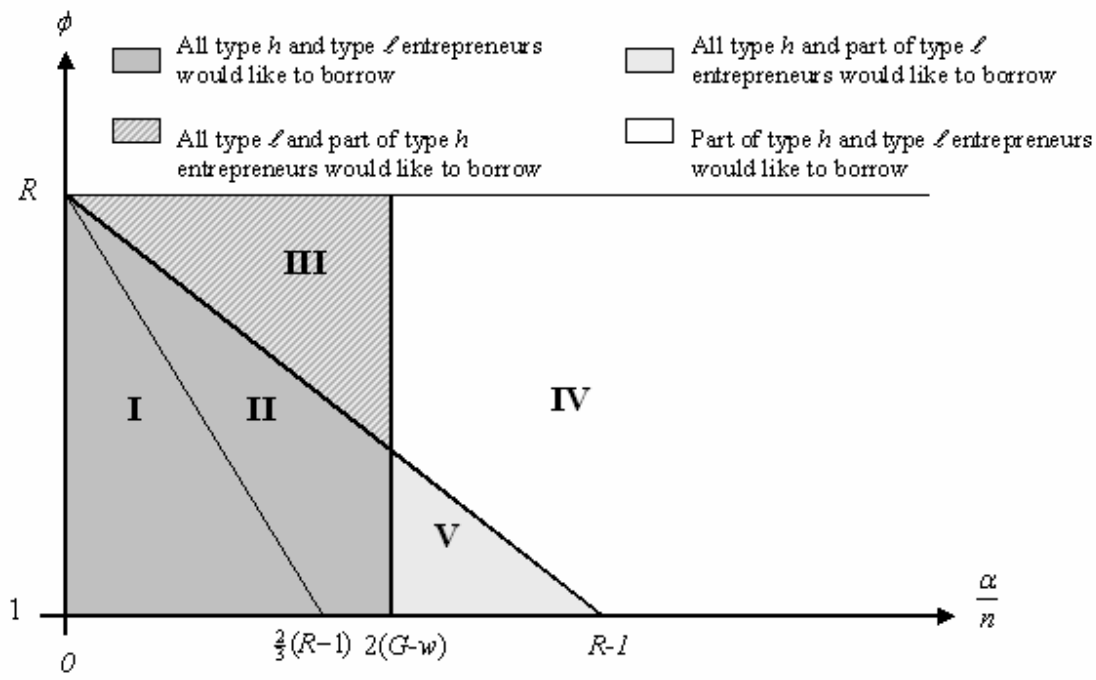

Figure 4: A Mapping of Credit Market Equilibria under Pooling Loan Contracts When $2(R-1)/3 < 2(G-w) < R-1$

