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Do capital market imperfections exacerbate output fluctuations?

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Abstract

We develop a dynamic general equilibrium macroeconomic model where a proportion of firms are credit constrained due to asymmetric information. In general, a macroeconomic shock has additional effects created by a reallocation of funds between credit-constrained and unconstrained firms, as they have different marginal productivities. We show, however, that the output response to shocks is not necessarily amplified and can be dampened by the presence of asymmetric information. This depends on the impact of the shock on the composition of external and internal funds for credit-constrained firms. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

A major challenge in macroeconomics is to understand the magnitude and the persistence of output fluctuations. The role of financial market

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imperfections, implying a departure from the Modigliani–Miller theorem, has received a growing attention in recent years. In particular, Bernanke and Gertler (1989), Greenwald and Stiglitz (1993), and Kiyotaki and Moore (1997) present dynamic general equilibrium models where informational imperfections in capital markets exacerbate output fluctuations.[1] More recent studies, such as Carlstrom and Fuerst (1997) and Bernanke et al. (1998), attempt to quantify the degree of exacerbation by calibrating and simulating these types of models.

Empirical studies at the microeconomic level have confirmed that financial factors, and in particular the source of funds, matter for firms' decisions. For example, Fazzari et al. (1988) show that investment depends on firms' cash flow. The empirical evidence also shows that financial factors matter especially for firms that are more likely to be subject to information asymmetries, such as small firms. For example, in the literature examining the transmission channels of monetary policy, Gertler and Gilchrist (1994) show that small firms are more affected by a monetary tightening than large firms. At the aggregate level, however, the role of financial factors has not been clearly established empirically. While there are episodes, such as the Great Depression, where developments in credit markets seem to have amplified output fluctuations (e.g., see Bernanke, 1983), there is no systematic evidence on the link between financial factors and business cycles.

The purpose of this paper is to present a tractable dynamic general equilibrium model with asymmetric information in credit markets that is consistent with the existing empirical evidence and that contributes to a better understanding of the macroeconomic role of credit markets. The previous literature has shown that the impact of informational asymmetries is reflected in the evolution of agency costs. The presumption is that agency costs are counter-cyclical, which implies that the aggregate influence of financial factors is to exacerbate the impact of shocks. However, we show that agency costs can also be pro-cyclical, and therefore that credit market imperfections can dampen output fluctuations. While we confirm the results of Bernanke and Gertler (1989) (henceforth BG) and Kiyotaki and Moore (1997) (henceforth KM) for unanticipated productivity shocks, we show that the impact of anticipated productivity shocks, fiscal shocks, or saving shocks is usually not amplified and may be dampened.

We present a simple model of the credit market where lenders cannot observe all the actions taken by borrowers. However, asymmetric information only matters whenever the level of internal funds and collateralizable assets is sufficiently small.[2] In equilibrium lenders find it optimal to restrict the amount

[1] See Gertler (1988), Bernanke (1993), Lowe and Rohling (1993), Bernanke et al. (1996) for surveys of the literature relating credit markets and macroeconomic activity.

[2] In the current version we focus exclusively in the relative level of internal funds. In the working paper version, Bacchetta and Caminal (1996), we also discuss the role of collateral.

of credit only to those firms that can self-finance a low proportion of desired investment. A crucial element in our analysis is the heterogeneity of firms: affluent firms (those with abundant cash flow) coexist with poor firms (little cash flow), and the latter suffer from credit rationing. Since firms are assumed to have decreasing returns to scale in production, credit-constrained firms have a higher marginal productivity.

Thus, asymmetric information in credit markets has an impact on relative output movements if it affects the allocation of funds between constrained and unconstrained firms. This composition effect will exacerbate the impact of a positive shock whenever the level of internal funds available to credit-constrained firms increases relative to the total amount of funds. Equivalently, this is the case when the ratio between internal funds and investment of credit-constrained firms increases. However, the composition effect can in general go in either direction, i.e., there can be either amplification or dampening of the shocks.

In this framework, consider an increase in the supply of funds external to firms, with internal funds remaining constant. The excess supply of funds reduces interest rates which allows firms to increase their investment. However, credit-constrained firms will increase their investment in a lower proportion: since the ratio of internal funds to investment declines, their lending constraint becomes tighter. Thus, there is a negative composition effect that dampens the positive impact of such a positive supply shock. This would be the case when a reduction in the stock of public debt has a 'crowding in' effect.

Alternatively, consider an unanticipated productivity shock. The cash flow of highly leveraged firms will increase more than proportionally, which improves the credit conditions for constrained firms and allow them to expand investment more than proportionally. In this case, the composition effect exacerbates the impact of the shock.

Whether or not there is a dampening effect is an issue that should be settled empirically in future research. What our results indicate, however, is that the presumption that capital market imperfections increase the amplitude or the persistence of shocks is not necessarily correct. This may be an explanation for the lack of systematic evidence on the aggregate impact of credit market imperfections. Our analysis actually determines the circumstances where there can be exacerbation. This should be useful for future analysis, both at the empirical and the theoretical level, on the role of financial factors in the business cycle.

