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CREDIT RATIONING, OUTPUT GAP, AND BUSINESS CYCLES

BY FRÉDÉRIC BOISSAY

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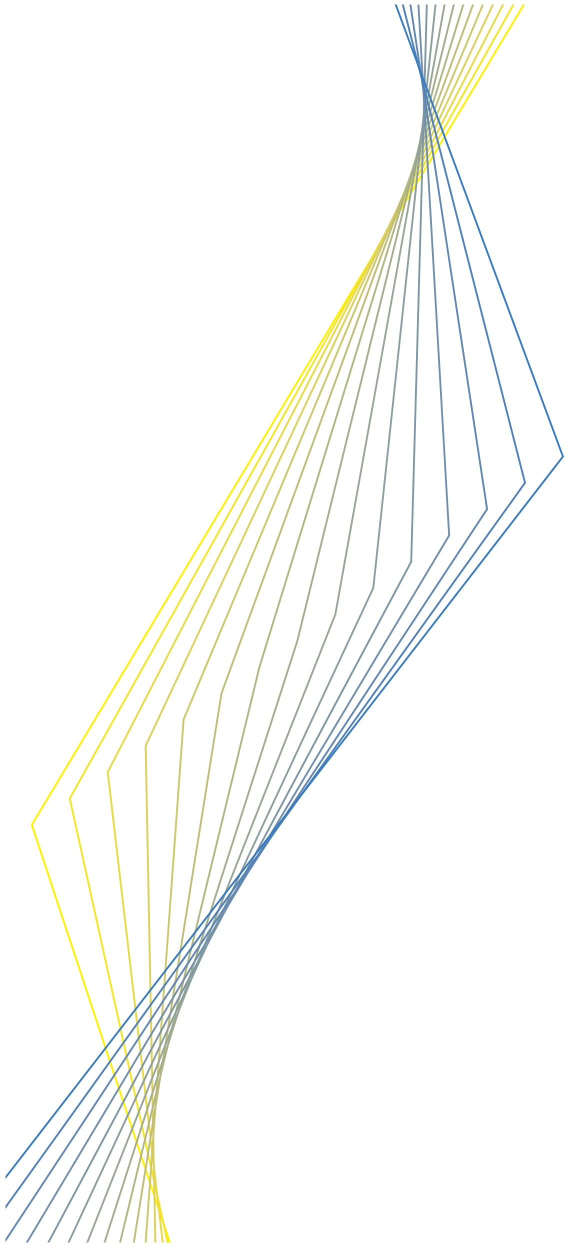

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CREDIT RATIONING, OUTPUT GAP, AND BUSINESS CYCLES

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November 2001

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Contents

Abstract 4

Non-technical summary 5

1 Introduction 6

2 The Model 10

3 Dynamics and Financial Accelerator 19
  3.1 Calibration 19
  3.2 Dynamic Analysis 20
    3.2.1 Quantity Rationing versus Price Rationing 23
    3.2.2 Accelerator and Dynamic Multiplier 24
  3.3 Quantitative Analysis 25

4 FinalRemarks 28

5 References 30

6 Appendix 33

Figures 36

European Central Bank Working Paper Series 39

Abstract

The cost-of-financing channel version of the financial accelerator proposed by Bernanke & Gertler [1989] is prominent in the literature. Yet, this particular channel has not been validated by empirical work. This paper presents an alternative version of the accelerator. This new accelerator, based on quantity credit rationing, is shown to be more powerful than the traditional accelerator. By causing factor under-utilization credit rationing generates an output gap persistent and sensitive to technology shocks. This accelerator is not a substitute to the traditional mechanism though, but rather a complement. My model helps improve the understanding of financial transmission mechanisms. It considers several types of collaterals. Financial frictions generate persistence when collaterals take the form of tangible assets. They generate amplification when collaterals take the form of cash flows or when asset prices are variable.

JEL classification: E32, E44

Keywords: Business Fluctuations, Credit Rationing, Financial Accelerator.

Non-technical Summary

Numerous empirical studies demonstrate that balance sheet variables like liquidity ratios or leverage ratios play a role in investment and inventory decisions (among others, Fazzari, Hubbard & Petersen [1988], Kashyap, Lamont, Stein [1994], Gertler & Gilchrist [1994]). The prominent explanation is due to Bernanke & Gertler [1989], whose basic idea is the following. Because banks have no a priori information about firms (credit market is imperfect), they use balance sheet variables to evaluate firms' ability to repay their debt. The better the balance sheet, the higher the probability of repayment, and therefore the lower the lending interest rate. According to this story, balance sheet variables play a role on investments and inventories when the latter are sensitive to the lending rates.

However, that demand for investments or inventories is sensitive to interest rates finds scant support in most empirical work. In this paper I instead consider a "loan-supply" transmission channel. The idea is that banks use the information from some firm's balance sheet variables to decide whether they finance this firm at the market interest rate or not (so that some firms get rationed). Consequently, in the presence of credit rationing good balance sheets have a positive impact on investment and inventories whatever the elasticity of the latter to the lending rate is.

Because credit conditions also depend positively on the economic activity (e.g. balance sheets are better during expansions) a "virtuous circle" arises during expansions and, a contrario, a "vicious circle" arises during recessions. The upshot is that credit market imperfections work to magnify and propagate to the future the effects of shocks to the economy. The principal conclusion of the present paper is that this so-called "financial accelerator" mechanism is particularly strong in the presence of credit rationing.

1 Introduction

From the 1930's Great Depression to the 1990's financial crises in Asia, there are numerous examples that show how the financial sector affects the business cycle. This is the view expressed by the proponents of the "broad credit channel". These authors argue that frictions on the financial market act to magnify and propagate to the future the effects of aggregate disturbances and that the broad credit channel therefore constitutes a natural explanation of several major stylized facts about business cycles. (Among these stylized facts is that the variance of output and output growth autocorrelations are high in the data compared with that of the shocks hitting the economy). The general mechanism that underlies the broad credit channel is known as the "financial accelerator mechanism". The prominent story behind the accelerator is due to Bernanke & Gertler [1989]. It begins with the idea that financial market frictions (typically, a costly state verification problem) drive a wedge between the cost of a firm's external funds and the market interest rate. The size of this wedge depends negatively on the firm's creditworthiness, which in turn depends partly on macroeconomic conditions. Aggregate disturbances do not only alter the market rate but also the size of this wedge, in a way that amplifies the effects of the initial shock. This is especially true during recessions and for small (non-creditworthy) firms, who generally face high external finance premia in bad times. According to this story, the financial accelerator mechanism is channelled to the economy through the lending interest rates.

As Kashyap, Lamont & Stein [1994, page 566] stressed, however, "there is one problem with this story. Its basic premise —that firms' investments and inventories are sensitive to interest rates— finds scant support in most empirical work". This result, on aggregate data, had been widely documented in the literature (see, for example, Blanchard [1986] and the well-known surveys of Blinder & Maccini [1991] and Chirinko [1993]). Bernanke & Gertler's accelerator is not supported by empirical work at the disaggregate level either. For instance, Mojon, Smets & Vermeulen [2001] recently concluded (page 15) that "there is no evidence that the interest rate cost of small firms reacts stronger than that of medium or large sized firms to monetary policy interest rates". So where does this leave the broad credit channel? In my view, these empirical results may say more about the inadequacies of the cost-of-financing channel version of the accelerator than about the inadequacies of the broad credit channel itself, for at least two reasons. First, numerous studies find that financial variables (cash flows, assets, coverage ratio) have a significant influence on inventories and investments, suggesting that interest rates do a poor job of capturing changes in "financial conditions"[1]. In a recent and comprehensive study, Strahan [1999] indeed shows that banks use both the price and non-price terms of loans (commitment, co-signers, collaterals) as complements in dealing with borrower risk. Second, some borrowers may face quantity rationing constraints of the sort described, for example, by Stiglitz & Weiss [1981], and thus be unable to obtain funds at the observed lending interest rate. This interpretation seems to be supported by empirical studies. For example, Sealey [1979] concluded that U.S. business loans are essentially supply determined and, more recently, Levenson & Willard [2000] found that 4.31% of the U.S. small businesses did not obtain the funding for which they applied in 1987-1988[2]. Several other papers also find indirect evidence for quantity rationing (see McCallum [1991] and especially Kashyap, Stein & Wilcox [1993]).

