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Financial Markets and Inflation under Imperfect Information

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Abstract

This paper studies the effect of inflation on the operation of financial markets, and shows how the ability of financial intermediaries to distinguish among heterogenous firms is reduced as inflation rises. This point is illustrated by presenting a simple model where inflation affects firms' productivity. In particular, productivity differentials narrow as inflation increases. This effect creates incentives for risky and less productive firms to behave as high productivity firms. At high rates of inflation this may result in financial intermediaries being unable to differentiate among customers.

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Summary

Although the effects of inflation on economic activity and welfare have been studied extensively, there is still considerable controversy about the mechanisms through which inflation affects economic performance. One issue that has received little attention but that seems to be well known to practitioners is the effects of inflation on the operation of financial markets, in particular, on their ability to channel funds to the most efficient activities.

This paper develops a formal model that links inflation and financial markets. The model is based on the premise that, as inflation rises, banks have more difficulty distinguishing the riskiness of different customers because risky customers must behave like safe customers in order to receive better credit terms. The model has two types of firms: one is less productive and has a positive probability of default, while the other is more productive and does not default. It is argued that inflation increases the similarity between the two types of firms, either because the productivity of safe firms declines with inflation, or, owing to higher search costs, because the demand of riskier firms increases relative to that of safe firms.

When inflation is low, a fully revealing equilibrium prevails, in which banks can perfectly identify each type of firm. However, as inflation rises, low-productivity firms have more incentive to behave like high-productivity firms because the costs of mimicking this behavior decline. In contrast, high-productivity firms have less incentive to signal their type because signaling costs increase. Thus, high inflation may induce a pooling equilibrium in which banks are unable to distinguish between the two types of firms.

The links between inflation and financial markets discussed in this paper are potentially relevant for a number of reasons. First, they may provide new insight into the effects of inflation on economic growth. The inability of financial intermediaries to distinguish the riskiness associated with different customers may have consequences for the ability of financial markets to allocate credit and foster economic growth. Second, they may help explain the marked recovery of credit to the private sector after the successful implementation of a stabilization program, which induces an increase in economic activity.

I. Introduction

Although there has been extensive work on the effects of inflation on economic activity and welfare, there is still considerable controversy about which are the most relevant mechanisms. Following Friedman's (1969) celebrated prescription of zero nominal interest rate to insure full liquidity, many economists have analyzed the distortions introduced by the inflation tax on the optimal amount of cash balances. Others have argued that the most important effect of inflation is through its impact on uncertainty. Although generally informal, the argument is that inflation is a proxy for the degree of macroeconomic uncertainty, which in turn, reduces the incentives to invest and save. Finally, the frictions that inflation induce in the trading process have been studied in the context of search theory. Despite the solid microfoundations of this approach, the welfare effects of inflation are generally ambiguous (e.g. Bènabou (1992), Casella and Feinstein (1990), and Tommasi (1993)).

An area that has received little attention, but seems to be well known by practitioners--especially in high-inflation countries--is the effect inflation has on the functioning of financial markets and their ability to channel funds to the most efficient activities. A contraction of credit to the private sector is usually observed in episodes of extreme inflation. Conversely, one of the most visible effects after the implementation of the Cavallo plan in Argentina was the reemergence of credit to the private sector. Figure 1 shows the evolution of credit from commercial banks to the private sector (in real terms) and inflation in three typical cases of high inflation and successful stabilization in Latin America. 1/ In the three cases, most notably Bolivia and Mexico, credit declines in periods of high inflation, reaching its lowest levels as stabilization occurs. 2/ After inflation is controlled credit recovers together with a further slowdown of inflation.

Another motivation to study the effect of inflation on the functioning of credit markets is the empirical evidence documenting a negative relationship between inflation and long-run growth (De Gregorio (1993) and Fischer (1993)) shows that inflation not only hampers growth by reducing investment, but also the productivity of investment. Indeed, De Gregorio (1993), analyzing a group of Latin American countries, shows that inflation affects growth mainly through its effects on productivity. Thus, inflation seems to have important allocative effects, and among the most obvious candidates to produce such inefficiencies are financial markets, which in

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1/ For further details on these experiences see Végh (1992).

2/ The figures correspond to credit from commercial banks to the private sector (line 22d IFS) deflated by the CPI (line 64 IFS) and the CPI inflation. In the case of Argentina, the growth of credit, and other related monetary aggregates, in the first semester of 1989 and early 1990 was characterized by unusually large fluctuations, for which we do not have an explanation.

the context of high inflation may not perform efficiently its allocative role.

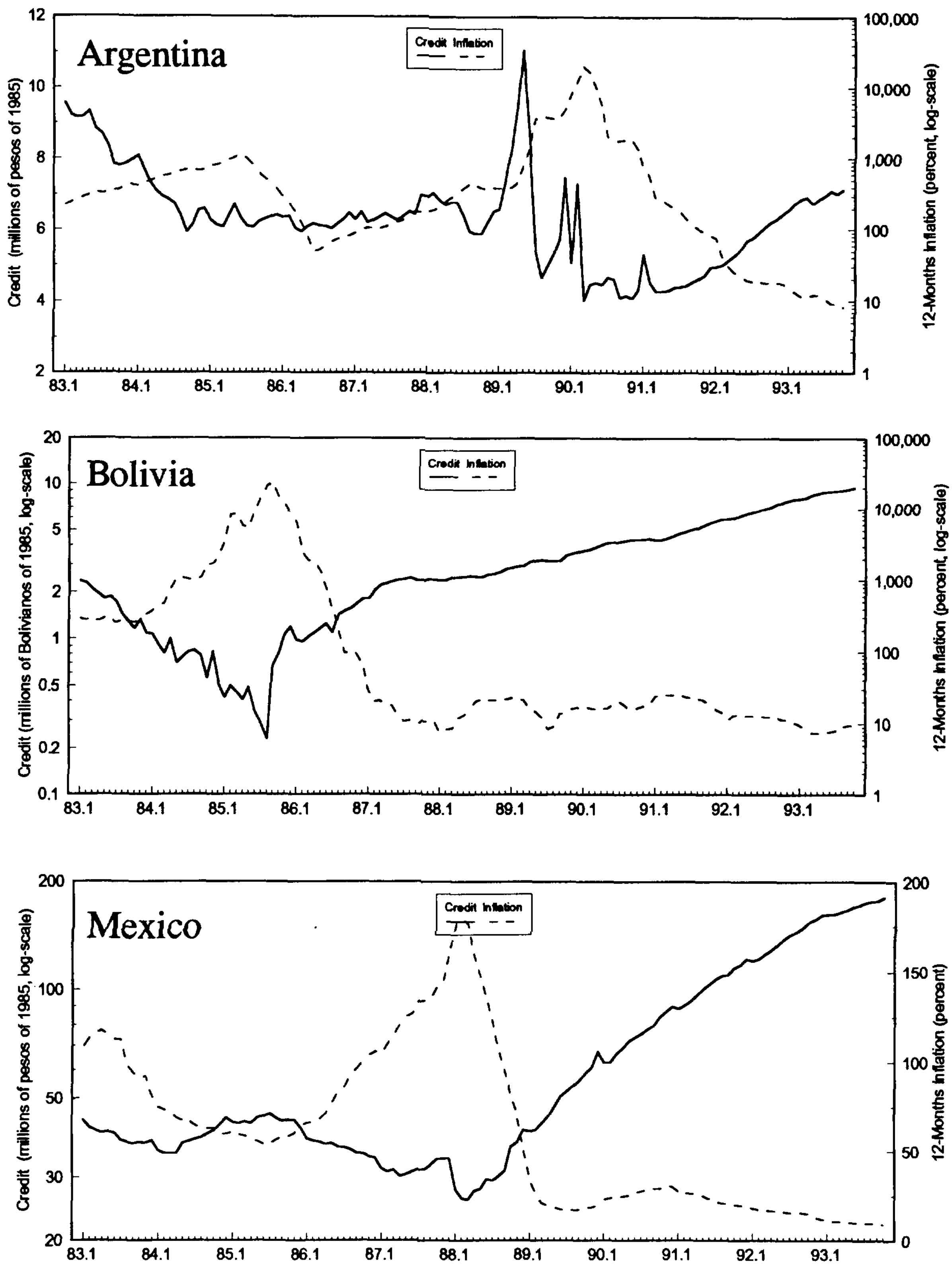
There are several channels through which inflation may affect the functioning of credit markets. An important mechanism is that the amount of funds that banks have available to lend may fall as inflation increases. For example, private agents may be discouraged to hold deposits, and thus, the supply of funds may decline. Azariadis and Smith (1993) develop this point in a model where money is a store of value. Neumeyer (1993), in turn, constructs a model where nominal financial markets disappear in high-inflation environments, causing welfare losses due to the lack of nominal assets to redistribute income across high-inflation states. Finally, McKinnon (1991) has argued that distortions in financial markets stemming from moral hazard and adverse selection problems and generating credit rationing à la Stiglitz and Weiss (1981), may be exacerbated in an unstable macroeconomic environment.