The rest of the paper is organized as follows. In Section 2, we present a static partial equilibrium model of the credit market. Section 3 incorporates the microeconomic model into a stylized dynamic macroeconomic framework with overlapping generations. Section 4 examines the impact of various macroeconomic shocks. Finally, Section 5 contains some concluding remarks.

2. A simple model of the credit market

In this section, we describe and analyze a static partial equilibrium model of the credit market with heterogeneous entrepreneurs. We assume that lenders cannot observe all the actions taken by borrowers during the production process, so that there is a potential moral hazard problem. What differs across entrepreneurs is the level of internal funds. Entrepreneurs with smaller internal funds have a more difficult access to credit and therefore carry out a smaller investment. Assuming decreasing returns to scale in production, smaller internal funds also imply a higher marginal productivity of capital. The reallocation of funds across heterogeneous firms will consequently affect aggregate productivity and output.[3] In other words there is a *composition effect*. Although these types of effects are in general complex, we present a simple and tractable model that allows us to examine the dynamic response to shocks. We first give a general overview of the composition effect in our framework and then present a microeconomic model of the credit market. In the next section, we embed such a market in a dynamic general equilibrium economy.

2.1. The composition effect

There are two types of entrepreneurs in the economy: High and Low. Both types have access to the same technology, represented by the production function $f(k)$, which is twice continuously differentiable, with $f(0) = 0, f'(k) > 0$ and $f''(k) < 0$. Moreover, in order to have a well-behaved investment function we assume that $\lim_{k\to 0} f'(k) = \infty$ and $\lim_{k\to\infty} f'(k) = 1$. High entrepreneurs face no constraint in the credit market and therefore profit maximization implies

$$f'(k^*) = r, \tag{1}$$

where k^* is the High capital stock and r is the safe (gross) interest rate. On the other hand, Low entrepreneurs are credit-constrained so that their capital stock is lower than for High. We can write

$$f'(k) = \varphi r, \quad \varphi \geq 1, \tag{2}$$

where k is the capital stock of Low types and φ is a measure of agency costs: the higher φ, the smaller investment of Low entrepreneurs. Moreover the higher φ, the higher the marginal productivity of capital of Low types. If we combine Eqs. (1) and (2) we obtain

$$\frac{f'(k)}{f'(k^*)} = \varphi. \tag{3}$$

[3] Bernanke et al. (1998) also consider heterogeneous firms but in equilibrium all types have the same net expected marginal productivity.

Eq. (3) shows that the ratio of the investment levels of High and Low type entrepreneurs, k^*/k, is an increasing function of φ. Changes in φ affect this ratio and generate a composition effect. For example, a decline in φ implies that a higher share of the capital stock goes to Low entrepreneurs. Since the marginal productivity of Low entrepreneurs is higher, output can increase even if the aggregate capital stock remains constant. In general, this composition effect takes place simultaneously with other changes, possibly including a change in the total capital stock, and can therefore exacerbate or dampen the impact of aggregate shocks.

It is crucial to specify how agency costs φ are determined and how they react to shocks. Below we develop a microeconomic model of credit with asymmetric information and moral hazard where φ depends on the distribution of internal funds.

2.2. Moral hazard and credit constraints

The supply side of the credit market is characterized by an inelastic supply of funds. The demand for credit comes from firms that require external funds in order to finance productive investment. Both lenders and borrowers are risk neutral.[4] The credit market is perfectly competitive: both lenders and borrowers take the expected return r as given, and r clears the market. The structure of the optimal financial contract is constrained by a standard moral hazard problem. We assume that lenders cannot observe some of the actions taken by entrepreneurs which influence the probability of loan repayment. Such an asymmetry of information shrinks the set of feasible contracts when entrepreneurs' limited liability is combined with a low level of firms' internal funds. The difference between High and Low entrepreneurs is precisely their level of internal funds. High-type entrepreneurs have enough funds so that they are not rationed, while Low types have limited funds.

Both types of entrepreneurs have access to the same technology set. There is a continuum of investment projects, indexed by α, which can be operated at different scales. If an entrepreneur invests k units of the good in period $t-1$ and selects a project α, she obtains in period t a level of output y, which is a random variable:

$$y = \begin{cases} \mu(\alpha) f(k) & \text{with probability } \alpha, \\ 0 & \text{with probability } 1-\alpha. \end{cases}$$

[4] Alternatively, lenders could be risk averse and lend to risk neutral financial intermediaries. In this case, the deposit contract between lenders and intermediaries must be defined carefully.

The parameter α is restricted to lie in the interval $[\underline{\alpha}, 1]$, with $0 < \underline{\alpha} < 1$. Moreover, the function $\mu(\alpha)$ is such that $\mu(1) = 1$ and $0 \leq \alpha\mu(\alpha) < 1$ for any $\alpha \in [\underline{\alpha}, 1)$. This specification implies that the project maximizing expected output is $\alpha = 1$. Lower levels of α imply lower expected levels of output and higher dispersion. While the level of investment k is public information, the choice of technology, α, is the entrepreneur's private information. As a result no financial contract can be written contingent on the choice of α, which may induce the entrepreneur to choose an inferior technology depending on the financial conditions.[5]

2.2.1. High-type entrepreneurs

Entrepreneurs with high internal funds are assumed to be net lenders, that is their internal funds, b^*, exceed the desired investment, k^*. Their excess funds $b^* - k^*$ are lent at the safe (gross) interest rate r. Thus, their optimization problem is the following. Given b^* and r, choose α and k^* in order to maximize profits:

$$\pi = \alpha\mu(\alpha) f(k^*) + r(b^* - k^*)$$

subject to $\alpha \in [\underline{\alpha}, 1]$.