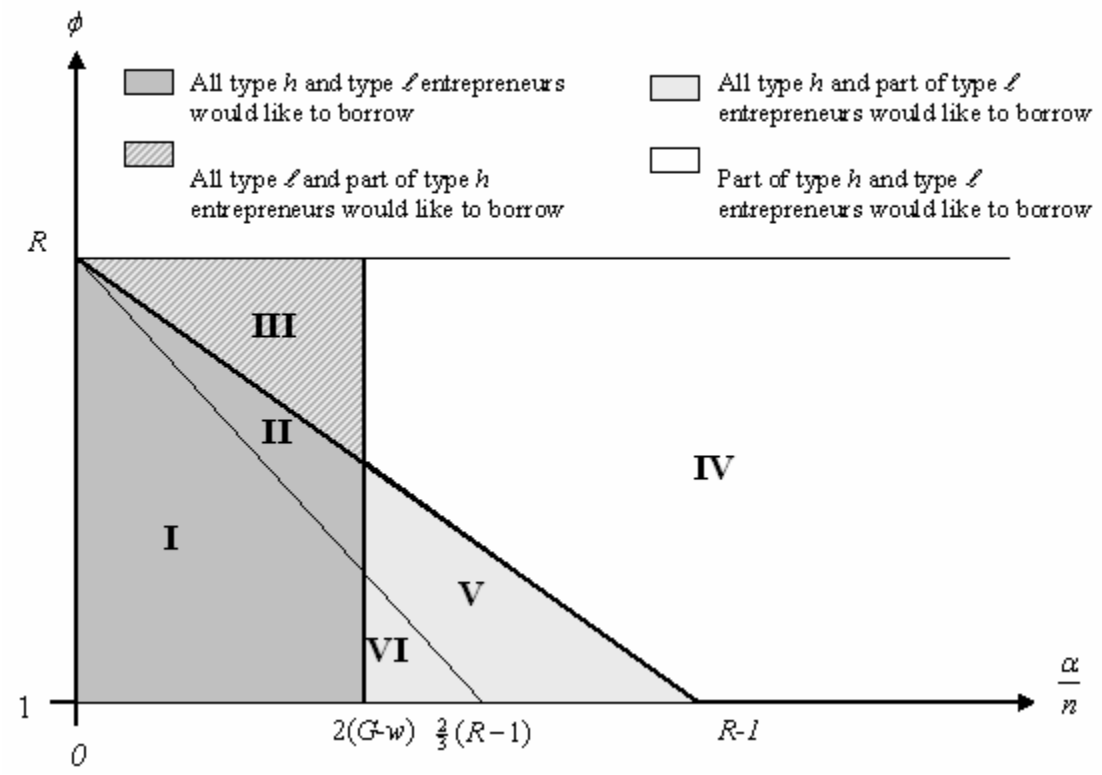

Figure 5: A Mapping of Credit Market Equilibria under Pooling Loan Contracts When $G - w < (R-1)/3$

The presence of type ℓ borrowers may render lending unprofitable. Clearly, a bank will choose to extend loans only if it can make non-negative profits. Let λ^p reflect a single bank's equilibrium decision as to whether to provide loans or not. Then:

$$\lambda^p = \begin{cases} 1 & if \quad \Pi^p \geq 0 \\ 0 & if \quad otherwise \end{cases} \tag{18}$$

The real effects of monetary policy under pooling loan contracts

Given that only type h entrepreneurs can produce industrial output, the economy's output under pooling loan contracts is captured by:

$$y^p \equiv \lambda^p Rq \cdot \min\left\{1 \quad , \quad \frac{R-\phi}{\alpha / n}\right\} \tag{19}$$

Using equation (12), y^p can be expressed as:

$$y^p \equiv \lambda^p y^s \tag{20}$$

Equation (20) states that output under pooling loan contracts is identical to output under separating loan contracts with one reservation: unlike in the case of separating loan contracts, under pooling loan contracts the credit market may undergo a credit crunch – in which case output becomes nil. Thus, all the outcomes regarding the real effects of monetary policy under separating loan contracts (see section II, subsection B) hold under pooling loan contracts as well, yet, in addition, under pooling loan contracts tight monetary policy may cast the economy into a credit crunch.

Monetary policy and the viability of the credit market

The single bank's participation constraint presented by equation (18) can be expressed as a stipulation on the level of the discount window rate, namely, that it does not exceed a certain threshold.

Proposition 5: *In each of the zones I - VI there exists a discount window rate threshold above which lending becomes unprofitable, so that banks are unwilling to lend. Thus, tight monetary policy that raises the discount window rate beyond its threshold level generates a credit crunch. Let* $\psi_I, \psi_{II}, ..., \psi_{VI}$ *denote the discount window rate thresholds corresponding to zones I, II,…,VI , then:*

$$\psi_I \equiv \frac{q}{1-q} \cdot \frac{\alpha}{n} + w \tag{21a}$$

$$\psi_{II} \equiv q\left(R - \frac{\alpha}{2n}\right) + (1-q)w$$

(21b)

$$\psi_{III} \equiv R + \frac{\alpha(1-q) - \sqrt{2\alpha nq(1-q)(R-w) + \alpha^2(1-q)^2}}{nq} \tag{21c}$$

$$\psi_{IV} \equiv R + \frac{2(1-q)(G-w) - 2\sqrt{q(1-q)(G-w)(R-w) + (1-q)^2(G-w)^2}}{q} \tag{21d}$$

$$\psi_V \equiv \frac{\frac{\alpha q}{n}\left(R - \frac{\alpha}{2n}\right) + 2w(1-q)(G-w)}{\frac{\alpha q}{n} + 2(1-q)(G-w)} \tag{21e}$$

$$\psi_{VI} \equiv \frac{q}{2(1-q)(G-w)} \cdot \left(\frac{\alpha}{n}\right)^2 + w \tag{21f}$$

Proof: see the Appendix.

Proposition 5 states that under pooling loan contracts, banks will provide loans as long as the discount window rate is sufficiently low. The discount window rate is the banks' per-unit cost of liquidity, and therefore, the marginal cost of extending a loan. Thus, the higher the discount window rate, the lower the profitability of lending. For a sufficiently high discount window rate banks' profits become nil. Any higher discount window rate would render lending strictly unprofitable and thereby induce the banks to withhold lending. Thus, the economy will undergo a credit crunch[12]– an overall collapse of the credit market. The discount window rate threshold level is the discount window rate at which banks break even. Since banks' profits depend on the configuration of the credit market, so does the discount window rate threshold. Therefore, each equilibrium zone yields a different discount window rate threshold.