The purpose of this paper is to develop a formal model that links inflation and the operation of financial markets. While Azariadis and Smith (1993) focus on the supply of funds, we focus on the demand for credit, and how the volume of credit as well as the allocation of credit is distorted by high inflation. We argue that banks face more difficulties in distinguishing the riskiness of different customers as inflation rises, which stems from the fact that risky customers have to act as safe customers in order to receive better credit arrangements.

We present a model with two types of firms. One type is less productive and has a positive probability of default, while the other is more productive and does not default. A central element of our model is that inflation increases the similarity between the two types of firms. This could occur because the productivity of safe firms declines with inflation, or, due to higher search costs, the demand of riskier firms increases relative to that of safe firms. We show that when inflation is low, a fully revealing equilibrium prevails, in which banks can perfectly identify each type of firm and charge interest rates according to the riskiness of each firm. However, as inflation rises, low-productivity firms have more incentives to appear like high-productivity firms since the costs of mimicking their behavior declines. On the other hand, high-productivity firms have less incentives to signal that they are of the good type, since signaling costs increase. Thus, high inflation may induce a pooling equilibrium in which banks are unable to distinguish between the two types of firms.

The paper follows in four sections. Section II presents the basic model. Section III discusses the equilibrium, and the effects of inflation in the type of equilibria (separating versus pooling). Section IV performs some comparative statics exercises. The final section presents the conclusions.

Figure 1: Banks' Credit to the Private Sector and Inflation



II. The Model

In this section we present a simple partial equilibrium model that captures the informational problems induced by inflation on the operation of financial markets alluded to in the introduction. In order to provide a minimum framework to illustrate our approach, we postulate the demand functions and assume that real wages do not change with inflation.

1. Firms

There are two type of firms, indexed by $i=h$ *and* l, to denote high and low productivity, respectively. For convenience, henceforth, they are called h-firms and l-firms. The mass of firms is normalized to 1 and h-firms represent a fraction α of the total.

Each firm is a monopolist producing differentiated products, and facing the following demand function:

$$y_i = p_i^{-\epsilon} \quad for \quad i = h, l, \tag{1}$$

where $\epsilon > 1$, to insure an interior solution to the monopolist's problem. For simplicity we assume that for $p_h = p_l$ both type of firms will face equal demand.

Labor is the only factor of production and each firm produces according to the following production function:

$$y_i = a_i \ell_i, \tag{2}$$

where ℓ_i is labor and a_i its marginal productivity. h-firms are more productive than l-firms, thus $a_h > a_l$. In addition we assume that h-firms productivity is always a_h. In contrast, we assume that l-firms default with probability q as a result of a bad draw that makes l-firms completely unproductive ($a_l = 0$). One can think of h-firms as well established firms, while l-firms are new firms on the market, which have not discovered yet whether they will be productive. 1/ Therefore, firms differ in two dimensions: productivity and failure rate.

Wages (w) have to be paid before output is sold. Thus, firms need working capital to initiate production. As discussed later, if banks are able to distinguish the type of firms applying for loans they will charge

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1/ This assumption is consistent with evidence on firm size, age, and failure rates, which shows that small young firms have the highest failure rates. See, e.g., Dunne, Roberts and Samuelson (1988). Since in our model labor is the only input, size comparisons could be made in terms of production or employment. In both cases h-firms are the largest ones since they are the most productive. See equation (2), and (4) below.

them different interest rates since firms' probabilities of default are different. The interest factor (interest payment plus principal) applied to i-firms (i=h,l) when each firm reveals its type is denoted by r_i.

When firms are charged an interest rate r_i-1, they solve the following optimization problem: 1/

$$\max(a_i \ell_i)^{(\epsilon-1)/\epsilon} - r_i \omega \ell_i \tag{3}$$

The optimal solution to this problem, which we call *unrestricted optimum*, is given by: 2/

$$\ell_i^*(r_i) = \left[\frac{\epsilon - 1}{\epsilon} \frac{a_i^{(\epsilon-1)/\epsilon}}{r_i\, w}\right]^{\epsilon} \tag{4}$$

and profits are

$$\nu_i^* = \theta a_i^{\epsilon-1}(r_i \omega)^{1-\epsilon} \tag{5}$$

where $\theta = (\epsilon-1)^{\epsilon-1}/\epsilon^{\epsilon}$.

2. The effects of inflation on firms

A crucial assumption we make is that firms' productivity, the a's, are a function of the rate of inflation. More precisely, we assume that as inflation rises the productivity differential between h-firms and l-firms becomes smaller. As a normalization, and without loss of generality, we set $a_l = 1$ and $a_h = a(\pi)$, where π is the rate of inflation, $a>1$, $a'<0$ and $\lim_{\pi\to\infty} a = 1$. That is, as inflation increases the productivity of h-firms declines, and in the limit equals that of l-firms.

Inflation affects the way in which firms operate. In high-inflation economies the protection against inflation becomes more important than improvements in the production of goods. 3/ Firms devote large amount of resources to financial management. They have also incentives to pursue inefficient vertical integration, to avoid excessive intermediation, thus

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1/ Implicitly our analysis assumes that l-firms maximize expected profits, and with probability 1-q they earn zero profits. Therefore, they only care about profits in the event that they do not fail.

2/ Since, as discussed later, firms may face different interest rates depending on the type of equilibrium, we denote by $\ell_i^*(r)$ the unrestricted optimal value of ℓ_i for an interest factor equal to r.