The purpose of this paper is to bridge this gap between theory and facts. I present a new financial accelerator generated by quantity credit rationing instead of price credit rationing. Like Jaffee & Stiglitz [1990], I define "price rationing" as a situation in which all borrowers get the funds they desire, but at a rate that includes a positive external finance premium. This

[1] See, for instance, the studies of Fazzari, Hubbard & Petersen [1988], Kashyap, Lamont & Stein [1994], Gertler & Gilchrist [1994], and Calomiris, Himmelberg & Wachtel [1995].

[2] Most empirical work on quantitative rationing dates back to the late 70's and the development of disequilibrium econometrics. In his study of the U.S. loan market over the period 1952-77, Sealey reported that 66 quarters, of the 102 quarters in his sample, were associated with excess demand while only 36 indicated excess supply. Using disequilibrium econometrics, Perez [2000] even found that about 60% of U.S. firms did not get all the credit they demanded in the 80s.

definition corresponds to the rationing that underlies Bernanke and Gertler's accelerator. In contrast, I will speak of "quantity rationing" whenever some borrower's demand for credit is turned down, even if this borrower is both willing and able to pay the interest rate of the loan contract[3].

The theoretical model presented in the paper has basically two components. First, in the same spirit as most existing theoretical models on the financial accelerator[4], I use a standard dynamic stochastic general equilibrium framework. Second, to introduce financial market imperfections, I use a simplified version of Hart & Moore [1994]'s model (with a precommitment problem on the credit market). Probably the papers closest to mine are Fuerst [1995] and Carlström & Fuerst [1997]. The key difference with these papers is the modelling of quantity rationing (I do not assume Costly State Verification) and the specific financial transmission channel which results from this. A related attempt to model quantitative credit rationing is provided by Kiyotaki & Moore [1997]. There are two differences between the current paper and theirs. First, I provide a measure of the intensity of credit rationing (in the Kiyotaki & Moore approach credit rationing is infinite). Second, I use a standard real business cycle (RBC) framework. These two features are important for they make it possible to compare between the new and the traditional accelerators, and to confront the model to the widespread RBC literature.

The principal conclusion of this paper is that the financial accelerator is more powerful in the presence of quantity rationing than in the presence of price rationing. My model generates

[3] It might be the case that the existence of a positive external finance premium deters some firms from participating to the credit market (*e.g.* the debtor interest rate overcomes the gross rate of return of firms' projects). This is not what I call "price rationing" because it is not consistent with the story of Bernanke and Gertler I am refering to. I borrowed the distinction between "price" and "quantity" rationings from Jaffee & Stiglitz [1990]. I use this distinction to facilitate the exposure, although one might consider that quantity rationing is the only true definition of rationing.

[4] See, among others, Bacchetta & Caminal [2000], Bernanke, Gertler & Gilchrist [1999], Carlström & Fuerst [1997, 1998], Cooley & Nam [1998], Fuerst [1995].

a sensitive response of output to technology shocks (amplification) and replicates the fact that output growth displays positive autocorrelations at short horizons (persistence). It therefore presents a solution to the hump-shaped response of output puzzle, which usually challenges the RBC literature (Cogley & Nason [1995]). Also, it performs better than the existing theoretical models on the financial accelerator, which exhibit either more amplification (Bernanke, Gertler & Gilchrist [1999]) or more persistence (Carlström & Fuerst [1997][5]) than the basic RBC model, but not both. The intuition is the following. In my model, firms produce with both fixed capital and working capital and they must borrow from banks to purchase working capital (I will explain this). However, because firms cannot precommit to repay their loans, they face borrowing constraints which prevent them from using all their production capacity in the equilibrium. Capital under-utilization induces a gap between actual output and potential output (defined here as the output that would prevail in the absence of quantity rationing). To the extent that credit rationing is high during recessions and low during expansions this gap is counter-cyclical. Output is highly sensitive because not only potential output increases but also, and mainly, because the output gap decreases following a positive technology shock.

Another innovation of the current work is to show that questions about persistence and amplification are intimately connected to the composition of collaterals. In the literature, collaterals take the form of either cash flows (Bernanke & Gertler [1989], Fuerst [1995], Carsltröm & Fuerst [1997], Fisher [1999]) or tangible assets (Kiyotaki & Moore [1997], Bernanke, Gertler & Gilchrist [1999]). In contrast, the present paper considers both. This feature makes it possible to identify various financial transmission channels and to analyze the role of each inside the accelerator mechanism. I find that persistence is imputable to the volume of tangible assets, whereas amplification comes from cash flows and asset prices.

[5] In this paper, the hump-shaped response of output is imputable to an instantaneous increase in the lending rate, which works to dampen the effects of the positive technology shock. Indeed, as the authors say (page 907), "the foremost problem [of their model] is the [pro]cyclical behavior of bankruptcy rates and the risk premia". This is a problem for two reasons. First, external finance premia are observationally counter-cyclical. Second, the financial transmission mechanism they describe does not fit the financial accelerator theory very well.

The paper is organized as follows. Section 2 of the paper develops the optimal financial contracts and lays out the complete general equilibrium environment. Section 3 presents the calibration, the analysis of the dynamics, and the quantitative evaluation of the accelerator. Section 4 concludes.

2 The Model

I consider a real economy with measure-one-continuums of households, banks, and firms. Banks and firms are risk-neutral and competitive. All the agents are rational (perfect foresights) and live infinitely. I index time by t. The sequence of events is summarized in Table 1.

Households take the main economic decisions (consumption and investment in capital goods). These decisions take place as follows. First, at the end of period t, households accumulate capital goods (k_{t+1}), *i.e.* they create new capital goods (i_t) using consumption goods, with a non-stochastic one-to-one transformation rate. They give these capital goods to the firms, in exchange for dividends at the end of period $t+1$ (Π_{t+1}). Firms belong to households and so give the capital goods back to households at the end of period $t+1$[6]. Once the capital goods installed, capital good market closes (capital goods cannot be reallocated among firms). Then an economy-wide technology shock occurs, which is publicly observable and alters period $t+1$'s technology, a_{t+1}. Second, households provide firms with their labour force (ℓ_{t+1}), in exchange for which they will get wages (w_{t+1}) at the end of period $t+1$. Third, households consume goods (c_t) and make bank deposits (d_{t+1}). The interest rate on bank deposits between t and $t+1$ will be denoted by r_{t+1}. In order to have banks —and thereby intermediated finance— exist in the economy, I assume that households do not have the technology to store final goods and that only banks do have it. It follows that households hold two kinds of assets: Tangible assets (capital

[6]The upshot of this assumption is that firms start from fresh at every period and have no intertemporal behavior. (Equivalently, I could have considered one period-lived firms).

goods) and bank deposits. There are two differences between these assets. First, deposits are more liquid than tangible assets because they are determined after the aggregate technology shock. Second, the property of tangible assets is transferred from households to firms, whereas bank deposits remain the property of households. The idea here is to have tangible assets be potential collaterals in the loan contracts between firms and banks. Corollarily, like in Carlström & Fuerst [1997], the model has the feature that the accumulation of collaterals is made by long-lived agents.