There are four different patterns for the discount window rate threshold, denoted by the subscripts *a, b, c* and *d*, depending on the comparative values of (G-w), $\frac{(1-q)(R-w)}{3-q}$ and $\frac{(1-q)(R-w)}{2-q}$. Pattern *a* applies when $\frac{(1-q)(R-w)}{2-q} \leq G-w$ and is given by the following

[12] It is however important to stress that the present paper is not about credit crunch. The term credit crunch is used to refer to a case where both type *h* and type ℓ entrepreneurs are credit constrained - a technical result due to the symmetry between banks and the focus on the short run (which is the appropriate time-frame for the analysis of monetary policy changes).

equation:

$$\psi_a = \begin{cases} \psi_I & for \quad \frac{\alpha}{n} < \frac{2(1-q)(R-w)}{3-q} \\ \psi_{II} & for \quad \frac{2(1-q)(R-w)}{3-q} \le \frac{\alpha}{n} < \frac{2(1-q)(R-w)}{2-q} \\ \psi_{III} & for \quad \frac{2(1-q)(R-w)}{2-q} \le \frac{\alpha}{n} < 2(G-w) \\ \psi_{IV} & for \quad \frac{\alpha}{n} \ge 2(G-w) \end{cases} \tag{22}$$

Pattern *b* holds when $\frac{9(1-q)(R-w)}{8(3-q)} \le G-w < \frac{(1-q)(R-w)}{2-q}$:

$$\psi_b = \begin{cases} \psi_I & for \quad \frac{\alpha}{n} < \frac{2(1-q)(R-w)}{3-q} \\ \psi_{II} & for \quad \frac{2(1-q)(R-w)}{3-q} \le \frac{\alpha}{n} < 2(G-w) \\ \psi_V & for \quad 2(G-w) \le \frac{\alpha}{n} < \frac{-2(1-q)(G-w)+2\sqrt{(1-q)^2(G-w)^2+q(1-q)(G-w)(R-w)}}{q} \\ \psi_{IV} & for \quad \frac{\alpha}{n} \ge \frac{-2(1-q)(G-w)+2\sqrt{(1-q)^2(G-w)^2+q(1-q)(G-w)(R-w)}}{q} \end{cases} \tag{23}$$

Pattern *c* holds when $\frac{(1-q)(R-w)}{3-q} \le G-w < \frac{9(1-q)(R-w)}{8(3-q)}$:

$$\psi_c = \begin{cases} \psi_I & for \quad \frac{\alpha}{n} < \frac{2(1-q)(R-w)}{3-q} \\ \psi_{II} & for \quad \frac{2(1-q)(R-w)}{3-q} \le \frac{\alpha}{n} < 2(G-w) \\ \psi_V & for \quad 2(G-w) \le \frac{\alpha}{n} < \frac{-2(1-q)(G-w)+2\sqrt{(1-q)^2(G-w)^2+q(1-q)(G-w)(R-w)}}{q} \\ \psi_{IV} & for \quad \frac{\alpha}{n} \ge \frac{-2(1-q)(G-w)+2\sqrt{(1-q)^2(G-w)^2+q(1-q)(G-w)(R-w)}}{q} \end{cases} \tag{24}$$

Finally, pattern d applies when $G - w < \frac{(1-q)(R-w)}{3-q}$:

$$\psi_d = \begin{cases} \psi_I & for \ \frac{\alpha}{n} < \frac{2(1-q)(R-w)}{3-q} \\ \psi_{II} & for \ \frac{2(1-q)(R-w)}{3-q} \le \frac{\alpha}{n} < \frac{-3(1-q)(G-w)+\sqrt{9(1-q)^2(G-w)^2+8q(1-q)(G-w)(R-w)}}{4q} \\ \psi_V & for \ \frac{-3(1-q)(G-w)+\sqrt{9(1-q)^2(G-w)^2+8q(1-q)(G-w)(R-w)}}{4q} \le \frac{\alpha}{n} < \frac{-2(1-q(G-w)+2\sqrt{(1-q)^2(G-w)^2+q(1-q)(G-w)(R-w)}}{q} \\ \psi_{VI} & for \ \frac{\alpha}{n} \ge \frac{-2(1-q)(G-w)+2\sqrt{(1-q)^2(G-w)^2+q(1-q)(G-w)(R-w)}}{q} \end{cases} \tag{25}$$

Figure 6 illustrate the above patterns.