3/ This point has been made, in different contexts, by Bresciani-Turroni (1937), Leijonhufvud (1977), and Carlton (1982).

reducing the burden of inflation, and to engage in short-term contracts to reduce uncertainty. Therefore, if we assume that firms are equally efficient in protecting themselves against inflation overall productivity of h-firms (which is an average of labor and "inflation-protection" productivities) will decline faster than productivity of l-firms as inflation rises, because efficiency in production will become less important. Inflation, therefore, would give an advantage to less productive firms. Another factor that gives a relative advantage to less efficient firms is that inflation benefits firms that produce and operate with greater flexibility, at a cost of reduced efficiency.

Bresciani-Turroni (1937), in his analysis of the German hyperinflation argues along similar lines:

> "The inflation profoundly altered the distribution of social saving. It is true that at first a certain mass of 'forced savings' was created. But it cannot be said that these savings became available to the most productive firms and to those entrepreneurs who were most able to employ rationally the capital at their disposal. On the contrary, inflation dispensed its favours blindly, and often the least meritorious enjoyed them. Firms socially less productive could continue to support themselves thanks to the profits derived from the inflation, although in normal conditions they would have been eliminated from the market, so that the productive energies which they employed could be turned to more useful objects."

Also, inflation is in many instances the reflection of a poor tax system, which relies more heavily on inflation tax because of the inability to collect regular taxes. One of the main inefficiencies in the tax system is the high degree of evasion. It can also be argued that tax evasion also benefits more inefficient producers, which at the cost of using inefficient technologies are able to evade more easily taxes. This is the case, for example, of the proliferation of informal activities in high-inflation economies.

Another dimension in which h- and l-firms could differ is in their demands, by considering that the demand function faced by each type of firm is $y_i=n_i p_i^{-\epsilon}$ $(i=h,l)$, where $n_h>n_l$. Thus, an alternative approach to model the effects of inflation would be to assume that inflation affects the relative demand across firms in such a way that the differential n_h-n_l falls with inflation. The analysis is similar to the case of productivity differentials, since in both cases inflation makes firms look more similar. This is the route taken in De Gregorio and Sturzenegger (1994) where, following Tommasi (1993), the effects of inflation on relative demands is derived in a search-theoretic framework. 1/ The intuition is as follows. Suppose that consumers have to search before buying goods and they face high- and low-productivity firms, and consequently low- and high-price stores. If inflation is high, consumers are more eager to buy, thereby increasing the average reservation value at which they decide to buy. Consequently, the relative demand for goods from the low-productivity firms increases with respect to the demand for goods from the high-productivity firms. The importance of our assumption is that inflation reduces the "profitability" gap between high- and low-productivity firms, and therefore, the analysis of considering different a's or different n's is analogous.

Our main concern in this paper is with the *relative* position of h-and l-firms, and hence, we do not focus on the levels of the parameters. For example, in an environment where inflation affects economic activity and productivity negatively, we would expect not only that the difference between a_h and a_l declines, but the absolute values of those parameters also decline.

3. Financial intermediaries

Financial institutions are perfectly competitive and offer debt contracts, i.e. they offer to lend at a given interest rate, which is given by the zero profits condition. Banks obtain their funds from an infinitely elastic supply (e.g., foreign investors) at an interest factor equal to ρ. As discussed before, the failure rate among h-firms is zero, and hence, they always pay the loan. The zero profits condition among banks (assuming also that they are risk neutral) implies that if they can be unequivocally identified by banks, they will be charged an interest factor $r_h=\rho$. In contrast, l-firms default with probability $1-q$, and they are unable to repay any part of the loan. Therefore, the zero profit condition for banks on loans to l-firms implies that the interest factor is $r_l=\rho/q$.

Firms' type is private information: only individual firms know their own type, and it cannot be verified by banks, although banks know that α is the actual fraction of h-firms. Therefore, whenever the equilibrium does not induce firms to reveal their type, banks will charge a uniform interest factor to all firms ($\bar{r}$), which is given by:

$$\bar{r} = \frac{\rho}{\alpha+(1-\alpha)q} \tag{6}$$

1/ The model of De Gregorio and Sturzenegger (1994) is a general equilibrium model that allows welfare analysis. Nevertheless, the model becomes intractable to discuss some issues we address in this paper, such as the comparative statics results. In addition, assuming that inflation affects productivity rather than demand greatly simplifies the algebra.

4. Firms borrowing decisions

Borrowing and employment is all that banks observe. Therefore, for a loan of size L, firms have to hire L/w units of labor. Thus, borrowing, and simultaneously employment, is the only signaling device available to firms. If all firms request a loan of the same amount, banks cannot discern the type of each firm. In contrast, when each type of firm borrows different amounts they implicitly reveal their type. 1/

Since $r_h < \bar{r} < r_l$, l-firms have the incentive to look like h-firms, since they will be charged a lower interest rate. However, l-firms need to act as h-firms in order to be charged a lower interest rate. They need to apply for a loan of the same size as that of h-firms. Thus, l-firms can reduce the interest rate they pay at the cost of having a larger loan, equal to that one requested by h-firms, which is larger since $a>1$. Then, l-firms' decision of whether or not to mimic h-firms will depend on the tradeoff between receiving a low interest rate with an excessive amount of credit and production on the one hand, and a higher interest rate with the optimal level of production in the other.

Since h-firms produce $a\ell_h$ units of goods, the following condition has to be satisfied in order for l-firms to be willing to mimic (demanding a loan of the same magnitude) h-firms:

$$\ell_h^{(\epsilon-1)/\epsilon} - r\ell_h w \geq (r_l w)^{1-\epsilon}\theta \tag{7}$$

Condition (7) establishes that l-firms will prefer to mimic h-firms whenever profits obtained by producing the same as h-firms and being charged $\bar{r}$ are greater than producing at a level equal to the fully revealing optimum and being charged r_l. The LHS of (7) is decreasing in ℓ_h, because $\ell_l^*(\bar{r})<\ell_h$ and profits are decreasing for ℓ above the optimum. 2/ Therefore, equality in equation (7) defines the maximum value of ℓ_h, denoted by $\bar{\ell}$, at which l-firms prefer a pooling equilibrium, because the benefits from paying a lower interest rate more than offset the costs of overproduction. For any $\ell_h>\bar{\ell}$ l-firms will not want to mimic h-firms behavior. The variable $\bar{\ell}$ is defined by:

1/ It could be possible to think of other variables that firms could use to signal their type. What is required for our model is that the difficulties in signaling each firm's type increase with the rate of inflation.

2/ As should be clear later, h-firms will produce at least $\ell_h^*(\bar{r})$. They may produce more than that since to signal their type they will need to choose a greater level of employment. Consequently, we can focus in cases where $\ell_h \geq \ell_h^*(\bar{r}) \geq \ell_l^*(r_l)$.

$$\bar{\ell}^{(\epsilon-1)/\epsilon} - \bar{r}\bar{\ell}w = (r_l w)^{1-\epsilon}\theta \tag{8}$$