Clearly, the solution is $\alpha = 1$ and k^* such that Eq. (1) holds. As there is no risk and zero demand for outside funds, these entrepreneurs choose the efficient project, $\alpha = 1$, and the efficient size (they equate the marginal product to the cost of funds). Small changes in the level of internal funds do not affect the investment decisions of these entrepreneurs.

2.2.2. Low-type entrepreneurs

Low-type entrepreneurs have a level of internal funds, b, which is assumed to be sufficiently small. Thus, they must borrow an amount $(k - b)$. It can be shown that it is optimal for lenders to offer a debt contract (i.e., with payment independent of output) if their cost of verifying the project return is large.[6] Thus, a financial contract specifies an interest rate R and amount of credit $(k - b)$. Given the triple (R, k, b), a Low entrepreneur chooses the project α in order to maximize

$$\pi = \alpha[\mu(\alpha) f(k) - R(k - b)]$$

subject to $\alpha \in [\underline{\alpha}, 1]$.

[5] The variable α can be interpreted as the technology used in the production process, but also as any other decision taken by the entrepreneur which is only observable by outsiders at a cost (which, for simplicity, is assumed to be infinite in our model), such as marketing, advertising or R&D policies.

[6] The argument is analogous to those in Townsend (1979), Diamond (1984) and Gale and Hellwig (1985). See Appendix A.

Since the parameter α is the entrepreneur's private information it cannot be part of the financial contracts, which opens the door to a potential moral hazard problem. The entrepreneur may choose an inefficient level of α because of limited liability and fixed payment. Although $\alpha < 1$ implies a reduction in expected output, the entrepreneur's expected profits may actually increase. The reason is that in case of success (which occurs with probability α) she appropriates all the extra output, while in case of failure (which occurs with probability $1-\alpha$) she shares the losses with the lender. In fact, a higher level of internal funds, b, induces the entrepreneur to put more weight on bad outcomes and to choose a higher α. If b is high enough the entrepreneur chooses $\alpha = 1$ and the incentive problem is not binding. In order to make the model interesting we consider only the case where the market interest rate r, and internal funds b, are such that a Low firm chooses $\alpha < 1$ if it is offered a 'first best' contract ($R = r$, $k = f'^{-1}(r)$). Below we provide a precise statement, labelled Condition B.

In the optimal financial contract asymmetric information may be reflected in either higher interest rates or credit rationing (or in a combination of both). In order to simplify the exposition we focus on a specific functional form for $\mu(\alpha)$ that implies that asymmetric information is exclusively reflected in a level of lending below the the first best. The qualitative results of the paper are insensitive to such specification, but both computations and intuitions are greatly simplified.[7] Thus, in the remaining we assume that

$$\mu(\alpha) = \frac{1 + (1-z)\ln\alpha}{\alpha},$$

where z is a constant, $0 < z < 1$. Notice that $\mu(1) = 1$ and that

$$\frac{\mathrm{d}\alpha\mu(\alpha)}{\mathrm{d}\alpha} = \frac{1-z}{\alpha}.$$

That is, expected output is increasing in α. In order to avoid negative levels of output, the lower limit of the feasible interval is $\underline{\alpha} = \exp\{-1/(1-z)\}$, i.e., $\mu(\underline{\alpha}) = 0$. As we will see below, z parametrizes the extent of the moral hazard problem, as a higher value of z decreases the incentives to choose the efficient project.

In the general equilibrium analysis we examine the investment and output variability due to asymmetric information problems. For general concave production functions $f(\,.\,)$, investment and output fluctuations will depend on their own levels. In order to emphasize the impact of capital market imperfections we rule out level effects by assuming a constant elasticity production function:

[7] See the discussion in Section 5.

$f(k)=k^{\lambda}$, where $1-z<\lambda<1$. Under these specific functional forms for $f(\,.\,)$ and $\mu(\,.\,)$ the equilibrium contract takes a simple form. If we denote $\omega \equiv \lambda/(1-z)$, $\omega>1$, and consider the following constraint on internal funds of Low firms:

$$b<\left(\frac{\lambda}{r}\right)^{1/(1-\lambda)}(1-\omega^{-1}). \qquad \text{(condition B)}$$

Then we have the following result:

Proposition. When condition B holds, in equilibrium Low entrepreneurs are offered credit at the safe interest rate r, but are credit-constrained, in the sense that investment is below its first best level. More specifically, k is given by

$$f'(k)=r\omega\left(1-\frac{b}{k}\right). \qquad (4)$$

The proof can be found in Appendix A. Notice that, in contrast with High entrepreneurs, the level of investment increases with the level of internal funds. In fact, $\mathrm{d}k/\mathrm{d}b>1$. Also, from Eq. (2) agency costs φ are a linear and negative function of the ratio of internal funds to the capital stock:

$$\varphi=\omega\left(1-\frac{b}{k}\right). \qquad (5)$$

Condition B combined with Eq. (4) implies that φ is higher than 1. It is important to emphasize that the size of agency costs does not depend on the absolute value of internal funds but its value relative to the investment level. This feature will be relevant to understand the effects of shocks in the general equilibrium analysis.[8]

3. The general equilibrium model

3.1. Optimal individual behavior

In this section, we incorporate the analysis of the previous section in a simple and tractable dynamic general equilibrium model. The purpose is to construct

[8] For some alternative specifications of $\mu(\alpha)$ the optimal contract induces the firm to choose $\alpha<1$ and a level of investment that equalizes the expected marginal product and the market interest rate: $\alpha\mu(\alpha)f'(k)=r$. In this case, the agency cost would be the output forgone because of the inefficient project choice. It can be shown that α would increase with b. Therefore agency costs would also be affected by exogenous shocks, which will either exacerbate or dampen the effect of these shocks on output volatility.

a simple framework that generates endogenously the main state variables (b, b^*) and that can be used to analyze the dynamic effects of various shocks. We consider an overlapping generations model with bequests, where individuals live for two periods, and population is constant. The justification for such a model is that it involves only one-period contracts and avoids the complications associated with multi-period contracts. Moreover, we include bequests as a source of dynamics. As we are interested in firms' internal funds, it is important to have a mechanism that allows to transfer these funds from period to period. A simple way of doing this is to introduce bequests.[9]

All individuals are at the same time consumers and entrepreneurs with access to the technology described in the previous section. In the first period of their life, individuals receive a bequest that can be used either to finance their own productive investment or to lend to other entrepreneurs. In the second period, they consume and leave a bequest.

There are two types of individuals: High and Low, in proportions β and $1-\beta$. High-type individuals receive a large bequest when young, which allows them to fully finance their investment. Moreover, they generally have excess funds that are lent to other individuals. These agents are not subject to any moral hazard problem, since they do not need to borrow. High-type dynasties remain of the same type over time by leaving large bequests to each next generation. On the other hand, Low-type individuals receive a bequest that is too small to fully finance their investment. Hence, they need to borrow and pay the agency costs. As described in Section 2, these entrepreneurs are credit-constrained. The distinction between constrained and unconstrained entrepreneurs is therefore endogenous and depends on the different propensities to leave bequests by High- and Low-type agents. In this model, the internal funds that matter are the bequests of Low type entrepreneurs. The funds lent by High type entrepreneurs represent the external funds.

3.1.1. High-type agents

A High-type entrepreneur born at time $t-1$ receives a bequest b^*_{t-1}. She uses a proportion of it to finance her investment k^*_{t-1} and lends the rest at the gross interest rate r_t. In period t, she consumes c^*_t and leaves a bequest b^*_t. Her budget constraint is therefore

$$c^*_t + b^*_t \leq f(k^*_{t-1}) + r_t(b^*_{t-1} - k^*_{t-1}).$$

[9] An alternative, and somewhat more complex, way is to have a labor market as in BG. In their framework, higher profits are reflected in higher wages which imply larger internal funds for entrepreneurs in the following period.

Subject to this constraint, she maximizes the following utility function:

$$\min\left\{c_t^*, \frac{1-\gamma^*}{\gamma^*} b_t^*\right\},$$

where $0 < \gamma^* < 1$.[10] The solution to the optimization problem gives

$$f'(k_{t-1}^*) = r_t, \tag{6}$$

$$b_t^* = \gamma^*[f(k_{t-1}^*) + r_t(b_{t-1}^* - k_{t-1}^*)]. \tag{7}$$

3.1.2. Low-type agents

Low-type individuals have a similar timing, but need to borrow $(k_{t-1} - b_{t-1})$ to finance their investment. As described in Section 2, they can borrow at the safe interest rate r. The budget constraint of a Low individual born in period $t-1$ is therefore

$$c_t + b_t \leq f(k_{t-1}) + r_t(b_{t-1} - k_{t-1}).$$

Low-type entrepreneurs are credit-constrained and need to satisfy the incentive compatibility constraint (4). Subject to the above two constraints, Low-type entrepreneurs born at time $t-1$ maximize the following utility function:

$$\min\left\{c_t, \frac{1-\gamma}{\gamma} b_t\right\},$$

where $0 < \gamma < \gamma^*$. The solution to the optimization problem gives

$$f'(k_{t-1}) = r_t\omega\left(1 - \frac{b_{t-1}}{k_{t-1}}\right), \tag{8}$$

$$b_t = \gamma[f(k_{t-1}) + r_t(b_{t-1} - k_{t-1})]. \tag{9}$$

3.2. Equilibrium conditions

Combining Eqs. (6) and (8), we find the analogue of Eq. (3):

$$\frac{f'(k_t)}{f'(k_t^*)} = \left(\frac{k_t^*}{k_t}\right)^{1-\lambda} = \omega\left(1 - \frac{b_t}{k_t}\right). \tag{10}$$

Also, the market clearing condition is

$$B_t \equiv \beta b_t^* + (1-\beta)b_t = \beta k_t^* + (1-\beta)k_t. \tag{11}$$

[10] The Leontief utility function gives the same optimal consumption and bequest as the log utility function. However, agents only worry about expected returns, while other utility functions introduce risk aversion that complicates the analysis. Consequently, such a specification of entrepreneurs' preferences justifies expected profit maximization as assumed in the previous section.