In the real world, the design of monetary policy is affected by a variety of considerations and goals[13]. Although monetary policymakers are normally preoccupied first and foremost by inflation and the stabilization of shocks to the economy, they are also likely to take into account, to that degree or another, financial system considerations. It would be plausible to assume that monetary policymakers would refrain from actions that are bound to undermine the proper functioning of the financial system. Thus, it may be cautiously argued that monetary policymakers' elbowroom in reacting to changing macroeconomic conditions is constrained by the concern for the proper functioning of the financial system[14]. The discount window rate threshold in the model captures the extant by which monetary policy is constrained by credit market viability considerations.

[13] Considerations such as the level of employment, the exchange rate, the integrity of the payment system and financial stability etc. are also likely to play a role in the design of monetary policy.

[14] Clearly, there is a variety of economic, political and social considerations that constrain monetary policymakers. The partial equilibrium analysis provided in this paper focuses on credit market viability.

The discount window rate threshold is affected, among other things, by the compound structural parameter α/n. To shed further light on the relation between CMS and monetary policy, it would be worthwhile to examine the effect of α/n on the discount window rate threshold and see what values of α/n allow for maximal monetary policy elbowroom.

Proposition 6: (i) Under perfect competition ($\alpha/n = 0$) the credit market is not viable; (ii) under monopolistic competition the discount window rate threshold is rising in α/n; (iii) under the hybrid configuration, the discount window rate threshold is declining in α/n in zone II and rising in α/n in zone V; (iv) under local monopolies the discount window rate threshold is declining in α/n in zone III and invariant to it in zone IV.

Proof: see the Appendix.

Under perfect competition, banks make null profits from lending to type h borrowers and, at the same time, suffer loses over the loans extended to type ℓ ones. Thus, on the whole, lending under perfect competition is unprofitable, and the banks choose to withhold lending. As the credit market moves away from perfect competition within the monopolistic competition zone, their potential profits from lending to type h borrowers, and hence, their overall profits rise; at some point, lending may become strictly profitable. Thus, under pooling loan contracts, some positive degree of concentration

and/or differentiation between credit institutions is required for the credit market to function.

Proposition 6 indicates that the relationship between the structural compound parameter α/n and the discount window rate threshold varies between equilibrium zones. Since the discount window rate threshold is defined as the level of the discount window rate at which banks break even, it increases in the profitability of lending. Thus, the direction by which α/n affects lending profitability is also the direction by which it affects the discount window rate threshold.

Proposition 7: *For all four patterns of the discount window rate threshold, there is a value of the compound structural parameter α/n that sustains both maximal monetary policy elbowroom and maximal output.*

Proof: see the Appendix.

The effect of CMS on the extent to which monetary policy elbowroom is constrained by credit market viability implies a reciprocal relevance of banking supervision policy towards CMS and monetary policy.

In the real world, the banking supervision authority's concern about the structural-competitive configuration of the banking system is normally attributed to two groups of considerations: (1) financial system soundness and stability and (2) consumer welfare.

The concern for credit market robustness to restrictive monetary policy fits into the first group of considerations.

In terms of the present model, banking supervision medium-long run policy can affect both the number of banks in the economy, n, and the extent of differentiation between them as credit providers, α. Therefore, in the context of the present model, those values of α/n that maximize the robustness of the credit market to restrictive monetary policy as well as the volume of successful loans should be preferred by the banking supervision authority.