Now, we can examine h-firms employment and borrowing decisions taking into account that they know that hiring more than $\bar{\ell}$ discourages l-firms from trying to mimic them. Figure 2, which is useful in discussing the plausible equilibria in the next section, shows the alternative employment choices of h-firms as a function of inflation. Note first that $\bar{\ell}$ is independent of the rate of inflation. Also, labor demand given by equation (4) depends negatively on the rate of inflation. h-firms would liked to be distinguished from l-firms since they would be charge r_h, but since $\bar{\ell}$ may be greater than $\ell^*{}_h(r_h)$ signaling is costly. When $\bar{\ell}$ is less than $\ell_h{}^*(r_h)$, the unrestricted optimal decision of h-firms prevents l-firms from acting like h-firms, that is, h-firms do not need to expand their borrowing and employment beyond the unrestricted optimum in order to be distinguished from l-firms. As the figure shows, this occurs at low levels of inflation. In contrast, at high levels of inflation, l-firms will want to mimic h-firms, and hence, the latter have to overproduce $(\bar{\ell}-\ell_h{}^*(r_h))$ in order to signal that they are of the high productivity type with no default risk. Consequently the value of ℓ_h that maximizes profits of h-firms when they want to prevent l-firms from pooling is: 1/

$$\ell_h = \begin{cases} \bar{\ell} \text{ for } \bar{\ell} > \ell_h^* \, (r_h) \\ \ell_h^* \text{ for } \bar{\ell} \le \ell_h^* \, (r_h) \end{cases} \tag{9}$$

However, h-firms may not want to separate, since overproduction is costly for them. Indeed, producing at $\bar{\ell}$ may yield less profits than producing the optimal amount of goods for the pooling interest rate. Formally, the condition that must hold in order for h-firms to be willing to separate is:

$$(a\ell_h)^{(\epsilon-1)/\epsilon} - r_h\ell_h\omega \ge a^{\epsilon-1}(\bar{r}\omega)^{1-\epsilon}\theta \tag{10}$$

that is, producing $\ell_h{}^*$ (from equation (9)) yields profits that are greater or equal than those when they cannot signal their type and choose the optimal amount of labor for an interest facto equal to $\bar{r}$. Since the LHS is decreasing in ℓ_h, equality in equation (10) defines the maximum value of ℓ at which h-firms want to separate.

By looking at unrestricted profits, profits in pooling equilibrium, and profits when h-firms overborrow to separate themselves from l-firms, the optimal choice of ℓ of h-firms, $\ell_h{}^{**}$, is:

1/ Since signaling is costly for h-firms, they will never choose employment greater than $\bar{\ell}$ to separate from l-firms. Strictly speaking, h-firms will choose ℓ infinitesimally above $\bar{\ell}$.

$$\ell_l^{**} = \begin{cases} \ell_h^*(r_h) & \text{for } \bar{\ell} \le \ell_h^* \\ \bar{\ell} & \text{for } \bar{\ell} > \ell_h^* \text{ and (10) holds} \\ \ell_h^*(\bar{r}) & \text{for } \bar{\ell} > \ell_h^* \text{ and (10) does not hold} \end{cases} \tag{11}$$

Given this optimal choice of *h*-firms, and the fact that they are the ones that ultimately decide whether or not the equilibrium is pooling or separating, the optimal choice of *l*-firms is determined as follows:

$$\ell_l^{**} = \begin{cases} \ell_l^*(r_l) & \text{for } \bar{\ell} \le \ell_h^*, \text{ or } \bar{\ell} > \ell_h^* \text{ and (10) holds} \\ \ell_h^*(\bar{r}) & \text{otherwise.} \end{cases} \tag{12}$$

According to (11)-(12) there are three possible equilibria:

- *Natural separation*. This is the case where $\bar{\ell} \le \ell_h^*(r_h)$, and *h*-firms can achieve their unrestricted optimum without effort in signalling their type, since *l*-firms have no incentives to mimic *h*-firms when the former demand $\ell_h^*(r_h)$ units of labor and each type of firm is charged a different interest rate. Therefore, *l*- and *h*-firms choose their unrestricted optimum.

- *Separation*. In this case $\bar{\ell} > \ell_h^*(r_h)$, and hence, *h*-firms have to produce more than their unrestricted optimum in order to separate from *l*-firms. In addition, *h*-firms will be willing to separate, at the cost of overproducing, since equation (10) holds. Because *h*-firms decide to produce $\bar{\ell}$, *l*-firms will have no incentive to mimic *h*-firms behavior, and hence, they choose their unrestricted optimal level of production. This equilibrium can also be called *costly separation*.

- *Pooling*. This case is also characterized by $\bar{\ell} > \ell_h^*(r_h)$, but it does not payoff to *h*-firms to overproduce in order to separate from *l*-firms, since (10) does not hold at $\ell_h = \bar{\ell}$. Under these conditions there is a pooling equilibrium, where *h*-firms choose the unrestricted optimum (for an interest factor equal to $\bar{r}$), and *l*-firms mimic this behavior because (7) holds. Note that in this equilibrium, the choice of ℓ is the optimal one for *h*-firms for the pooling interest rate. In contrast, *l*-firms overborrow, and overproduce, in order to be charged the pooling interest rate.

Finally, because the conditions that define each possible outcome are mutually exclusive the equilibrium is unique and will depend on the value of the parameters. In particular, in the next section we focus on the effects of the rate of inflation on the particular equilibrium the economy reaches.

III. Equilibria and the Effects of Inflation

In this section we characterize the three possible equilibria, and show the main effects that changes in the rate of inflation have on the prevailing equilibrium. More specifically, we show, as it is apparent from Figure 2, that for low values of inflation the equilibrium is natural separating, then as the inflation rate increases the equilibrium becomes separating, and finally become a pooling equilibrium at high rates of inflation.

We proceed by analyzing the optimal decision of h-firms, taking into account that l-firms will decide whether or not to behave as h-firms depending on whether ℓ_h is less or greater than $\bar{\ell}$, respectively. Before characterizing the ranges of inflation, and analogously a, at which the different equilibria prevail it is useful to define the following expressions for profits of h-firms in each equilibrium:

$$\nu_h(\pi;r_h) = a(\pi)^{\epsilon-1}(r_h\omega)^{1-\epsilon}\theta, \tag{13}$$

$$\nu_h(\pi;\bar{\ell}) = (a(\pi)\ell)^{(\epsilon-1)/\epsilon} - r_h\omega\bar{\ell}, \tag{14}$$

$$\nu_h(\pi;\bar{r}) = a(\pi)^{\epsilon-1}\,(\bar{r}\omega)^{1-\epsilon}\theta \tag{15}$$

The function $\nu_h(\pi;r_h)$ corresponds to profits of h-firms in a separating equilibrium, where they can choose the optimal amount of labor and r_h-1 is the interest rate. It is a decreasing and convex function of inflation. Next, $\nu_h(\pi;\bar{\ell})$ denotes profits for h-firms when they separate from l-firms, but separation cannot be achieved at ℓ_h^*. Hence, they produce $\bar{\ell}$ and pay an interest rate r_h-1. It is easy to show that the function $\nu_h(\pi;\bar{\ell})$ is decreasing in π, but it could be either concave or convex. Finally, $\nu_h(\pi;\bar{r})$ are profits when h-firms do not find beneficial to separate, so they are charged $\bar{r}$. In a pooling equilibrium h-firms choose the optimal amount of labor, given factor prices, and hence, profits are also a decreasing and convex function of inflation.