Thus, Eqs. (7), (9)–(11) fully describe the dynamics of this economy. It can be shown that an equilibrium exists and is unique provided that γ and γ^* are sufficiently different.[11]

3.3. The composition effect and output variability

A crucial element in the analysis is the relative investment by the two types of firms. First, it is clear from Eq. (10) that investment by a High-type firm is larger than that by a Low-type firm, and hence their marginal products differ. As a result of agency costs, for the same aggregate investment level, aggregate output is lower than in the case of complete information. This represents a level effect. In addition, the dynamics of the system are driven by the evolution of the relative investment of both types of firms. The next result indicates that the relative investment depends on the distribution of funds among High- and Low-type individuals or, equivalently, among internal and external funds for Low type entrepreneurs. This is an important ingredient of the analysis of shocks carried out in the next section.

Result 1 (*The composition effect*). *The relative investment of credit-constrained firms moves in the same direction as the proportion of their internal funds and in the opposite direction from agency costs, i.e., both k_t/k_t^* and b_t/k_t increase with b_t/b_t^*.*

This result comes directly from Eqs. (10) and (11). The intuition is the following. The relative investment of credit-constrained firms increases (decreases) when agency costs fall (rise). Also, agency costs are a decreasing function of b_t/k_t. Suppose b_t and b_t^* increase in the same proportion. The investment of credit-rationed firms must increase in the same proportion, otherwise agency costs and the relative investment of credit-constrained firms move in opposite directions. Only when b_t increases proportionally more than b_t^*, agency costs fall and the relative investment of credit-rationed firms increases.

Since the interesting aspect is the output response to shocks, we can establish a second result, shown in Appendix B.

Result 2 (*Output volatility and the composition of funds*). *Suppose that the economy at time 0 experiences an exogenous and transitory increase in the total amount of funds. The relative effect on output at $t = 1$ is higher, equal or lower than in the case of perfect capital markets if b_0/b_0^* increases, stays constant or decreases, respectively.*

Thus, asymmetric information exacerbates or dampens output fluctuations depending on whether there is a redistribution of funds in favor or against

[11] The proof can be found in the working paper version, Bacchetta and Caminal (1996), and is available upon request.

credit-constrained firms. The intuition is that if the internal funds of rationed firms increase relatively more than external funds, agency costs decrease and their investment increases relatively more. Given that these firms have a higher marginal product than the unconstrained firms, such a change in the composition of investment exacerbates output expansion.

In Result 2 we have focused on the short-run effects of a change in the amount and composition of funds. The relative performance of output in subsequent periods, however, depends not only on the composition of funds, b_t/b_t^* (and thus, on agency costs), but also on the total amount of funds, B_t ($t = 1, 2, 3, \ldots$). The evolution of B_t depends on how saving and the persistence mechanism are introduced in the model, which makes the comparison of the evolution of B_t with and without asymmetric information in general ambiguous. This element will also be present in the analysis of specific shocks in the next section. However, changes in agency costs keep the same sign after a shock as t increases, as shown below.

Result 3 (*The persistence of agency costs*). *Changes in the composition of funds are persistent over time, i.e.,* b_{t+1}/b_{t+1}^* *increases with* b_t/b_t^*.

This result comes immediately from Eqs. (7), (9)–(11). A redistribution of funds in favor of credit-constrained firms not only increases the relative investment by these firms but also their relative income. As a result, the composition of funds in subsequent periods will also be more favorable to rationed firms.

To summarize, there are two state variables in the model: The composition and the total amount of funds. The composition of funds determines the agency costs and the relative investment in the two sectors of production. A redistribution of investment towards credit-constrained firms increases the level of output. Consequently, changes in the composition of funds may amplify or dampen output volatility. These effects are likely to be robust to most changes in the specification of the agency problem.

However, the evolution of these state variables crucially depend on the specification of the persistence mechanism. For the purpose of illustration, we chose to close the model with the bequest functions (7) and (9). A particular implication of such a specification is that a redistribution of income from High- to Low-type individuals decreases the total amount of funds in the next period, since both types have different propensities to save (to leave bequests). Alternative specifications of the saving functions may alter some of the dynamic implications of the shocks examined in the next section.

4. The impact of shocks

In this section, we examine the impact of various shocks on output, with and without asymmetric information. First, we identify two shocks that have exactly the same relative impact in both scenarios: an anticipated productivity shock and a change in saving behavior. Second, we examine two shocks that have the opposite impact on the correlation between agency costs and output: an unanticipated productivity shock and a fiscal shock.