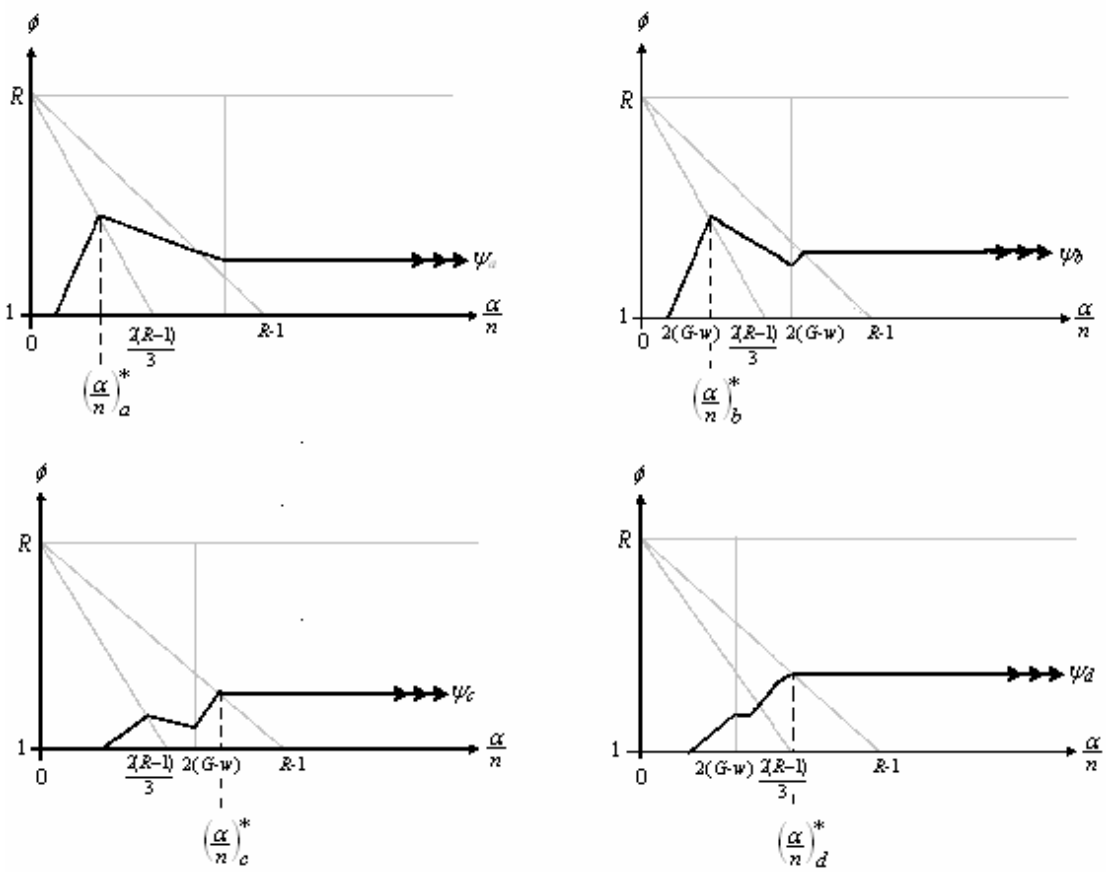

Figure 6: The Four Patterns of the Discount Window Rate Threshold

5. CONCLUDING REMARKS

The paper points to the relevance of CMS to monetary policy in the short run. It shows that under some conditions CMS affects monetary transmission and that in the case where creditors cannot screen out bad borrowers it also affects the robustness of the credit market to contractive monetary policy.

Both the stance of monetary policy and CMS are found to determine the type of credit market equilibrium. When the credit market is highly differentiated and/or monetary policy is highly restrictive, banks act as local monopolies. In this case, due to the high compound cost of credit, not all productive entrepreneurs can access the credit market; thus, the economy-wide credit volume, and thereby real activity, fall bellow their maximal levels. This state of affairs calls for Central Bank intervention: by relaxing its monetary stance, the Central Bank can induce banks to lower debitory rates. The resulting reduction in the compound cost of credit to borrowers would thus expand the economy-wide volume of credit, and with it, real activity[15]. This mechanism is reminiscent of the well known bank-lending channel of monetary transmission. Yet, unlike the bank lending channel, in which monetary relaxation expands the volume of lending by rendering relatively low-return projects profitable, in the transmission mechanism described in this paper monetary relaxation enhances the attractiveness of loans to "peripheral" entrepreneurs, who incur a higher credit accessibility cost, and who

[15] It is important to stress that this result should not be interpreted as a recommendation for expansionary monetary policy, or any monetary stance whatsoever.

previously refrained from borrowing due to the high compound cost of credit. Thus, whereas the bank-lending channel is driven by projects' differential expected returns, the transmission mechanism generated in this paper is driven by borrowers' differential credit accessibility costs - induced by the differentiation between banks as credit providers. Another important result pertaining to the local monopolies' equilibrium is that the greater the extent of credit market differentiation, the weaker the intensity of transmission, or, alternatively, the larger the change in monetary policy required to achieve a given real effect.

When the credit market is relatively little differentiated and/or the monetary stance is relatively loose, banks act as monopolistic competitors. Under monopolistic competition, the overall volume of credit attains its maximal level, so that a single bank cannot expand its market share without reducing that of its counterparts. Thus, monetary relaxation cannot enhance real activity. It is important to stress that had there been a range of technologies in the model, each yielding a different return, monetary policy would have generated real effects under monopolistic competition as well, through a traditional bank-lending channel. Yet, even then, the real effects generated under monopolistic competition would have been weaker than the ones produced under local monopolies, which on top of the traditional bank-lending channel, involves a CMS-driven channel.