The objective of the representative household consists in maximizing his intertemporal utility function:

$$\max_{\{k_{t+1},\ell_t\}_{t=\tau,..}} \mathbb{E}_\tau \max_{\{d_{t+1},c_t\}_{t=\tau,..}} \mathbb{E}_{\tau+1} \sum_{t=\tau}^{t=+\infty} \beta^{t-\tau} \left[u(c_t) + \upsilon(\ell_t)\right] \tag{1}$$

with respect to the instantaneous budget constraint $(\forall\, t)$:

$$\begin{cases} c_t + d_{t+1} + i_t \leqslant (1+r_t)d_t + w_t\ell_t + \Pi_t \\ \text{with } i_t = k_{t+1} - (1-\delta)k_t \end{cases} \tag{2}$$

where u is the instantaneous utility function of consumption and υ is the instantaneous disutility function of labour (u and υ are well-behaved), $\mathbb{E}_t = \mathbb{E}\,(.\mid a_t, k_t)$ is the expectation operator conditional on the information available at the time households choose k_{t+1}, $\beta \in (0,1)$ is the personal discount factor, and δ is the rate of depreciation of capital.

At the end of period t, firms are identical, *i.e.* they are endowed with the same project, the same technology, and the same quantity of capital. After the aggregate technology shock occurred, they hire labour for period $t+1$, ℓ_{t+1}. The combination of capital, labour, and technology determines next period output, $y_{t+1} = a_{t+1}k_{t+1}^{\alpha}\ell_{t+1}^{1-\alpha}$. Then, deposit and labour markets close and period $t+1$ begins.

Table 1 — The Sequence of Events in Period t/t+1

1.	Households choose the capital stock for next period (k_{t+1}). Capital good market closes.
2.	The aggregate shock on next period's technology occurs (a_{t+1}).
3.	Firms hire labour for next period (ℓ_{t+1}).
4.	Households make their consumption and bank deposit decisions (c_t and d_{t+1}).
5.	Labour and deposit markets close. Period t ends.
6.	Period t+1 starts. Credit market opens. The idiosyncratic shocks are realized (ν).
7.	Firms demand bank loans ($\phi_{t+1}(\nu)$). The credit market closes.
8.	Those firms who got funds from banks produce (y_{t+1}).

So far the model is a very standard RBC model in the same vein as, for instance, Kydland & Prescott [1982] and King, Plosser & Rebelo [1988]. I need further assumptions to introduce bank loans. So I assume that the firms need also a certain quantity ϕ_{t+1} of final goods at the beginning of period $t+1$ to start producing[7]. Since only banks have the final goods in hand at the beginning of period $t+1$, firms will have to go on the credit market to purchase these goods. To stress the difference between the final goods consumed by households and these final goods used by firms, I will refer to the latter as "intermediate goods" or "working capital goods" in the rest of the paper. ϕ_{t+1} is supposed to be proportional to the size of the firm and independent of the productivity parameter: $\phi_{t+1} = \nu k_{t+1}^{\alpha} \ell_{t+1}^{1-\alpha}$, with $\nu \in [0,1]$. To gain in generality I will assume that firms are heterogenous, in the sense that every firm has her own parameter ν. More

[7] One somehow natural alternative is to assume a "cash-in-advance"-type constraint on salaries, the idea being that firms must have final goods in hand at the beginning of period $t+1$ in order to pay the wage bill at the end of period $t+1$ (see, for example, Christiano & Eichenbaum [1992]). I did not make this choice because, for comparison purpose, I wished to avoid having the capitalistic intensity differ from the basic RBC model. This point is not crucial in the model. As it will become clear later, what is important, though, is to have financial frictions affect the *short-run* productive capacity of the economy (*i.e.* working capital) and thereby generate capital under-utilization. This supply-side approach of the financial transmission mechanism is consistent with the recent empirical work of Barth & Ramey [2000].

precisely, firms incur idiosyncratic shocks ν distributed over $[0,1]$ with distribution $F(\nu)$[8]. In the following, I will refer to firm ν as the firm who got the shock ν and I will denote by $\phi_{t+1}(\nu)$ the amount of external funds she needs. To gain in tractability, and following the suggestion of Gertler [1995], I will also suppose that $\phi_{t+1}(\nu)$ is lumpy: If the firm ν does not pay this cost, then she cannot produce (see footnote 11 for a discussion). Idiosyncratic shocks occur at the beginning of period $t+1$ and are publicly observable.

I assume that credit contracts are intraperiodic. To keep the model as simple as possible and to avoid having multiple credit market equilibria, I do not allow for multiperiodic contracts[9]. At the beginning of period $t+1$, banks give firm ν the $\phi_{t+1}(\nu)$ units of working capital goods she demands against her promise to repay $(1+r_{t+1})\phi_{t+1}(\nu)$ units of final goods at the end of period $t+1$ (competition on the credit market makes banks require only the break-even interest rate r_{t+1}). I introduce credit market frictions by supposing that such a promise may not be credible. As in Kiyotaki & Moore [1997], I assume that firms have always the freedom to go away without honoring their debt. In the language of Hart & Moore [1994], the firms' outcomes are inalienable so that firms are unable to precommit to repay their debt[10]. Banks know this

[8] I make no specific assumption on F (excepted that $F(0) \geqslant 0$, $F(1) = 1$, and $F^{'}(\nu) \geqslant 0$ $\forall \nu \in [0,1]$). If $F(.) = \mathbf{1}_{[\underline{\nu},1]}(.)$ then firms have all the same ν, with $\nu = \underline{\nu}$. The introduction of firm heterogeneity will make it possible to discuss the role of the distribution of risks on the financial transmission mechanism.

[9] This assumption is also present, for instance, in Carlström & Fuerst [1997] and Bernanke, Gertler & Gilchrist [1999], as these authors assume "enough anonymity" on the credit market (*i.e.* lenders loose track of borrowers after every period).

[10] Hart & Moore [1994] consider the inalienability of entrepreneurs' human capital instead of entrepreneurs' assets. Several other types of market frictions may generate credit rationing. In a former version of the paper, I considered an adverse selection problem (*à la* Besanko & Thakor [1987]) instead of a precommitment problem. One could also consider a moral hazard problem (*e.g.* Williamson [1987]). The spirit and the results of the model are not fundamentally affected by what causes credit rationing. I chose a precommitment problem to keep the modelling simple. Note that households are by assumption not affected by the precommitment problem because they own the firms. Also, because they are risk-adverse, households strictly prefer to capitalize all the firms *ex ante* (rather than only one firm) in order to obtain a certain financial income.

possibility in advance and so take care never allow the size of the debt (gross of interest) to exceed the value of firms' collateral. I assume that banks can get back only a fraction $\mu \in (0,1]$ of firms' cash flow, y_{t+1}, as well as only a fraction $\gamma \in (0,1]$ of firms' capital stock (net of its depreciation rate), $(1-\delta)k_{t+1}$. The total value of collaterals is thus $\gamma(1-\delta)k_{t+1} + \mu y_{t+1}$. Only firms whose debt is secured get a bank loan. These are the firms who have the lowest financial needs:

$$\nu \leqslant \min\left\{\gamma\frac{(1-\delta)}{1+r_{t+1}}\left(\frac{k_{t+1}}{\ell_{t+1}}\right)^{1-\alpha} + \mu\frac{a_{t+1}}{1+r_{t+1}}, 1\right\} \equiv \overline{\nu}_{t+1} \tag{3}$$