4.1. Anticipated productivity shocks

Consider a multiplicative shock to the production function, i.e., $Y_{t+1} = \eta_{t+1} f(k_t)$ for both types of firms, and suppose that the productivity factor η_t experiences a permanent change at time 1, which is fully anticipated at time 0. Eqs. (10) and (11) indicate that both k^*_{t-1} and k_{t-1} are independent of η_t, but the interest rate r_t changes in the same proportion as η_t (Eqs. (6) and (8)). As a result, the proportional change of Y_1 is the same with and without asymmetric information.

In order to see the effect in subsequent periods, notice that, from Eqs. (7) and (9), the rate of change in b^*_t and b_t is the same as the rate of change of η_t, and hence the total amount of funds, B_t, changes in the same proportion with and without asymmetric information, while the ratio b_t/b^*_t is not affected. Adapting Result 1, we conclude that the rate of change of output in periods $t = 2, 3, \ldots$ is the same with and without asymmetric information.

The intuition is the following. An anticipated productivity shock increases Low type firms' demand for funds, but also decreases High-type firms' supply of funds. As a result the interest rate increases to the point where investment levels remain unchanged, and agency costs stay constant. As relative investment does not change, relative income and bequests by the two types of agents also stays constant. Consequently, agency costs are not altered and output volatility is the same as in the case of perfect capital markets. In other words, with anticipated productivity shocks agency costs are acyclical and, therefore, asymmetric information does not affect output volatility.

4.2. Aggregate saving shocks

Suppose that the propensity to leave bequest by both types of individuals, γ and γ^*, is multiplied by a factor κ at time 0, i.e., γ/γ^* stays constant. From Eqs. (7) and (9), b_0/b^*_0 remains constant, and total saving, B_0, is multiplied by κ. From Result 2, the rate of change of output at time 1 is the same with and without asymmetric information, as k_0/k^*_0 stays constant. Finally, in subsequent periods b^*_t and b_t change in the same proportion, between themselves and with respect to the case of complete information. Therefore, agency costs remain constant over time and output volatility is unaffected by the presence of asymmetric information.

The intuition is also very simple. A proportional change in internal and external funds lowers interest rates and increases investment by both types of firms, while keeping their ratio constant since agency costs remain unchanged. Once more, agency costs are acyclical.

4.3. Unanticipated productivity shocks

Consider again a multiplicative shock to the production function, i.e., $Y_{t+1} = \eta_{t+1} f(k_t)$ for both types of firms, and suppose that the productivity factor η_t experiences a permanent change at time 1. Suppose now that the productivity parameter η_1 is not known when investment decisions are made at time 0. Obviously, k_0 and k_0^* do not change. It can be easily seen from Eqs. (7) and (9) that if η_1 increases, b_1/b_1^* also increases. The reason is that profits of leveraged firms increase more than proportionally, while profits of net lenders increase less than proportionally. Moreover, because of asymmetric information, the total amount of funds, B_1, increases at a higher rate,[12] since the relative increase in output is higher for those agents with a higher propensity to save (High type). Consequently, adapting Result 2, the rate of change in output in period 1 is larger with asymmetric information for two reasons: the ratio of internal to external funds increases and the total amount of funds also increases. The same result holds for subsequent periods since the composition effect will persist over time (Result 3). The reason is that under asymmetric information credit-constrained firms are less affected by the interest rate increase (as they borrow less) and can more easily increase their saving.

Thus, an unexpected positive productivity shock implies a relative income transfer from High- to Low-type individuals, since the income of indebted agents increases relatively more than the income of agents in a net lending position. This result is similar to the findings in BG. In their model a positive productivity shock increases the internal funds of entrepreneurs affected by an asymmetric information problem, reduces their agency costs and increases investment and output above the level obtained under perfect capital markets. Here, we also obtain such counter-cyclical agency costs in the case of productivity shocks, but only when these shocks are unexpected. Otherwise the shock is reflected in the interest rate (which is exogenous in BG) and the proportion of internal versus external funds remains unchanged.

4.4. Fiscal shocks

The model can be easily extended to include a government sector. We only consider a simple fiscal experiment which consists of a one-period debt increase. At time 0, the government issues a debt d and wastes this revenue. To balance

[12] At least, for the set of parameter values for which a stationary equilibrium exists.

the government intertemporal budget constraint, we assume that at time 1 a tax is perceived on the High-type entrepreneurs to repay the debt.[13] The debt issuance in period 0 implies a crowding-out effect and a decline in investment. Such a negative effect on output is dampened by the composition effect as the debt reduces the amount of external funds (Result 2), while internal funds are obviously unaffected by the fiscal policy experiment. As a result agency costs fall, and credit-constrained firms are relatively more protected from the crowding out effect. It is precisely the relative redistribution of funds from low to high marginal product firms which reduces the negative output effect of the fiscal shock.