Another outcome of the paper is that tight monetary policy can be conducive to a credit crunch. When potential borrowers have little wealth to pledge as collateral, banks cannot use collateral requirements as a means of screening out unworthy borrowers. The

inevitable presence of such borrowers lowers banks' profits and might even render lending unprofitable, in which case the banks would refrain from extending credit. Given that the cost of procuring loanable funds from the Central Bank negatively affects banks' profitability, the Central Bank can play an active role in restoring banks' profitability and the proper functioning of the credit market by loosening its monetary stance. In the same way, it may be the case that monetary tightening generates a credit crunch. Therefore, short-term monetary policy affects the viability of the credit market[16]. In the light of this result, the Central Bank should be cautious when considering the use of contractionary policy, and take into account the structure of the credit market.

Another implication of the paper's outcomes pertains to the relationship between the depth of borrowers' pockets and the eventuality of a credit crunch. In the model, borrowers' wealth determines the maximal collateral they can pledge, and thereby, whether equilibrium loan contracts are separating or pooling. Since under pooling loan contracts contractive monetary policy may beget a credit crunch, it can be said that the model predicts a linkage between borrowers' "shallow pockets" and the eventuality of a credit crunch. Therefore, according to the model, poorer economies or economies undergoing an economic slowdown are more prone to credit shortages. This is a prediction that should be tested empirically in future research.

This paper calls for follow-up research. The framework presented in the recent paper can be elaborated in many ways. One of many interesting directions for future research

[16] It should be stressed that this result stems, among other things, from the symmetry between banks and lack of multi-period dynamic considerations in the present model.

would be to check the long-run implications of the relation between CMS and monetary policy. In the long run, both the number of banks in the system and the degree of differentiation between them can be endogenously treated. The extent of differentiation between banks summarizes a variety of factors, among them banking system regulation and bank's deliberate strategic differentiation policy. It would therefore be contributive to the understanding of the interactions between CMS and Central Bank policy to investigate the long run relationship between the number of banks in the economy, banking system regulation and the long-run monetary stance. Other elaborations of the present framework would be the introduction of a foreign credit market or the possibility of mergers and branching. It would be also interesting to bring the model to the data and check whether its predictions are confirmed.

APPENDIX

Proof of proposition 5:

Substituting equation (16) in equation (6) yields:

$$L_h^p(x_h^p) = \begin{cases} L_h^p(\bar{x}_h^p) = \dfrac{q(R-\phi)}{\alpha} & for \quad \dfrac{\alpha}{n} \geq R-\phi \\ L_h^p(\tilde{x}_h^p) = \dfrac{q}{n} & for \quad \dfrac{2}{3}(R-\phi) < \dfrac{\alpha}{n} < R-\phi \\ L_h^p(\hat{x}_h^p) = \dfrac{q}{n} & for \quad \dfrac{\alpha}{n} \leq \dfrac{2}{3}(R-\phi) \end{cases} \tag{A1}$$

By substituting equations (14), (16) and (A1) into equation (15) and using the definition of each equilibrium zone obtains the profit of a bank under pooling loan contracts in each equilibrium zone:

$$\Pi^{I} = \frac{\alpha q}{n^2} + \frac{(1-q)(w-\phi)}{n} \tag{A2}$$

$$\Pi^{II} = \frac{q}{n}\left(R - \frac{\alpha}{2n} - \phi\right) + \frac{(1-q)(w-\phi)}{n} \tag{A3}$$

$$\Pi^{III} = \frac{q(R-\phi)^2}{2\alpha} + \frac{(1-q)(w-\phi)}{n} \tag{A4}$$

$$\Pi^{IV} = \frac{q(R-\phi)^2}{2\alpha} + \frac{2(1-q)(G-w)(w-\phi)}{\alpha} \tag{A5}$$

$$\Pi^{V} = \frac{q}{n}\left(R - \frac{\alpha}{2n} - \phi\right) + \frac{2(1-q)(G-w)(w-\phi)}{\alpha} \tag{A6}$$

$$\Pi^{VI} = \frac{\alpha q}{n^2} + \frac{2(1-q)(G-w)(w-\phi)}{\alpha} \tag{A7}$$

Equation (18) states that under pooling loan contracts, a bank will be willing to provide loans as long as its profits are non-negative. The condition for the non-negativity of a bank's profit in each and every equilibrium zone can be expressed as a condition on ϕ, namely, that ϕ does not exceed a certain threshold:

$$\Pi^{I} \geq 0 \;\; iff \;\; \phi \leq \frac{\alpha q}{n(1-q)} + w \;\equiv\; \phi^{I}_{\max} \tag{A8}$$

$$\Pi^{II} \geq 0 \;\; iff \;\; \phi \leq q\left(R - \frac{\alpha}{2n}\right) + (1-q)w \tag{A9}$$

$$\Pi^{III} \geq 0 \;\; iff \;\; nq\phi^2 - 2\left[nqR + \alpha(1-q)\right]\phi + nqR^2 + 2\alpha(1-q)w \geq 0 \tag{A10}$$