The ν's functions are drawn in Figure 3. The function $\nu_h(\pi;r_h)$ is above $\nu_h(\pi;\bar{r})$ and $\nu_h(\pi;\bar{\ell})$ for all π, but it is not always feasible to achieve this first best because l-firms may have the incentive to mimic h-firms behavior. In that figure we assume that the following two cutoff values for inflation exist:

$$\pi_s: \qquad \nu_h(\pi_s;r_h) = \nu_h(\pi_s;\bar{\ell}), \tag{16}$$

and

Figure 2: *h*-firms employment

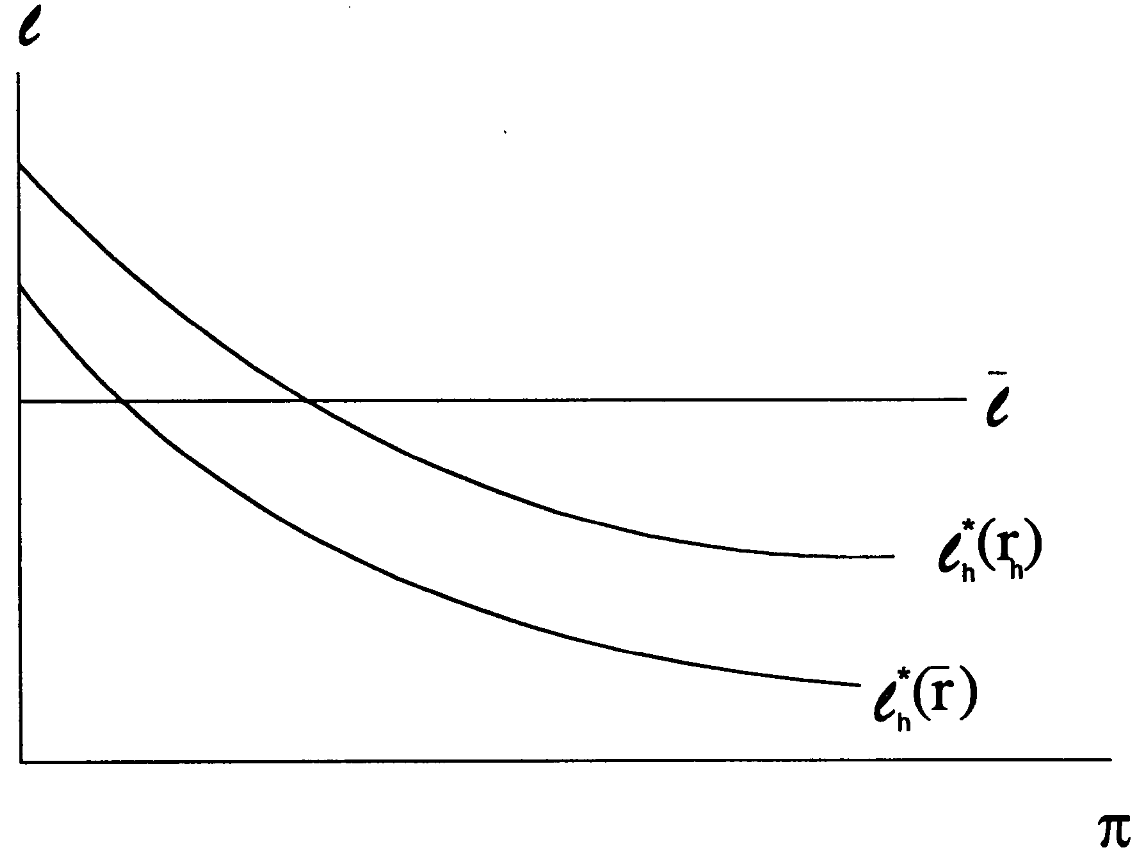
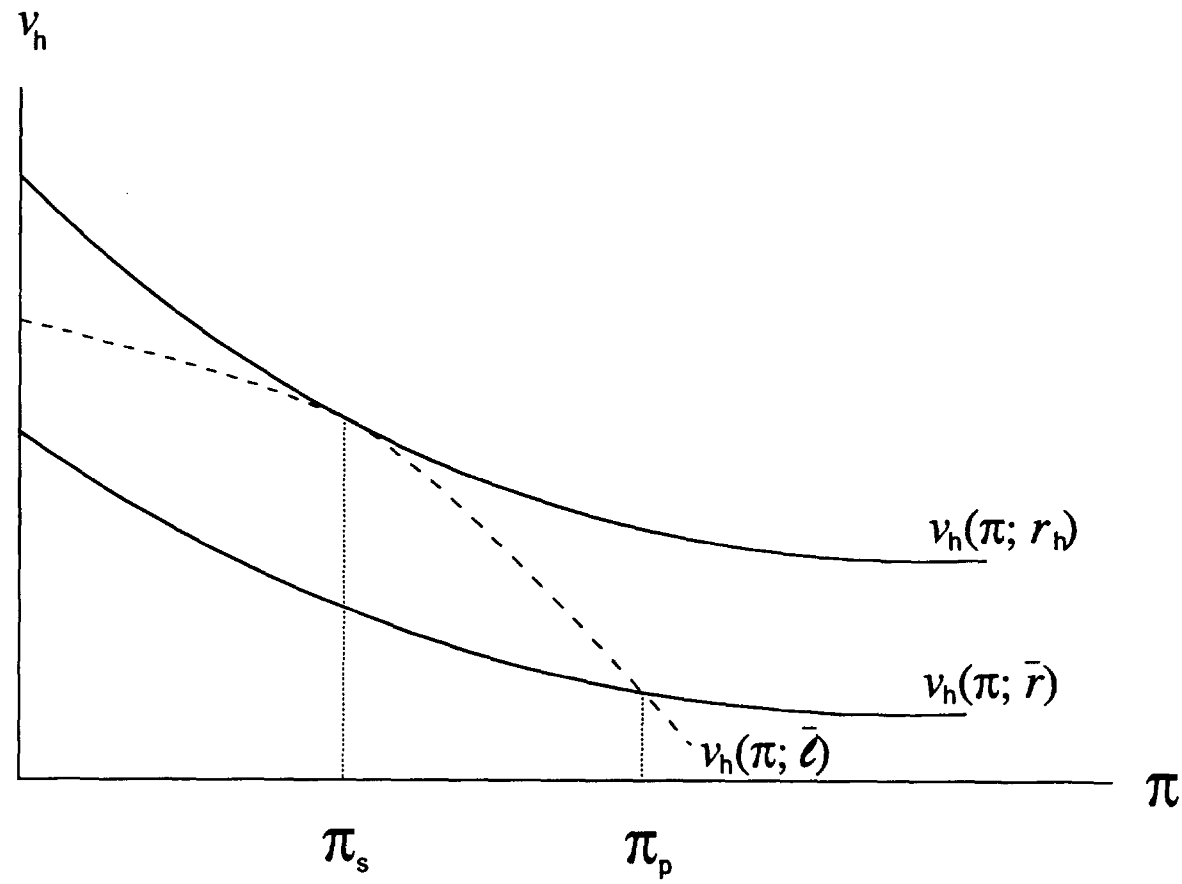


Figure 3: Equilibrium



$$\pi_p: \qquad \nu_h(\pi_p;\bar{\ell}) = \nu_h(\pi_p;\bar{r}), \tag{17}$$

where the subscripts s and p denote separating and pooling, respectively, and $\pi_s<\pi_p$. 1/

The main results and characterization of the type of equilibrium can be summarized in the following proposition:

Proposition 1:

Assume that π_s and π_p exist, then,
(i) For all $\pi \in [0,\pi_s]$ the equilibrium is natural separating.
(ii) For all $\pi \in [\pi_s,\pi_p]$ the equilibrium is separating.
(iii) For all $\pi > \pi_p$ the equilibrium is pooling.