The other firms are credit constrained, cannot afford the working capital goods and are unable to activate their project. For these firms, credit rationing generates factor under-utilization. (Note that households are interested in selling these firms to banks at this time since banks would then own firms and the precommitment problem would vanish. However, my assumption that the capital market closes before period $t+1$ starts rules this case out). The crucial variable here is $\overline{\nu}_{t+1}$, which has two connected interpretations. First, it corresponds to firms' leverage ratio. Second, $1-F(\overline{\nu}_{t+1})$ corresponds to the intensity of credit rationing[11]. The latter depends negatively on the capital stock (k_{t+1}), the productivity parameter (a_{t+1}), and it depends positively on the interest rate (r_{t+1}) and labour (ℓ_{t+1}). The reason why credit rationing is high when capitalistic intensity is low is that capital is a collateralizable asset (unlike labour) and is a more valuable input than labour from banks' point of view. Inputs therefore play two roles in the economy: A productive role and a financial role. Capital tends to improve financing con-

[11] Note that the assumption that investments in working capital are lumpy has no crucial effect in the model and that quantity rationing would exist even without it. Indeed, assume that entrepreneurs' projects are divisible: Since the entrepreneur ν can afford only a fraction $\overline{\nu}_{t+1}/\nu$ of the working capital he needs, then he can use only a fraction $\overline{\nu}_{t+1}/\nu$ of his production capacity. Entrepreneurs $\nu \in [0, \overline{\nu}_{t+1}]$ would still produce y_{t+1} (they are fully financed) but entrepreneurs $\nu \in]\overline{\nu}_{t+1}, 1]$ would produce only $\frac{\overline{\nu}_{t+1}}{\nu} y_{t+1}$ (instead of 0 in the case of lumpiness). It follows that the measure of credit rationing would be $\int_{\overline{\nu}_{t+1}}^{1} \frac{\nu-\overline{\nu}_{t+1}}{\nu} dF(\nu)$ which is indeed lower than $1-F(\overline{\nu}_{t+1})$ but still strictly positive. Note further that short term investment's lumpiness is consistent with a number of empirical studies (*e.g.* Cooper & Haltiwanger [1994]).

ditions, whereas labour tends to worsen them. One can already perceive the interrelations that exist between financing conditions and factor demands. On the one hand, financing conditions depend on productive factors. On the other hand, credit rationing lowers the returns on capital and labour so that factor demands depend positively on the financing conditions (see Table 2). To simplify the model, I will assume that neither households nor firms internalize the effect of factor demands on financing conditions (they take $\overline{\nu}_{t+1}$ as given)[12].

The representative firm's objective at the end of period t merely consists in maximizing her expected instantaneous profit by hiring the optimal number of workers (for $t+1$) and choosing the best bank at the beginning of period $t+1$. Her program at the end of period t is static and writes[13]:

$$\max_{\ell_{t+1}} \Pi_{t+1} = \left[F(\overline{\nu}_{t+1})a_{t+1} - E(\overline{\nu}_{t+1})(1+r_{t+1})\right] k_{t+1}^{\alpha}\ell_{t+1}^{1-\alpha} - w_{t+1}\ell_{t+1} \tag{4}$$

where $E(\overline{\nu}) \equiv \int_0^{\overline{\nu}} \nu dF(\nu)$. Firms are in position to lever funds from banks with probability $F(\overline{\nu}_{t+1})$. Hence, the *ex post* aggregate output (Y_{t+1}) is equal to $Y_{t+1} = F(\overline{\nu}_{t+1})a_{t+1}k_{t+1}^{\alpha}\ell_{t+1}^{1-\alpha}$

[12]This assumption is not crucial in the model. It simplifies equations 5 and 6 in Table 2, as well as the mechanisms behind the dynamics of the economy. In a previous version of the paper I found that this assumption had only second order effects. Absent this assumption, the capital stock would be slightly higher and labour lower at the steady state and the dynamics of the economy would hardly differ. The reason why the capital stock would be higher is the following (a symmetric argument holds for labor). Should households internalize the financial role of capital, they would increase their capital stock in order to lessen firms' borrowing constraints. Households are constrained from raising the size of the firms indefinitely by the fact that capital has decreasing marginal returns. They would actually increase their capital stock only until the gain from lessening borrowing constraints was offset by the loss due to the decrease in marginal productivity. Interestingly, capital would have a shadow (endogenous) price in this case. Notably, because households have always the possibility to produce capital goods at unit cost and capital plays also a financial role, the market price of capital would be *below* 1 and *pro*-cyclical.

[13]Wages are paid even by firms who do not get bank loans, because these firms can always liquidate their capital stock to do so. Alternatively, I could assume that wages are paid by the financed firms only. This would not alter the general equilibrium (excepted w_t) if one assumed that every household supplies all firms equally with his labour force (*i.e.* if there is no uncertainty about labour incomes).

and the *ex post* aggregate amount of loans is $E(\overline{\nu}_{t+1})k_{t+1}^{\alpha}\ell_{t+1}^{1-\alpha}$. Since $F(\overline{\nu}) \geqslant E(\overline{\nu})\ \forall \overline{\nu} \in [0,1]$, a sufficient condition to make sure that all the projects have a strictly positive expected net present value is $a_{t+1} > 1 + r_{t+1}$. In the rest of the paper, I will assume that $\beta a > 1$ to have this condition fulfilled in the neighborhood of the steady state[14].

Table 2 — Equations of the Model

1.	$u'(c_t) = \beta \mathbb{E}_t(1 + r_{t+1})u'(c_{t+1})$
2.	$Y_t = c_t + i_t + E(\overline{\nu}_{t+1})k_{t+1}^{\alpha}\ell_{t+1}^{1-\alpha}$
3.	$Y_t = F(\overline{\nu}_t)a_t k_t^{\alpha}\ell_t^{1-\alpha}$
4.	$i_t = k_{t+1} - (1-\delta)k_t$
5.	$[F(\overline{\nu}_t)a_t - E(\overline{\nu}_t)(1 + r_t)]\, \alpha k_t^{\alpha-1}\ell_t^{1-\alpha} = r_t + \delta$
6.	$[F(\overline{\nu}_t)a_t - E(\overline{\nu}_t)(1 + r_t)]\,(1-\alpha)k_t^{\alpha}\ell_t^{-\alpha} = \frac{-v'(\ell_t)}{u'(c_t)}$
7.	$\overline{\nu}_t = \min\left\{\gamma\frac{(1-\delta)}{1+r_t}\left(\frac{k_t}{\ell_t}\right)^{1-\alpha} + \mu\frac{a_t}{1+r_t}, 1\right\}$

The recursive general equilibrium is defined by decisions rules for k_{t+1}, c_t, Y_t, i_t, $\overline{\nu}_t$, r_t, and ℓ_t, where these decision rules are stationary functions of (k_t, a_t) and satisfy the equations of Table 2. If firms do not experience the idiosyncratic shocks ($F(.) \equiv \mathbf{1}_{\nu\in[0,1]}(.) \Rightarrow E(.) \equiv 0$) then the model collapses to the textbook RBC model. Equation 2 is the final good market equilibrium condition. (Aggregate demand has three components: Consumption, investment, and intermediate goods). The labour market implicitly clears, $w_t = -v'(\ell_t)/u'(c_t)$, as well as the loanable funds market, $d_{t+1} = E(\overline{\nu}_{t+1})k_{t+1}^{\alpha}\ell_{t+1}^{1-\alpha}$ (Walras' law applies). Equation 3 expresses the gap between actual output, Y_t, and firms' production capacity, y_t. The latter may also be interpreted as the *potential* aggregate output, *i.e.* the aggregate output that would prevail in the absence of quantity rationing. When the leverage ratio is lower than one (equation 7) then $Y_t < y_t$ and borrowing constraints induce an *output gap* equal to a fraction $1 - F(\overline{\nu}_t)$ of potential output. Equations 5 and 6 are the first order conditions for fixed capital and labour

[14] Non time-indexed variables will denote steady state values.

demands. Factor demands depend positively on credit conditions through $\overline{\nu}_t$ (one can verify that $F(\overline{\nu}_t)a_t - E(\overline{\nu}_t)(1+r_t)$ is increasing in $\overline{\nu}_t$). The reason is the following. At the time they choose k_t and ℓ_t, households and firms anticipate that only a fraction $F(\overline{\nu}_t)$ of the projects will be funded (they perfectly foresee the credit market equilibrium). As a result, if the leverage ratio is low, then factor under-utilization will be high, the return on capital and labour will be low, as well as factor demands.