By solving the roots of the quadratic expression $nq\phi^2 - 2\left[nqR + \alpha(1-q)\right]\phi + nqR^2 + 2\alpha(1-q)w$ and recalling that the relevant values for the discount window rate range from 1 to R, (A10) can be re-written as:

$$\Pi^{III} \geq 0 \;\; iff \;\; \phi \leq R + \frac{\alpha(1-q) - \sqrt{2\alpha nq(1-q)(R-w) + \alpha^2(1-q)^2}}{nq} \equiv \phi^{III}_{\max} \tag{A11}$$

$$\Pi^{IV} \geq 0 \;\; iff \;\; q(R-\phi)^2 + 4(1-q)(G-w)(w-\phi) \geq 0 \tag{A12}$$

By solving the roots of the quadratic expression $nq\phi^2 - 2\left[nqR + \alpha(1-q)\right]\phi + nqR^2 + 2\alpha(1-q)w$ and recalling that the relevant values for the discount window rate range from 1 to R, (A12) can be re-written as:

$$\Pi^{IV} \geq 0 \;\; iff \;\; \phi \leq \frac{qR + 2(1-q)R - 2\sqrt{q(1-q)(G-w)(R-w) + (1-q)^2(G-w)^2}}{q} \equiv \phi^{IV}_{\max} \tag{A13}$$

Note that $\phi_{\max}^{IV} \geq 1$ *iff* $q/(1-q) \geq [4(G-w)(1-w)]/(R-1)^2$. Thus, unless the proportion of type *h* entrepreneurs in the population is sufficiently high, banks cannot make non-negative profits in zone IV.

$$\Pi^{V} \geq 0 \ \textit{iff} \ \ \phi \leq \frac{q\,\frac{\alpha}{n}\left(R-\frac{\alpha}{2n}\right)+(1-q)(G-w)w}{q\,\frac{\alpha}{n}+2(1-q)(G-w)} \equiv \phi_{\max}^{V} \tag{A14}$$

$$\Pi^{VI} \geq 0 \ \textit{iff} \ \ \phi \leq \frac{q\left(\frac{\alpha}{n}\right)^2}{2(1-q)(G-w)} + w \equiv \phi_{\max}^{VI} \tag{A15}$$

Proof of proposition 6:

Proof of corollary (ii): by definition, both zones I and VI are monopolistic competition equilibrium zones. Differentiating equation (21a) with respect to α/n gives:

$$\frac{\partial \phi_{\max}^{I}}{\partial\left(\frac{\alpha}{n}\right)} = \frac{q}{1-q} > 0 \tag{A16}$$

Differentiating equation (21f) with respect to α/n obtains:

$$\frac{\partial \phi_{\max}^{VI}}{\partial\left(\frac{\alpha}{n}\right)} = \frac{q}{(1-q)(G-w)} \cdot \frac{\alpha}{n} > 0 \tag{A17}$$

Thus, both $\phi_{\max}^{I}$ and $\phi_{\max}^{VI}$ are rising in α/n.

Proof of corollary (iii): by definition, both zones II and V are hybrid equilibrium zones. Differentiating equation (21b) with respect to α/n yields:

$$\frac{\partial \phi_{\max}^{II}}{\partial\left(\frac{\alpha}{n}\right)} = -\frac{q}{2} < 0 \tag{A18}$$

Differentiating equation (21e) with respect to α/n and rearranging gives:

$$\frac{\partial \phi_{\max}^{V}}{\partial\left(\frac{\alpha}{n}\right)} = \frac{2(1-q)(G-w)\left(R-\frac{\alpha}{n}-w\right)-\frac{q}{2}\left(\frac{\alpha}{n}\right)^2}{\left[q\,\frac{\alpha}{n}+2(1-q)(G-w)\right]^2} \tag{A19}$$

Thus, $\phi_{\max}^{V}$ is rising in α/n iff $-q(\alpha/n)^2 - 2(1-q)(G-w)(\alpha/n) + 2w(1-q)(G-w) > 0$.

Solving the roots of $-q(\alpha/n)^2 - 2(1-q)(G-w)(\alpha/n) + 2w(1-q)(G-w)$ and recalling that α/n must be positive obtains:

$$\frac{\partial \phi_{\max}^{V}}{\partial\left(\frac{\alpha}{n}\right)} > 0 \quad iff \qquad \frac{\alpha}{n} < \frac{(1-q)(G-w)+\sqrt{(1-q)^2(G-w)^2+2qw(1-q)(G-w)}}{q}$$

(A20)

Thus, $\phi_{\max}^{II}$ declines in α/n whereas $\phi_{\max}^{V}$ can either rise or decline in α/n.