Proof: See Appendix A ‖

The previous proposition establishes that when productivity of both firms are far apart, which happens at low rates of inflation, the equilibrium is natural separating. Since l-firms need to overproduce a large amount of goods to mimic h-firms when a is high, the benefits from obtaining a low interest rate do not offset the costs of overproducing.

The proposition shows that when natural separation is not feasible, h-firms still prefer to separate, but for this to happen they need to produce beyond their unrestricted optimum ($\bar{\ell}$ instead of $\ell_h^*(r_h)$). The proof is straightforward since it relies on the envelope theorem: a small change in ℓ_h around its optimum leads to a second order loss, while a step increase in the interest rate leads to a first order loss. Finally, the proposition establishes that there may be a point at which separation becomes too expensive for h-firms, so they "give up" and accept the pooling equilibrium. This happens at high inflation rates, above π_p.

In proposition 1 we assume that π_s and π_p both exist, but their existence is not guaranteed and it will depend on the parameters' configuration. In the case of π_s it will not exist if $\bar{\ell}$ lies always below $\ell_h^*(r_h)$ in Figure 1. This may occur if the benefits that l-firms obtain from pooling are low because the differential $\bar{r}-r_h$ is low.

The cutoff for a pooling equilibrium, π_p, could also not exist. A sufficient condition for the no existence of π_p is that $\nu_h(\infty;\bar{r}) < \nu_h(\infty;\bar{\ell})$, that is, even when labor productivity is the same for h- and l-firms it

1/ As can be seen in Figure 3, it could be possible that equation (17) may have two solutions for π_p, but we will only focus on the solution where $\pi_s<\pi_p$, which is the only economically meaningful solution. In addition, regardless the second derivative of $\nu_h(\pi;\bar{\ell})$ it is easy to show that whenever π_s exist it is also unique.

pays off for h-firms to separate because the increase in interest rates (from r_h to $\bar{r}$) may be too large and accepting pooling equilibrium may be unprofitable. After some manipulations, and using the fact that $a(\infty)=1$, the condition for the non existence of π_p becomes:

$$(r_h w)^{1-\epsilon}\theta > (r_l w)^{1-\epsilon}\theta+(\bar{r}-r_h)w\bar{\ell}$$

which shows that this may happen for high values of $\bar{r}-r_h$.

What ultimately determines the existence of the cutoff values of inflation, and consequently the extent in which each equilibrium is feasible, are the values of the exogenous parameters, in particular α and q. This issue is addressed in the next section.

As mentioned in the introduction, high-inflation experiences show that there is a negative relationship between credit and inflation. In this model--where credit is demand determined since banks have access to an infinitely elastic supply of funds--it is possible to show that this is generally the case. Total credit in natural separating equilibrium is $w[\alpha\ell_h^*(r_h)+(1-\alpha)\ell_l^*(r_l)]$. It is easy to see that in this region credit declines since borrowing of h-firms declines, while borrowing of l-firms remains constant.

Then, once inflation is in the region of separating equilibrium total credit is equal to $w[\alpha\bar{\ell}+(1-\alpha)\ell_l^*(r_l)]$. In this region, credit of l- and h-firms remain constant, although the total is less than in natural separation. Finally, total credit in a pooling equilibrium is $w\ell_h^*(\bar{r})$. As inflation rises above π_p, credit continue to decline. There is, however, a discrete change at π_p, whose sign is a priori ambiguous. The reason is that while h-firms reduce their demand for credit (since r jumps from r_h to $\bar{r}$ at π_p) l-firms' borrowing increases. Although this change will depend on the parameters and some formal conditions can be derived, it is reasonable to expect that at π_p total credit declines since the largest firms are the ones that are reducing borrowing. Moreover, as we argue in the final section, aggregation across different sectors of the economy should reduce the impact of this discrete change in total credit.

IV. Comparative Statics

In this section we study the effects of changes in α and q on π_s and π_p, allowing us to discuss issues of existence and the likelihood that an economy may be in a given equilibrium for different configurations of the parameters.

The effects of changes in α can be summarized in the following proposition:

Proposition 2:

$$\frac{d\pi}{d\alpha} < 0 \quad and \quad \frac{d\pi_p}{d\alpha} < 0.$$

Proof: See appendix A ‖

The intuition for this result is simple. If α is low, there are few h-firms, in which case r_l is not too different from $\bar{r}$, so l-firms do not have much incentive to pool. In contrast, when α is high, l-firms have a large incentive to look like h-firms, since they may enjoy a big reduction in interest rates by pooling. This implies that (costly) separation and pooling are more likely to occur (π_s and π_p decline) when α is large.

Figure 4 presents a numerical simulation of the two cutoff values as a function of α. Those simulations assume that $\epsilon=1.3$ and $q=0.5$, but a qualitatively similar diagram would be obtained for any value of q and ϵ. For presentational purposes we have drawn in the horizontal axis $\pi/(1+\pi)$. For the function $a(\pi)$ we use $(1+\pi)/\pi$ (which satisfies $a'<0$ and $a(\infty)=1$). The simulations solve the nonlinear system of equations (13)-(17), where $\bar{l}$ is obtained from (8) and w is normalized to 1.

The figure shows two additional interesting results to those established in proposition 2. First, as α goes to zero the only equilibrium is natural separating, since π_s and π_p do not exist. The reason for this is that when α is close to zero, the benefits that l-firms obtain from pooling are small. Second, for α close to 1 the range of inflation where separating equilibrium prevails is small since most of the economy is composed of productive firms, and hence r_h is close to $\bar{r}$. Therefore the higher financial cost faced by h-firms in pooling equilibrium is low. In the limit, when α is close to 1 the economy jumps directly from natural separating to pooling.

The comparative statics results for q are less clear cut, because changes in q not only affect $\bar{r}$--in the same way as changes in α do--but also affect r_l. An increase in q reduces $\bar{r}$, increasing the incentives for pooling. But, contrary to the case of a change in α, an increase in q also reduces r_l, reducing the incentives for pooling.

In Figure 5 we present several cases, depending on the specific value of α. We slightly change the value of ϵ from the previous simulations to 1.8 to illustrate more extreme cases. The figure shows that the relationships between q and π_s, and π_p are non monotonic. The figure also shows that at $q=1$ only a natural separating equilibrium exists. The reason for this is that at $q=1$ all interest rates are the same, so l-firms do not have the incentive to mimic h-firms since they would have to overproduce (as long as $a>1$).

For high values of α the range of natural separation declines. This happens because l-firms have a greater incentive to pool since r_l is much greater than $\bar{r}$, especially when α is large (see (6)). It is interesting to note, however, that for q close to 0 there is still a range in which l-firms do not want to pool. In this case l-firms profits' are equal to zero in a separating equilibrium. However, attempting to behave as h-firms may yield negative profits, specially at low levels of inflation, where productivity differentials are large. Finally, Figure 5 shows that pooling equilibrium may not exist, specially for values of α relatively low. 1/

V. Conclusions

In this paper we have presented a model where inflation induces informational frictions that affect credit markets equilibrium. Inflation is assumed to affect the relative profitability among firms, generating incentives for low-productivity firms to mimic the behavior of high-productivity firms. When inflation is low the equilibrium is such that there is full revelation of information. Each type of firm reveals its type when demanding working capital. However, as inflation rises high-productivity firms may need to overborrow, and consequently overproduce, in order to signal their type. In contrast, low-productivity firms have the incentive to mimic high-productivity firms in order to be charged a lower interest rate.