Quantity versus Price Rationing

There is one key difference between the current model and the models in which the financial accelerator is generated by price rationing. In the latter models, the existence of an external finance premium hinders fixed capital investment. Given this premium, however, the capital stock is optimal and there is no capital under-utilization. In contrast, credit rationing implies both under-investment (equations 5 and 6 in Table 2) and factor under-utilization (equation 3) and, *ex post*, households wish they had not invested capital in the rationed firms. Factor under-utilization is an additional effect that enhances the traditional mechanism.

To detail the different mechanisms at work and to compare them with those already present in the literature (*e.g.* Bernanke & Gertler [1989], Bernanke, Gertler & Gilchrist [1999]), I need to introduce additional notations. First, I introduce an "implicit external finance premium", e_t, which I define as the fictive premium that would generate the same factor demands in the economy[15]. One gets $1 + e_t(\overline{\nu}_t) \equiv \frac{1-F(\overline{\nu}_t)}{E(1)} \frac{a_t}{1+r_t} + \frac{E(\overline{\nu}_t)}{E(1)} \geqslant 1$. This premium depends negatively on firms' balance sheet ($\overline{\nu}_t$) and is equal to zero when $\overline{\nu}_t = 1$. Second, I refer to $f_t \equiv k_t^{\alpha} \ell_t^{1-\alpha}$ as factor demands, so that the aggregate output simply writes $Y_t = F(\overline{\nu}_t)a_t f_t$ (from equation 3 in Table 2). Given equations 5 and 6 in Table 2 and the definition of the implicit premium, f_t is

[15] More precisely, e_t is such that the *ex ante* gross return on investment in the economy with quantity rationing, $F(\overline{\nu}_t)a_t - E(\overline{\nu}_t)(1+r_t)$, is equal to the one that would be in an economy with price rationing (where all firms obtain funds), $F(1)a_t - E(1)(1+r_t)(1+e_t)$. See equations 5 and 6 in Table 2. Further details are given in appendix.

a function $f(a_t, e_t)$ which depends positively on a_t and negatively on $e_t(\overline{\nu}_t)$. The equation (5) below decomposes the instantaneous response of output to a technology shock into three terms:

$$\frac{\partial Y_t}{\partial a_t} = \underbrace{F(\overline{\nu}_t)f_t + F(\overline{\nu}_t)a_t f_1^{'}(a_t, e_t)}_{\text{"perfect credit market" effect}} + \underbrace{F(\overline{\nu}_t)a_t f_2^{'}(a_t, e_t)e_t^{'}(\overline{\nu}_t)\frac{\partial \overline{\nu}_t}{\partial a_t}}_{\text{"pseudo-price rationing" effect}} + \underbrace{F^{'}(\overline{\nu}_t)a_t f_t \frac{\partial \overline{\nu}_t}{\partial a_t}}_{\text{"quantity credit rationing" effect}} \quad (5)$$

This equation summarizes the main transmission mechanisms at work in the model. Basically, three distinctive forces drive aggregate output: The "perfect credit market" force, the "pseudo-price rationing" force, and the "quantitative rationing" force. The first two terms on the right-hand-side of equation (5) represent the variation in actual output due to the variation in potential output. More precisely, the first term on the right hand side, which I call the "perfect credit market" effect, corresponds to the variation of the aggregate output that would prevail in a perfect credit market situation (no precommitment issue)[16]. The second effect corresponds to the change in potential output due to the change in the leverage ratio. This effect is not direct to the extent that it relies on two elasticities. First, it depends on the elasticity of factor demands to financing conditions (through the term $f_2^{'}(a_t, e_t)$). Second, it depends on the elasticity of financing conditions to balance sheet variables (through $e_t^{'}(\overline{\nu}_t)$). I call this effect the "pseudo-price rationing" effect because it is very comparable with the effect generated by models based on the external finance premium. In particular, as in Bernanke & Gertler [1989], Cooley & Nam [1998], Fuerst [1995] and others, this effect generates under-investment. I will show in section 3.2 that the main influence of credit rationing on output fluctuations does not go through changes in under-investment though. Rather, it goes through changes in factor under-utilization (term $F^{'}(\overline{\nu}_t)$ in the right-hand side). I call this latter effect the "quantity credit rationing" effect because it is directly linked to the rationing behavior of banks and is independent of the elasticity of factor demands to financing conditions. (For this reason, the accelerator presented in this paper can be viewed as a *(credit) supply-side* effect, in contrast with the *(credit) demand-side* effect of Bernanke and Gertler).

[16] *Stricto sensu*, the true "perfect credit market" effect is $f_t + a_t f_1^{'}(a_t, e_t)$.

3 Dynamics and Financial Accelerator

The purpose of this section is twofold. First, I will analyze the dynamics of the model. I will compare it with the dynamics of the frictionless model, which I will use as a benchmark. This perfect information case corresponds to the model described in Table 2 when parameters μ and/or γ are high enough to make the precommitment problem vanish ($\overline{\nu}_t = 1 \ \forall t$). As shown in the appendix the dynamic behavior of such a model is close to the standard RBC model. In what follows, I will consider a non-anticipated and positive shock on parameter a_t, which I will refer to as a technology shock. I will assume that the logarithm of a_t follows a one order autoregressive process with root ρ. The second purpose of this section is to provide a quantitative evaluation of the financial accelerator. By doing so, I will show that the broad credit channel theory can help explain why aggregate output has a high variance and why output growth presents positive autocorrelations at short horizons.

3.1 Calibration

Where I can, I set parameters according to their values in the business cycle literature. I also assume that the model generates quarterly data. Consequently, I set the discount factor (β), the capital's share (α), the depreciation rate (δ), and the autoregressive root (ρ) as follows:

Table 3 — Standard Parameters

β	α	δ	ρ
0.98	0.36	0.025	0.9

Household preferences are given by $u(c) = \ln(c)$ and $v(\ell) = \eta \ln(1 - \ell)$. The parameter η is set to 0.1 to have labour supply elasticity be consistent with the empirical Labour Economics literature (see, for example, the survey of Blundell & Macurdy [1999])[17]. I take the uniform distribution function for $F(\nu)$[18]. The value of parameter a is set to 1.2 so that the gross rate of return of the project $(a-\nu(1+r))$ is approximately equal to 20% for the firm $\nu=1$ and to 70% for the average firm. Calibration is more delicate for the non-standard parameters γ and μ to the extent that the dynamics of the economy with credit rationing is very sensitive to them. For example, if γ is high and $\mu=0$ then the collateral is a fraction γ of the capital stock and inherits capital's sluggishness. If, in contrast, $\gamma=0$ and μ is high then the collateral is a fraction μ of the expected cash flow and will be very sensitive to the technology shock. So in the numerical analysis I will consider three sets of parameters, which will make it possible to discuss how dynamics is connected to collaterals: $(\gamma,\mu)=(0.18,0)$, $(\gamma,\mu)=(0,0.8)$ and $(\gamma,\mu)=(0.15,0.15)$. (Changes in the standard parameters of Table 3 have well known implications so I will not consider them). In these three cases γ and μ are set in order to have the rate of capacity utilization equal 95% at the steady state[19]. The average U.S. rate of capacity utilization has been around 81% since the early 60s. Nevertheless, because capacity under-utilization may also find its origin in demand or price stickiness, which I abstracted from, I found it acceptable to retain $F(\overline{\nu})=0.95$. Also, this parametrization is consistent with the findings of Levenson & Willard [2000] that about 5% of small U.S. firms are credit constrained.