After period 0, the composition effect still exerts a dampening influence (Result 3 plus the tax structure assumed), but there is a total saving effect that might go in the opposite direction. While we are unable to show that the composition effect always dominates, this is the case for all the numerical simulations we computed (see Bacchetta and Caminal, 1996). Since the fiscal shock has a negative impact on output, such a negative response is dampened by the presence of asymmetric information in credit markets.[14]

5. Concluding remarks

The main conclusion of this paper is that financial constraints may amplify or dampen output fluctuations depending on the type of shock.[15] Thus, our analysis has questioned the presumption that capital market imperfections systematically amplify the business cycle. Such a presumption is partly based on the intuition provided by theoretical models constructed on somewhat special assumptions. We have shown that when some firms are financially constrained, the impact of various shocks might be dampened. This implies that empirical studies that show that some groups of firms are constrained, as in Fazzari et al. (1988), do not provide evidence on the macroeconomic implications of these constraints. Our results may explain why no clear evidence on the aggregate impact of capital market imperfections has been found. It suggests that a finer analysis should be undertaken. In particular, it is necessary to identify the type

[13] Many other tax schemes could be considered, affecting differently the economy from time 1 on.

[14] We have also examined the effect of a reserves requirement on lenders. That is, lenders are required to hold a below-market interest rate asset issued by the government, in proportion of the amount lent to type L firms. Provided z is high enough we have also obtained that the negative output effect of such a requirement is dampened by a pro-cyclical agency cost.

[15] In Bacchetta and Caminal (1996) we also show that the form of net worth affecting the level of agency costs may be crucial to determine whether a particular shock is exacerbated or dampened by capital markets imperfections.

of shock. Whether a shock initially affects funds that are internal or external to firms makes a significant difference.[16]

While careful empirical analyses are needed, it is interesting to consider the pattern of the business cycle. For a typical cycle, it is the amplifying effect that appears more likely. For this effect to dominate, we should see credit-constrained firms contracting more during recessions and expanding more during booms. Typically, small firms are more likely to be credit-constrained during recessions, which may cause a reallocation of funds from marginally more productive to less productive firms. Therefore, such a behavior is consistent with an exacerbation from capital market imperfections.[17] According to our model, this implies that the economy is dominated by shocks to internal funds, like unanticipated productivity shocks.

As our purpose was to develop a simple and tractable model providing economic insights on the role of credit market imperfections, several interesting aspects were absent from our analysis. In particular, the model is deterministic and only one-shot unexpected shocks have been considered. Although the introduction of uncertainty would be of considerable interest, the current strategy is justified by the fact that the objective was to highlight the main underlying mechanisms and provide clear economic intuitions. The model is far too simple to be used fruitfully in empirical work and hence the benefits of a stochastic version are modest.

Another useful extension is to consider the case where the moral hazard problem is reflected in higher lending rates and the investment level equates the expected marginal product to the lending rate. This can be easily done by changing the specification of the function $\mu(\alpha)$. In this case shocks may affect the premium charged to Low firms. Changes in the distribution of funds between Low and High firms have effects analogous to those we have analyzed in this paper. The reason is that in this case Low firms take more or less efficient actions in response to shocks (instead of suffering from various degrees of credit rationing) which results in different levels of average output. As a result agency costs can also exhibit a cyclical pattern and asymmetric information may exacerbate or dampen the effect of exogenous shocks.

A third important extension would be to endogenize the proportion of credit-constrained firms, i.e., to have β variable. For instance, medium-size firms

[16] As one referee pointed out, an important feature missing from the model is the counter-cyclical demand for funds arising from the cyclical behavior or unintended inventories. It could be argued that inventories may tend to make agency costs counter-cyclical, since in a recession credit-constrained firms need additional external funds. However, this is not necessarily the case in our model. What matters is the evolution of the ratio of unintended inventories by unconstrained and constrained firms, which influences the proportion of internal to external funds for rationed firms.

[17] The differential behavior between small and large firms could however be explained by non-financial factors.

could be credit-constrained only in recessions. This extension, considered for example in BG, would reinforce the impact of credit market imperfections and is likely to introduce asymmetries in the response of shocks that affect output positively or negatively.

Fourth, we could introduce firms' collateral as a guarantee for loan contracts, along the lines of KM and Carlstrom and Fuerst (1997). The basic mechanism for the response to shocks is likely to be altered. However, we can still have a composition effect that can exacerbate or dampen the impact of shocks. For example, assume that credit-constrained firms have different levels of collateral. Positive shocks that increase asset prices can generate a redistribution of lending away from firms with very low collateral. If these firms have a higher marginal productivity, such a redistribution implies a negative composition effect.

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Appendix A

Following Townsend (1979), Diamond (1984) and Gale and Hellwig (1985), we assume that output y can only be observed and verified by outsiders by paying a cost η (ex-post verification costs). As explained in the text α is not observable, and thus not contractible. Let us restrict for the moment to standard debt contracts, i.e., the entrepreneur must pay a fixed rate R to the lender, and if it does not do so then the lender verifies the output and takes everything. The lender expects that given (R, k, b), the entrepreneur's optimal action is the solution to

$$\operatorname*{Max}_{\alpha} \qquad \pi = \alpha \left\{ \left[\frac{1 + (1 - z)\ln \alpha}{\alpha} \right] f(k) - R(k - b) \right\}$$

subject to $\alpha \in [\underline{\alpha}, 1]$.