We have shown that depending on the level of inflation, there are three types of equilibria. For low rates of inflation, the equilibrium is fully revealing and neither type of firm have the incentive to deviate from their unrestricted optimum. At an intermediate range for the rate of inflation, the equilibrium is fully revealing, but high-productivity firms have to overproduce in order to signal their type, and to receive a better loan contract. Finally, at high rates of inflation it may not payoff for high-productivity firms to signal their type, and hence this may result in a pooling equilibrium.

An empirical motivation for this paper is the decline of credit to the private sector as inflation increases (see Figure 1). The model presented in this paper is capable of reproducing this stylized fact. Except for a discontinuity at π_p, it is generally the case that total credit declines as inflation increases. Moreover, it is useful to think of this model as a description of a sector of the economy. In an economy with many sectors, where each sector has specifics π_s and π_p, aggregation would tend to reduce the discontinuity that occurs when each individual sector enters in pooling equilibrium and would generate a smooth negative relationship between credit and inflation.

In the absence of a fully specified general equilibrium model it is difficult to make statements about welfare. In particular, at the outset we

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1/ This can also be seen in Figure 4.

Figure 4: Changes in α
(q=0.8)

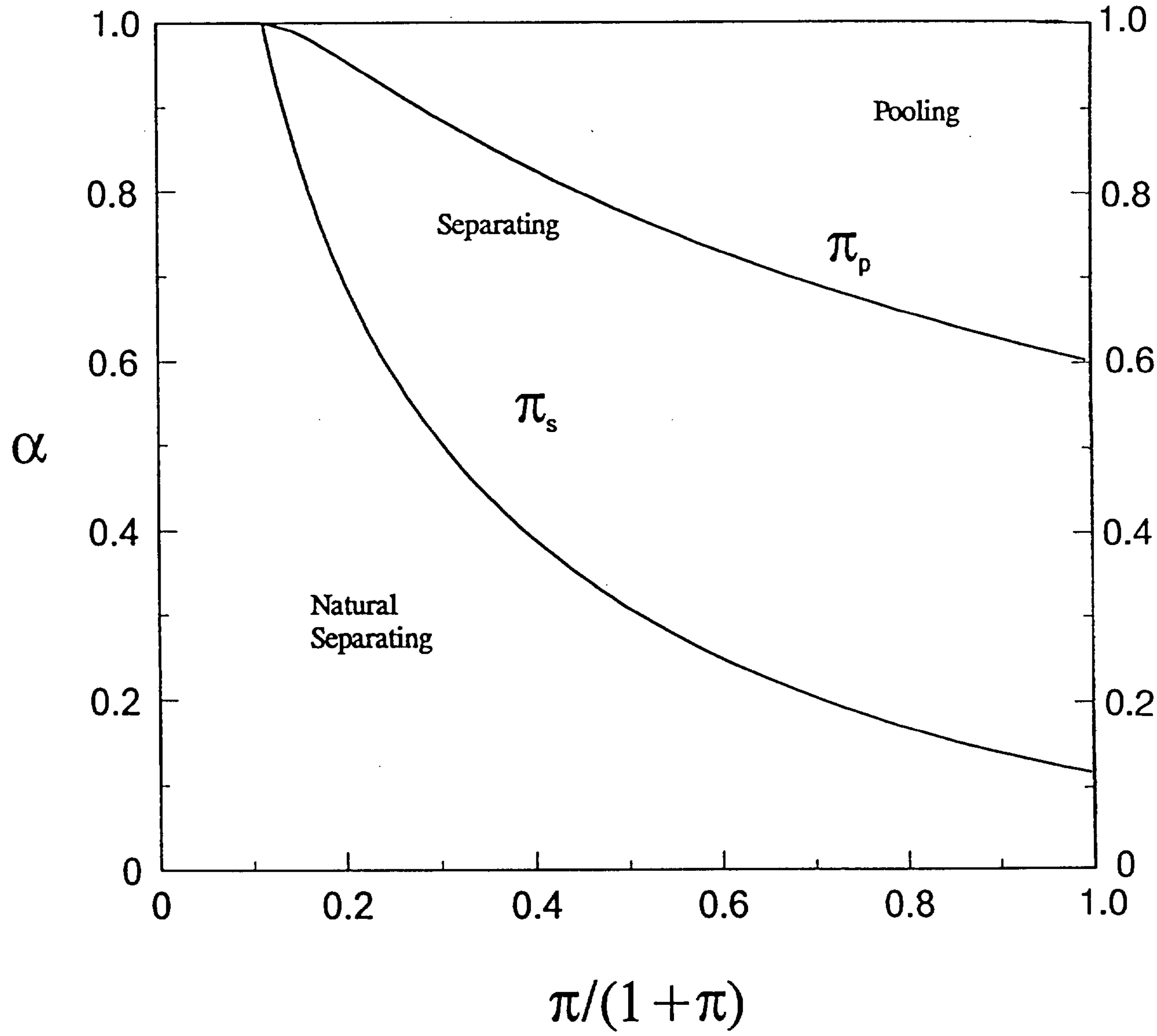
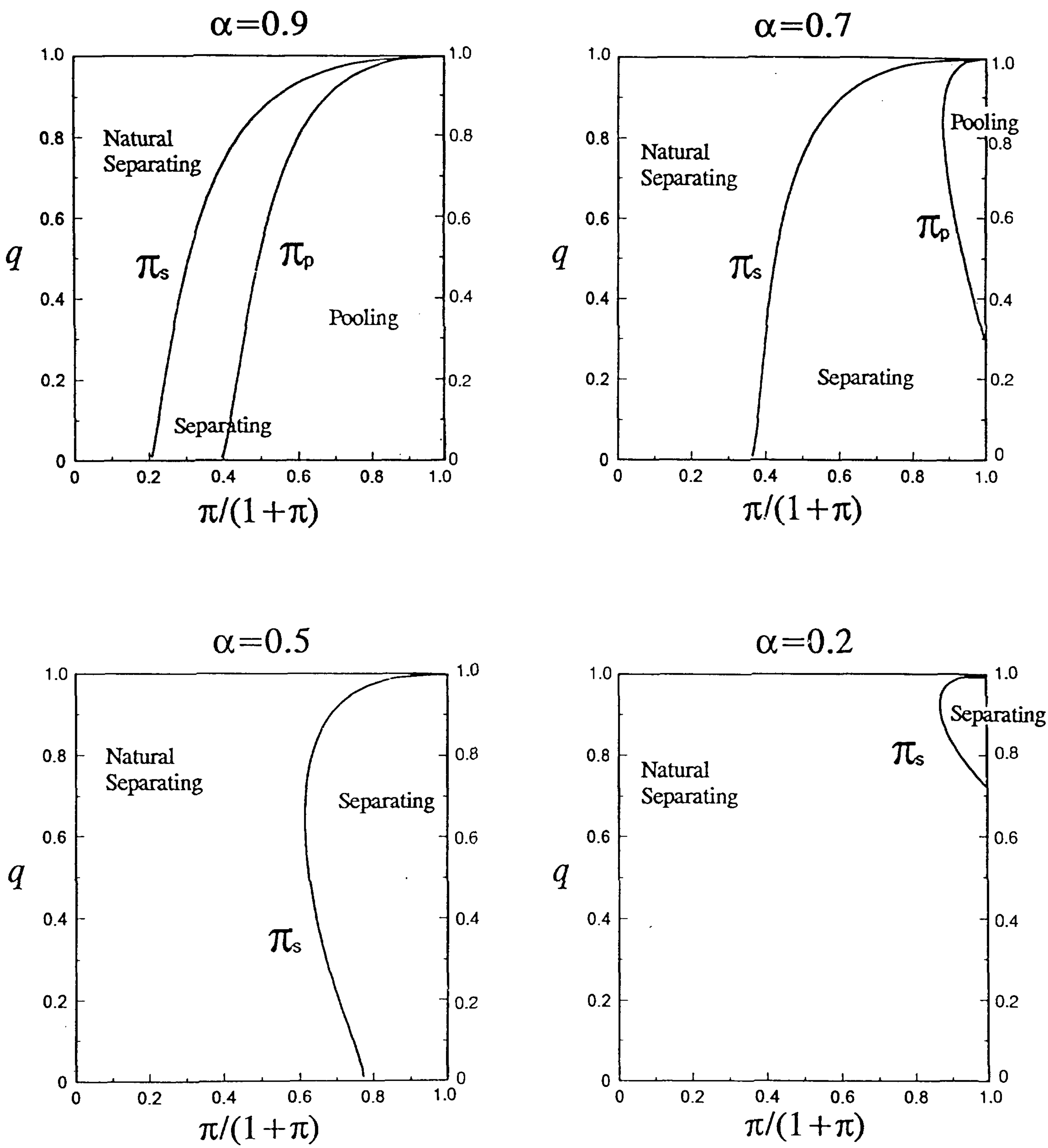