3.2 Dynamic Analysis

I consider a shock to aggregate productivity: The parameter a_t rises by 1% above its steady state value. The equilibrium conditions in Table 2 are linearized about the steady state and I used the standard method of simulation. Figures 1A-1H report the step-by-step analysis of the dynamics for the frictionless economy and for the three credit-constrained economies.

[17] In the literature, labour supply elasticity ranges from -0.10 for men to 0.7 for women. It equals 0.13 in my benchmark model.

[18] Section 3.3 provides some sensitivity analysis to help assess the role of the distribution function on the dynamics.

[19] The upshot of this calibration is that the steady states will be identical in the three cases, as well as the welfare losses that markets frictions generate.

The benchmark dynamics is familiar. There is a spike in investment, labour and output as productivity increases, then each series slowly returns to normal as productivity starts declining back to its steady state. As Cogley and Nason [1995] demonstrate, the dynamics of investment, labour, and output are all inherited from the autocorrelation structure of the technology shock. Capital adds little propagation to these variables in and of itself.

In the presence of credit rationing, the dynamics is different. Let me consider the polar case $(\gamma, \mu) = (0.18, 0)$ first. In this case, firms can precommit to repay at most 18% of their capital stock, which is the only collateral. On impact, investment and labour demands go up. Improvement in technology and rises in factor demands cause an increase in potential and actual outputs. The latter is weaker than in the benchmark economy though. This is because factor under-utilization (the output gap) goes up and partly offsets the variation in the potential output. The output gap increases because more firms face credit rationing. The reason why firms' external financing conditions deteriorate is clear given equation 7 in Table 2. As labour and the interest rate increase, the leverage ratio falls because the capital stock is predetermined. Every firm needs a higher loan but less firms get the loan. Also, less firms can afford activating their project and factor under-utilization increases. Subsequently, financing conditions start improving as the capital stock adjusts to technology. The output gap shrinks, passing below its steady state level three quarters after the shock. Driven by the output gap, aggregate output keeps rising ten quarters after the shock. Thereby, the model exhibits a hump-shaped response of output which is consistent with the findings of Cogley & Nason [1995]. At this point, the economic dynamics has a pattern very similar to that in Carsltröm & Fuerst [1997]: Credit market imperfections do generate persistence but do not generate amplification. As Carlström and Fuerst explained, the reason is that external financing conditions deteriorate instantaneously and so work to dampen the business fluctuations at the impact. As a result, with this calibration, financial frictions generate a decelerating effect, which does not fit the financial accelerator theory well.

Insert Figure 1

The obvious reason why the model $(\gamma, \mu) = (0.18, 0)$ fails to generate amplification is that collateral is too sluggish relatively to the demand for working capital. To understand this better it is worth investigating the opposite case, $(\gamma, \mu) = (0, 0.8)$. In this case, firms can precommit to repay at most 80% of their future cash flow, which is the only collateral. On impact, again, investment and labour go up and drive potential output above its steady state level. The new point here is the soar of the aggregate output by almost 2% above its steady state level (against 1.2% in the benchmark model and 0.95% in the first polar case). This sharp increase in output is imputable to the decrease in the output gap. The reason why the output gap diminishes is the opposite reason why it increased in the previous case. When the collateral incorporates only the expected cash flow it adjusts more rapidly to the technology shock than the demand for working capital. As a result, the leverage ratio increases, credit constraints relax and factor under-utilization decreases instantaneously. The model's dynamics hereafter mirrors the benchmark dynamics. The good point of this model is that it contains a strong amplification channel, which is partly consistent with the financial accelerator mechanism. Its caveat is that there is no persistence any longer.

Insert Figure 2

Clearly, both capital and expected cash flow must be part of collaterals to get both persistence and amplification. So I also considered the case $(\gamma, \mu) = (0.15, 0.15)$. This model can be viewed as the "mean" of the two polar models described above. On impact, the demand for working capital increases. Although the capital stock is predetermined, the leverage ratio rises because the expected cash flow goes up. Consequently, external financing conditions improve, credit constraints relax, output gap diminishes, and aggregate output increases more than in the benchmark economy. External financing conditions keep improving even after the shock because the rise in the capital stock drives the leverage ratio up. The consequence is a persistent decrease in the output gap, which offsets the return of potential output back to its steady state. In this case, aggregate output keeps rising until the fourth quarter after the initial shock, and its response is both amplified and persistent.

3.2.1 Quantity Rationing versus Price Rationing

It is natural to compare the new accelerator with the traditional accelerator described by Bernanke & Gertler [1989]. For this I use the claim of section 2 that potential output's sensitivity to financing conditions is assimilable to a price rationing effect, whilst output gap's sensitivity is a specific outcome of quantity rationing. Hence, the comparison between the two accelerators consists merely in the comparison between the responses of potential and actual outputs. Figures 1A, 1C, and 1D show that the conclusion is unambiguous (Figure 2 also illustrates this point[20]). Sensitivity and persistence of aggregate output are mainly due to the output gap and to the borrowing constraints that induce it. Consistently with the literature (Fuerst [1995], Fisher [1999]), the traditional accelerator is almost insignificant whatever the composition of collaterals is. In the case $(\gamma, \mu) = (0.18, 0)$, notably, the response of *potential* output (Figure 1C) is very similar to the response of output in Fuerst [1995] (his Figure 2C)[21].

[20] Figure 2 reports the dynamics of output generated by a chronicle of 200 independent technology shocks in the benchmark model and in the model with quantity rationing. These shocks are $N(0,1)$ and I used the parameters of Table 3 and $(\gamma, \mu) = (0.15, 0.15)$. The economy with price rationing refers to the fictive economy described in the appendix. The large gap between the grey line and the bold line corresponds to the output gap, and therefore to the specific effect of quantity rationing. The small difference between the grey line and the thin line comes from the implicit external finance premium.

[21] This is because the elasticity of the demand for working capital to credit conditions —upon which the traditional accelerator relies— is weak. See Fuerst [1995, page 1331], and also Fisher [1999, page 201] for an insightful discussion on the link between investment/interest rate elasticity and the importance of the (traditional)

Insert Figure 3

3.2.2 Accelerator and "Dynamic Multiplier"

Figures 3A-3B report the dynamics of the actual and the output gap when households face quadratic capital adjustment costs on investment. Now, households must use $(1+0.5\kappa i_t)i_t$ units of final goods to get i_t units of capital goods; I will consider $\kappa = 0.5$. In this case, the price of capital, denoted by q_t, is variable and equal to 1.1 in the steady state. As in Kiyotaki & Moore [1997] and Bernanke, Gertler & Gilchrist [1999], the idea is to have asset price variability contribute to volatility in firms' leverage ratio. One thus gets:

$$\overline{\nu}_t = \min\left\{\gamma\frac{(1-\delta)q_t}{1+r_t}\left(\frac{k_t}{\ell_t}\right)^{1-\alpha} + \mu\frac{a_t}{1+r_t}, 1\right\}$$

Following a persistent positive technology shock, households anticipate a rise in future cash flows and accumulate more capital goods at the impact. This entails an increase in the price of capital and therefore an increase in the leverage ratio. In this case, increases in expected *future* cash flows improve the *current* external financing conditions and stimulate the economy at the date of the shock. Basically, this is the kind of dynamic feedback that Kiyotaki & Moore [1997] call the "dynamic multiplier".