The first-order condition for an interior solution is

$$\alpha = \frac{(1 - z) f(k)}{R(k - b)}. \tag{A.1}$$

Thus, the lender's expected return (gross of verification costs) per unit of investment, αR, only depends on k and b, but not on R. In other words, it is not possible to change the lender's expected profit (gross of verification costs) by changing the interest rate. In fact, the lender's total expected profit is

$$B = (\alpha R - r)(k - b) - (1 - \alpha)\eta = (1 - z) f(k) - r(k - b) - (1 - \alpha)\eta.$$

The entrepreneur's expected profit is

$$\pi = \alpha\mu(\alpha) f(k) - \alpha R(k - b) = \{1 + (1 - z)[\ln\alpha - 1]\} f(k).$$

The optimal debt contract (k, R) is the solution that maximizes π subject to $B \geq 0$ and α given by Eq. (A.1). Notice that R does not directly affect either π or B, and both π and B increase with α. Thus, for any given k and b the lower R the higher α and the higher both π and B. Hence, the optimal debt contract consists of a pair (k, R) such that it induces the firm to choose the highest α, that is $\alpha = 1$. From the entrepreneur's optimal action choice, this implies that we have either an interior solution or a corner solution at $\alpha = 1$, i.e.,

$$(1 - z) f(k) \geq R(k - b). \tag{A.2}$$

Finally, the arbitrage condition ($B = 0$) implies that $R = r$ (in equilibrium the probability of failure is zero) and k such that the above incentive constraint holds with equality. Low-type entrepreneurs are assumed to have such a low level of internal funds that if they were offered the first best contract (r, k^*), where k^* is given by Eq. (1) in the text, then the incentive constraint (A.2) would be violated:

$$(1 - z) f(k^*) < r(k^* - b),$$

which is equivalent to condition B in the text. Thus, in the equilibrium contract Low firms' investment k is such that

$$(1 - z) f(k) = r(k - b).$$

The reason is that, provided the incentive constraint (A.2) is satisfied, firms' profits increase with k while banks' profits do not fall.

So far we have assumed that the optimal contract is a standard debt contract. Since α can be inferred from y, then a potential alternative would be to make repayment conditional on y. For instance, we could have

$$R(k - b) = \begin{cases} r(k - b) & \text{if } y = f(k), \\ y & \text{otherwise.} \end{cases}$$

Such a repayment function would give the entrepreneur incentives to choose $\alpha = 1$, but would cost η with probability one. Provided verification costs are high enough then the optimal contract is a standard debt contract, and incentives are provided by credit rationing unless the level of internal funds is high enough.

Appendix B

In this appendix we prove Result 2, stated in the text. Let B_t be the total amount of funds in period t, i.e., $B_t \equiv \beta b_t^* + (1-\beta)b_t$. From the market clearing condition (11)

$$\frac{dB_t}{B_t} = \frac{\beta k_t^*}{B_t}\frac{dk_t^*}{k_t^*} + \frac{(1-\beta)k_t}{B_t}\frac{dk_t}{k_t}. \tag{B.1}$$

Aggregate output is given by

$$Y_t = \beta f(k_{t-1}^*) + (1-\beta) f(k_{t-1}). \tag{B.2}$$

Hence,

$$\frac{dY_t}{Y_t} = \lambda\left[\frac{\beta f(k_{t-1}^*)}{Y_t}\frac{dk_{t-1}^*}{k_{t-1}^*} + \frac{(1-\beta) f(k_{t-1})}{Y_t}\frac{dk_{t-1}}{k_{t-1}}\right].$$

Plugging Eq. (13) into the above equation we get

$$\frac{dY_t}{Y_t} = \lambda\left[\frac{dB_{t-1}}{B_{t-1}} + \delta\left(\frac{dB_{t-1}}{B_{t-1}} - \frac{dk_{t-1}^*}{k_{t-1}^*}\right)\right], \tag{B.3}$$

where

$$\delta \equiv \frac{\beta k_{t-1}^*}{Y_t}\left[\frac{f(k_{t-1}^*)}{k_{t-1}^*} - \frac{f(k_{t-1})}{k_{t-1}}\right].$$

With perfect capital markets $k_{t-1}^* = k_{t-1}$, and hence

$$\frac{dB_{t-1}}{B_{t-1}} = \frac{dk_{t-1}^*}{k_{t-1}^*} = \frac{dk_{t-1}}{k_{t-1}}.$$

In this case, $\delta = 0$ and

$$\frac{dY_t}{Y_t} = \lambda\frac{dB_{t-1}}{B_{t-1}},$$

i.e., output growth is proportional to the growth of total funds. In contrast, in the case of asymmetric information, according to Result 1,

$$\frac{dB_{t-1}}{B_{t-1}} > \frac{dk_{t-1}^*}{k_{t-1}^*} \quad \text{if and only if} \quad \frac{b_{t-1}}{b_{t-1}^*} \text{ increases.}$$

Finally,

$$\frac{dB_{t-1}}{B_{t-1}} > \frac{dk^*_{t-1}}{k^*_{t-1}}$$

is equivalent to $\delta > 0$ and

$$\frac{dY_t}{Y_t} > \lambda \frac{dB_{t-1}}{B_{t-1}}.$$

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