Proof of corollary (iv): by definition, both zones III and IV are local monopolies equilibrium zones. Differentiating equation (21c) with respect to α/n obtains:

$$\frac{\partial \phi_{\max}^{III}}{\partial\left(\frac{\alpha}{n}\right)} = \frac{1-q}{q}\left[1-\frac{q(R-w)+(1-q)\cdot\frac{\alpha}{n}}{\sqrt{2q(1-q)(R-w)\cdot\frac{\alpha}{n}+(1-q)^2\cdot\left(\frac{\alpha}{n}\right)^2}}\right] \tag{A21}$$

Equation (A21) implies that $\phi_{\max}^{III}$ is rising in α/n if and only if the expression in the square brackets on the right hand of the equation is positive. It can be checked that:

$$1-\frac{q(R-w)+(1-q)\cdot\frac{\alpha}{n}}{\sqrt{2q(1-q)(R-w)\cdot\frac{\alpha}{n}+(1-q)^2\cdot\left(\frac{\alpha}{n}\right)^2}} > 0 \;\; iff \;\; q(R-w) < 0 \tag{A22}$$

Assumptions 1 and 2 imply that $R > w$. Thus $q(R-w) > 0$ so that $\phi_{\max}^{III}$ is declining in α/n.

Equation (21d) indicates that $\phi_{\max}^{IV}$ does not depend on α/n. Thus, under local monopolies the discount window rate threshold level either declines in α/n (in zone III) or is invariant to α/n (zone IV).

Proof of proposition 7:

Let $(\alpha/n)_a, (\alpha/n)_b, (\alpha/n)_c$ and $(\alpha/n)_d$ denote the values of α/n that maximize ψ_a, ψ_b, ψ_c and ψ_d, respectively (*ceteris paribus*):

$$\left(\frac{\alpha}{n}\right)_a = \frac{2(1-q)(R-w)}{3-q} \tag{A23}$$

$$\left(\frac{\alpha}{n}\right)_b = \frac{2(1-q)(R-w)}{3-q} \tag{A24}$$

$$\left(\frac{\alpha}{n}\right)_c = \left[\frac{-2(1-q)(G-w)+2\sqrt{(1-q)^2(G-w)^2+q(1-q)(G-w)(R-w)}}{q} \quad , \quad \infty\right) \tag{A25}$$

$$\left(\frac{\alpha}{n}\right)_d = \left[\frac{-2(1-q)(G-w)+2\sqrt{(1-q)^2(G-w)^2+q(1-q)(G-w)(R-w)}}{q} \quad , \quad \infty\right) \tag{A26}$$

Both $(\alpha/n)_a$ and $(\alpha/n)_b$ yield a discount window rate threshold level that is located on the border between zones I and II where all type *h* entrepreneurs obtain loans, so that output reaches its maximal level. The lower support of the interval of α/n values that maximize ψ_c and ψ_d (given by equations (A25) and (A26)) yields a discount window rate threshold level that is located on the border between zones V and IV, where all type *h* entrepreneurs obtain loans, so that output reaches its maximal level. Higher values of

α/n on that interval correspond to discount window rate threshold levels that are strictly within zone IV, so that only a share of type h entrepreneurs borrow (recall that under local monopolies the higher α/n, the lower the share of borrowers in the type h population). Thus, the lower support of $\left[\frac{-2(1-q(G-w)+2\sqrt{(1-q)^2(G-w)^2+q(1-q)(G-w)(R-w)}}{q}\ ,\ \infty\right)$ is output-wise superior to the rest of the points on the interval. Let $(\alpha/n)_a^*$ - $(\alpha/n)_d^*$ denote the value of α/n that sustains both maximal monetary policy elbowroom and output, then:

$$\left(\frac{\alpha}{n}\right)_a^* = \frac{2(1-q)(R-w)}{3-q} \tag{A27}$$

$$\left(\frac{\alpha}{n}\right)_b^* = \frac{2(1-q)(R-w)}{3-q} \tag{A28}$$

$$\left(\frac{\alpha}{n}\right)_c^* = \frac{-2(1-q)(G-w)+2\sqrt{(1-q)^2(G-w)^2+q(1-q)(G-w)(R-w)}}{q} \tag{A29}$$

$$\left(\frac{\alpha}{n}\right)_d^* = \frac{-2(1-q)(G-w)+2\sqrt{(1-q)^2(G-w)^2+q(1-q)(G-w)(R-w)}}{q} \tag{A30}$$

$(\alpha/n)_a^*$ - $(\alpha/n)_d^*$ are depicted in figure 6.

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