How powerful is this asset prices channel compared with the static mechanism I have described so far? To answer this question, I considered five cases in Figures 3A-3B. The first two cases correspond to the frictionless economy and to the economy with credit rationing (with parameters $(\gamma, \mu) = (0.15, 0.15)$). In the other cases, I simulated the model holding two of the collateral's components (q_t, k_t and a_t) constant each time[22]. The "only q_t" case shows that the rise in q_t does play a specific and important role in the dynamics. Consistently with Kiyotaki &

accelerator.

[22] Given equation 7 in Table 2 the linearized dynamics of $\overline{\nu}_t$ can be written : $\widehat{\overline{\nu}}_t = \varepsilon_q\widehat{q}_t + \varepsilon_k\widehat{k}_t + \varepsilon_a\widehat{a}_t - \varepsilon_r\widehat{r}_t - \varepsilon_\ell\widehat{\ell}_t$ where $\widehat{x}_t$ denotes the deviation of variable x from its steady state and ε_x is the elasticity of the leverage ratio to x. The case "q_t only", for example, corresponds to output's dynamics when ε_k and ε_a are arbitrarily set to zero.

Moore [1997] and Bernanke, Gertler & Gilchrist [1999], output is more volatile when the price of tangible assets is variable. However, the asset prices transmission channel does not appear to be particularly stronger than the cash flow channel (compare the "only q_t" case with the "only a_t" case). It is also unable to generate the hump shape. The reason is that all agents in the economy internalize all the rise in future cash flows at the impact and therefore react instantaneously. It follows that asset prices variability does help RBC models generate amplification *but not* persistence.

3.3 Quantitative Analysis

Many RBC models have weak internal propagation mechanisms which do not generate interesting dynamics in their internal structure. As a result they fail to replicate several major stylized facts about business cycles. Among these failures is that output presents a lower variance and output growth presents lower autocorrelations than in the data (see Table 4). The aim of this section is to quantify the new financial accelerator and to show how the incorporation of quantity rationing may help RBC models replicate these stylized facts. Also, the proponents of the broad credit channel claim that financial frictions can explain the observed dynamics of output. So I will use the variance of output *and* the autocorrelation function (ACF) of output growth as measures of the financial accelerator mechanism[23].

Table 4 reports the statistics for the U.S. economy between 1960:1 and 2000:4, the basic RBC model ($F \equiv \mathbf{1}_{\nu \in [0,1]}$), the benchmark, and the economy with credit rationing when $\gamma = \mu = 0.15$ (this latter economy corresponds to Figures 1A-1H). The third row shows that the benchmark model behaves like the basic RBC model (see also Figures A1-A6 in the appendix). Consistently with Figure 1A, the last row reports that the presence of tangible assets in collaterals works to increase persistence. Output growth's first autocorrelations are positive and higher than in

[23] To my knowledge, the only paper that provides a measure of the accelerator is Carlström & Fuerst [1997]. However, their measure is partial to the extent that only the ACF is considered.

the benchmark model (0.034 against -0.02 at the first order). Also in line with the financial accelerator theory is that the variance of output is higher in the economy with credit rationing. The incorporation of quantity rationing into the standard RBC model thus helps replicate the observed dynamics of output. The statistics of the model with credit rationing in Table 4 remain lower than the observed statistics though. In what follows I show how one can very improve the quantitative fit of the model.

Table 4 — Actual Data and Theoretical Models[24]

		ACF for output growth		
	σ_Y	γ_1	γ_2	γ_3
U.S. data	0.016	0.298	0.200	0.093
RBC	0.009	-0.030	-0.029	-0.028
Benchmark	0.009	-0.020	-0.021	-0.023
CR I	0.011	0.034	0.026	0.017

The last term in equation (5) suggests that there are basically two ways to improve the model: By increasing the leverage ratio's sensitivity to the macroeconomy ($\partial\overline{\nu}_t/\partial a_t$), or by increasing the sensitivity of the macroeconomy to the leverage ratio ($F^{'}(\overline{\nu}_t)$[25]). The first way is perhaps the most direct. It merely consists in varying the composition of collaterals in the appropriate way. As I have shown in the previous section, make the capital price vary is one possibility. Another possibility is to consider "complementarities" between the components of collaterals, the idea

[24] I averaged the statistics on 500 simulations for which the feasability condition $\overline{\nu}_t < 1$ were satisfied all periods in models CR I and CR II-III (*cf.* Table 5). Each simulation was 300 periods in length, and the statistics were calculated only over the last 200 periods. The standard deviation of the aggregate technology shock was equal to the standard 0.007 and I used the parameters of Table 3. The variance was calculated for the HP-filtered (actual and simulated) series of output. The data were not filtered for the ACF growth statistics.

[25] This could be achieved by varying factor demand elasticity (through $f_2^{'}(a_t, e_t)e_t^{'}(\overline{\nu}_t)$) as well. I do not consider this case because this would require varying the standard parameters of the model (Table 3).

being that the higher the size of the firm (k_t) the higher the proportion of seizable cash flows: $\mu = \mu(k_t)$ (with $\mu^{'}(k_t) > 0$)[26]. Although insightful, such alterations have quite straightforward outcomes so, for the sake of parsimony, I will not report the corresponding statistics. More interesting is the second way (increase the sensitivity of the economy to the leverage ratio). This consists in varying the distribution of idiosyncratic shocks, F. To illustrate the discussion I will consider the following distribution functions: $F_p(\nu) = \nu^{1+p}$, with $p \in (-1, +\infty)$, and several p[27].

Insert Figure 4

The strength of the accelerator depends positively on the capacity utilization rate's elasticity to the leverage ratio (see equation (5)). In particular, for a given leverage ratio, the higher p, the higher the slope of the risk distribution, and the stronger the financial accelerator. In other words, the financial accelerator depends on the distribution of risks[28]. The intuition is the following. When the slope of F is high at the steady state the number of "on-the-edge"

[26] Such a complementarity can be justified by the fact that it is probably more difficult for large firms to hire cash flows from banks than for small firms. In this case, the leverage ratio would write $\overline{\nu}_t = \min\left\{\gamma \frac{(1-\delta)}{1+r_t}\left(\frac{k_t}{\ell_t}\right)^{1-\alpha} + \mu(k_t)\frac{a_t}{1+r_t}, 1\right\}$. The present model is flexible and various ways exist to increase the leverage ratio's sensitivity. On the households' side, for instance, it would be possible to introduce real estate accumulation and variable house prices. On the firms' side, it would be possible to consider capital vintages, the idea being that only the new capital goods (1, 2... quarters old) can be resold by banks and therefore are collateralizable assets. In this case, the leverage ratio would write $\overline{\nu}_t = \min\left\{\gamma \frac{(1-\delta)i_{t-1}+(1-\delta)^2 i_{t-2}+...}{(1+r_t)k_t^{\alpha}\ell_t^{1-\alpha}} + \mu\frac{a_t}{1+r_t}, 1\right\}$.

[27] The subsequent reasoning would hold with any risk distribution (*e.g.* the lognormal distribution). This particular class of distribution functions has three advantages. First, the capacity utilization rate's elasticity to the leverage ratio simply writes $1 + p$. Second, the distribution collapses to the uniform distribution when $p = 0$. (Note that the uniform distribution used in the model CR I was quite neutral regarding its implications on dynamics). Third, this family of distributions is consistent with the observed distributions of a number of financial ratios, which may be skewed towards 0 (like distribution of the liquidity/total assets ratio).