Figure 5: Changes in q



have assumed, reasonably, that inflation is welfare reducing by assuming that average productivity in the economy declines with inflation ($a'<0$). However, and excluding this effect, some remarks can be made on the potential welfare properties of the model. First, the difference from going from natural separating to separating equilibrium is that h-firms have to overproduce. As it is well-known from the literature on monopolistic competition (e.g., Dixit and Stiglitz, 1977), firms underproduce with respect to the competitive equilibrium, and the extent of underproduction is greater the greater is the monopoly power of firms. Therefore, overproduction could be welfare reducing if monopoly power is not too large, and h-firms end up overproducing with respect to the competitive solution. Then, going from separating equilibrium to pooling will most likely imply a reduction in welfare since it induces underproduction of the most productive firms and overproduction of the least productive ones. Of course, a full assessment of these welfare effects requires including the global effects of inflation on aggregate productivity along the lines of more traditional models of inflation and economic activity together with the informational costs emphasized in this paper.

Despite the simplifications of this model, we think that the mechanisms we discuss in this paper are potentially relevant for a number of applications. First, they may provide new insights on the effects of inflation on economic growth. The inability of financial intermediaries to distinguish the riskiness associated to different customers may have consequences on the ability of financial markets to allocate credit and foster economic growth. Second, they may also help to explain the marked recovery of credit to the private sector after a stabilization program is successfully implemented, which induces an increase in economic activity.

APPENDIX : Proof of Propositions

Proof of Proposition 1:

(i) Since,

$$\nu_h(\pi;r_h) = \max(a(\pi)\ell_h)^{(\epsilon-1)/\epsilon} - r_h\ell w > (a(\pi)\bar{\ell})^{(\epsilon-1)/\epsilon} - r_h\bar{\ell}\omega = \nu_h(\pi;\bar{\ell})$$

for $\bar{\ell}\neq\ell_h^*(r_h)$ h-firms prefer natural separating to separating. In addition, since $\nu_h(\pi;r_h)$ is decreasing in r_h, and $r_h<\bar{r}$, h-firms prefer natural separating to pooling.

Finally, for $\pi<\pi_s$ natural separation is feasible since $\ell_h^*(r_h)>\bar{\ell}$. This implies that l-firms are not interested in pooling, and therefore the equilibrium is natural separating.

(ii) For $\pi_s<\pi<\pi_p$ we have that $\ell^*{}_h(r_h)<\bar{\ell}$, and hence, l-firms would mimic h-firms by borrowing $w\ell_h^*(r_h)$ and natural separation is not feasible. To show that the equilibrium is separating, instead of jumping straight to pooling equilibrium, one needs to show that for π slightly greater than π_s h-firms prefer to separate. This is a consequence of the envelope theorem: a small increase in $\ell_h^*(r_h)-\bar{\ell}$ (at $\pi-\pi_s$) implies a second order loss, while the decline in profits is discrete since
r would rise from r_h to $\bar{r}$.

(iii) We first show that $d(\nu_h(\pi;\bar{\ell})-\nu_h(\pi;\bar{r}))/d\pi<0$:

$$\frac{d\nu_h(\pi;\bar{\ell})}{d\pi} = \frac{\epsilon-1}{\epsilon}a^{-1/\epsilon}a'\bar{\ell}^{(\epsilon-1)/\epsilon} < 0,$$

$$\frac{d\nu_h(\pi;\bar{r})}{d\pi} = \frac{\epsilon-1}{\epsilon}a^{-1/\epsilon}a'\ell_h^*(\bar{r})^{(\epsilon-1)/\epsilon} < 0,$$

and since $\bar{\ell}>\ell^*{}_h(\bar{r})$ for $\pi>\pi_p$, the difference between the above two expressions is negative.

Then, provided that π_p satisfying (16) exists, the previous result implies that for all rates of inflation greater than π_p we have $\nu_h(\pi;\bar{\ell})<\nu_h(\pi;\bar{r})$, and hence, h-firms prefer pooling equilibrium. This completes the proof. ‖

Proof of Proposition 2:

Differentiating (16) with respect to α and defining Δ by $\nu_h(\pi;r_h)-\nu_h(\pi;\bar{\ell})$, we obtain:

$$\frac{d\Delta}{d\pi_s}\frac{d\pi_s}{d\alpha}=\frac{d\nu_h(\pi_s;\bar{\ell})}{d\bar{\ell}}\frac{d\bar{\ell}}{d\alpha}.$$

Similarly to (iii) in proof of proposition 1 it is easy to show that $d\Delta/d\pi_s>0$. The expression $d\nu_h(.)/d\bar{\ell}$ is negative because $\bar{\ell}>\ell^*{}_h(r_h)$. Finally, differentiating (8) it can be verified that $d\bar{\ell}/d\alpha>0$ since l-firms are more tempted to mimic h-firms when α is large because the reduction in the interest rate they pay in pooling equilibrium is also large. Therefore $d\pi_s/d\alpha<0$.

Now, differentiating (17) with respect to α and defining Δ' by $\nu_h(\pi;\bar{\ell})-\nu_h(\pi;\bar{r})$, we obtain:

$$\frac{d\Delta'}{d\pi_p}\frac{d\pi_p}{d\alpha}=\frac{d\nu_h(\pi_p;\bar{\ell})}{d\bar{\ell}}\frac{d\bar{\ell}}{d\alpha}+\frac{d\nu_h(\pi_p;\bar{r})}{d\bar{r}}\frac{d\bar{r}}{d\alpha}.$$

Using (iii) from proposition 1 we know that $d\Delta'/d\pi_p<0$. It can also be easily checked that $d\nu(\pi_p;\bar{r})/d\bar{r}$ and $d\bar{r}/dq$ are both negative. Therefore, the LHS is positive and hence $d\pi_p/d\alpha$ is negative. ‖

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