[28] This feature is also present in the traditional models on the financial accelerator (Carslträm & Fuerst [1997] and Bernanke, Gertler & Gilchrist [1999], for example, who assumed a lognormal distribution) but, to my knowledge, the role of the risk distribution has never been investigated.

firms is large and a small movement $\Delta\overline{\nu}_t$ in balance sheet variables is sufficient to generate a large variation $\Delta F(\overline{\nu}_t)$ in the number of financed firms. The upshot is that small changes at the microeconomic level may result in large aggregate disturbances. Table 5 and Figure 4 illustrate this point. I considered two models with credit rationing, CR II and III, respectively with $p = 1$ and $p = 1.7$. (The models CR I, II, and III are comparable because they all present the same rate of capacity utilization at their steady state). Variances and autocorrelations move in the expected way: The higher p, the stronger the financial accelerator mechanism. The model CR III exhibits a more powerful accelerator than models CR I and II.

Table 5 — Accelerator and Risk-Distributions[29]

		ACF for output growth		
	σ_Y	γ_1	γ_2	γ_3
CR II	0.013	0.120	0.099	0.084
CR III	0.016	0.170	0.151	0.132

This model generates both significant amplification and significant persistence. It therefore performs better than the basic RBC model and better than the traditional models with the financial accelerator, which exhibit only either more amplification (Bernanke, Gertler & Gilchrist [1999]) or more persistence (Carlström & Fuerst [1997]) than the basic RBC model.

4 Final Remarks

This paper proposes a parsimonious and tractable way of modelling the role of credit rationing in the business cycle, and describes a new financial accelerator mechanism. In contrast with the traditional accelerator of Bernanke and Gertler, this accelerator does not go through the external finance premium. It is independent from investment/interest rate elasticity, which is generally

[29] In order to have $F(\overline{\nu}) = 0.95$ at the steady state, I set $\gamma = \mu = 0.19$ as $p = 1$ and $\gamma = \mu = 0.21$ as $p = 1.7$. Because there is no *a priori* reason why banks could seize proportionally more cash flows than tangible assets (and *vice-versa*) I considered the cases $\gamma = \mu$ only. One could fit the U.S. statistics even better by allowing $\gamma > \mu$.

too weak in the usual RBC models to make financial frictions have significant consequences on the business cycle. Also, the loan-supply transmission channel described in this paper is consistent with the empirical study of Kashyap, Stein & Wilcox [1993].

My main result is that the financial accelerator is stronger in the presence of quantity rationing than in the presence of price rationing on the credit market. The reason is that, by creating a gap between potential and actual outputs, quantity rationing has a direct effect on the economic activity. Two quantitative conclusions warrant restatement. First, credit rationing magnifies the response of output to technology shocks. Second, the model replicates the empirical fact that output growth displays positive autocorrelations at short horizons.

Another contribution of the paper is to demonstrate how questions about persistence and amplification are intimately connected to the composition of the collateral. Basically, persistence is imputable to the volume of tangible assets, whereas amplification comes from cash flows and asset prices. (The dynamic feedbacks generated by the latter are shown to be generating amplification only).

There are several natural extensions of the current work. First, the model is amenable to considering other shocks to the economy. For example, Carlström & Fuerst [2000], Bernanke & Gertler [1999] recently examined the effect of monetary shocks in related models. Second, the model may provide a comprehensive framework to replicate the observed flight-to-quality effect, that models with the traditional accelerator fail to reproduce (Fisher [1999]). Third, in the current paper I have presented a very parsimonious framework which allows for considering a large variety of collaterals, like real estates and house prices. The loan-supply channel version of the accelerator must be viewed as a complement of, rather than a substitute to, the traditional version. Therefore, a fourth natural extension is to incorporate price rationing into the model in order to describe both the price and non-price channels underlying the financial accelerator mechanism.

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6 Appendix

The Implicit External Finance Premium

One peculiarity of my model is that agency costs are measured through the output gap, not through an interest rate premium. As a result, the debtor interest rate is equal to the safe interest rate and there is no facial premium. So, to make it easier the comparison between the new and the traditional accelerators, I introduced the notion of "implicit external finance premium" (e_t). I define the latter as the fictive premium that would make the economy have the same factor demands under price rationing as it does under quantity rationing. It is thereby possible to describe a fictive economy with interest rate rationing, in which factor demands are the same as in the economy with quantity rationing. In this fictive economy, under-investment of the same type as Bernanke & Gertler [1989] exists. Also, every firm get external funds so that the dynamics of *actual* ouput is the same as the dynamics of *potential* ouptut in the economy with quantity rationing (Figure 1C). Table 2' below reports the equations that differ from table 2 for such an economy.

Table 2' — The Fictive Model with "Price Rationing"[30]

2'.	$y_t = c_t + i_t + E(1)k_{t+1}^{\alpha}\ell_{t+1}^{1-\alpha} +$ agency costs
3'.	$y_t = a_t k_t^{\alpha}\ell_t^{1-\alpha}$
5'.	$[a_t - E(1)(1+r_t)(1+e_t)]\,\alpha k_t^{\alpha-1}\ell_t^{1-\alpha} = r_t + \delta$
6'.	$[a_t - E(1)(1+r_t)(1+e_t)]\,(1-\alpha)k_t^{\alpha}\ell_t^{-\alpha} = \frac{-v'(\ell_t)}{u'(c_t)}$
8'.	$e_t \equiv \frac{1-F(\overline{\nu}_t)}{E(1)}\frac{a_t}{1+r_t} + \frac{E(\overline{\nu}_t)}{E(1)} - 1$

By definition of "interest rate rationing", all firms must participate to the credit market. This requires that the worse firm's project has a positive return: $a_t \geqslant (1+r_t)(1+e_t)\ \forall t$. One can verify (by using equation 8') that this condition is satisfied whenever $\overline{\nu}_t$ is close to one, which is the case in the neighborhood of the steady state ($\overline{\nu} = 0.95$). As a result, the existence of a positive external finance premium implies under-investment (equations 5' and 6') but not capital under-utilization: $y_t = Y_t$[31]. At the steady state of this fictive economy, the implicit external finance premium is equal to 2% and the implied agency costs approximately amount to 1% of the potential ouptut (instead of 5% in the economy with quantity rationing).

[30] Equations 1, 4 and 7 of Table 2 are still valid. In this fictive economy, agency costs are equal to $(1-F(\overline{\nu}_t))y_t - (E(1) - E(\overline{\nu}_{t+1}))k_{t+1}^{\alpha}\ell_{t+1}^{1-\alpha}$.

[31] Should the external finance premium be very high, the entrepreneur $\nu = 1$ would not be willing to undertake. However, this case does not correspond to my definition of price rationing (see the Introduction), since the participation constraint of some borrowers would not be satisfied.

The RBC model and the Benchmark

Figures A1-A6 report the dynamics of the standard RBC model and the dynamics of the model with intermediate goods I used as benchmark in the paper. These are the responses to a technology shock, and parameters are the same as in Table 3. Basically, differences between the two models are quantitative. Factors and output are more sensitive in the benchmark model than in the standard RBC model. Factor demands increase more at the impact because they are pulled up by the demand for final goods. The demand for final goods rises in period t owing to the rise in period $t+1$ demand for working capital goods. As a result, the interest rate is more volatile at the impact. Despite the rise in the interest rate, consumption reacts stronger in the benchmark model because of a stronger wealth effect. In the economy with intermediate goods, the wealth effect is particularly tough because output is more persistent. This persistence is mainly due to capital stock's behavior, which is stimulated by the decrease of the interest rate back to its steady state.

Insert Figure A

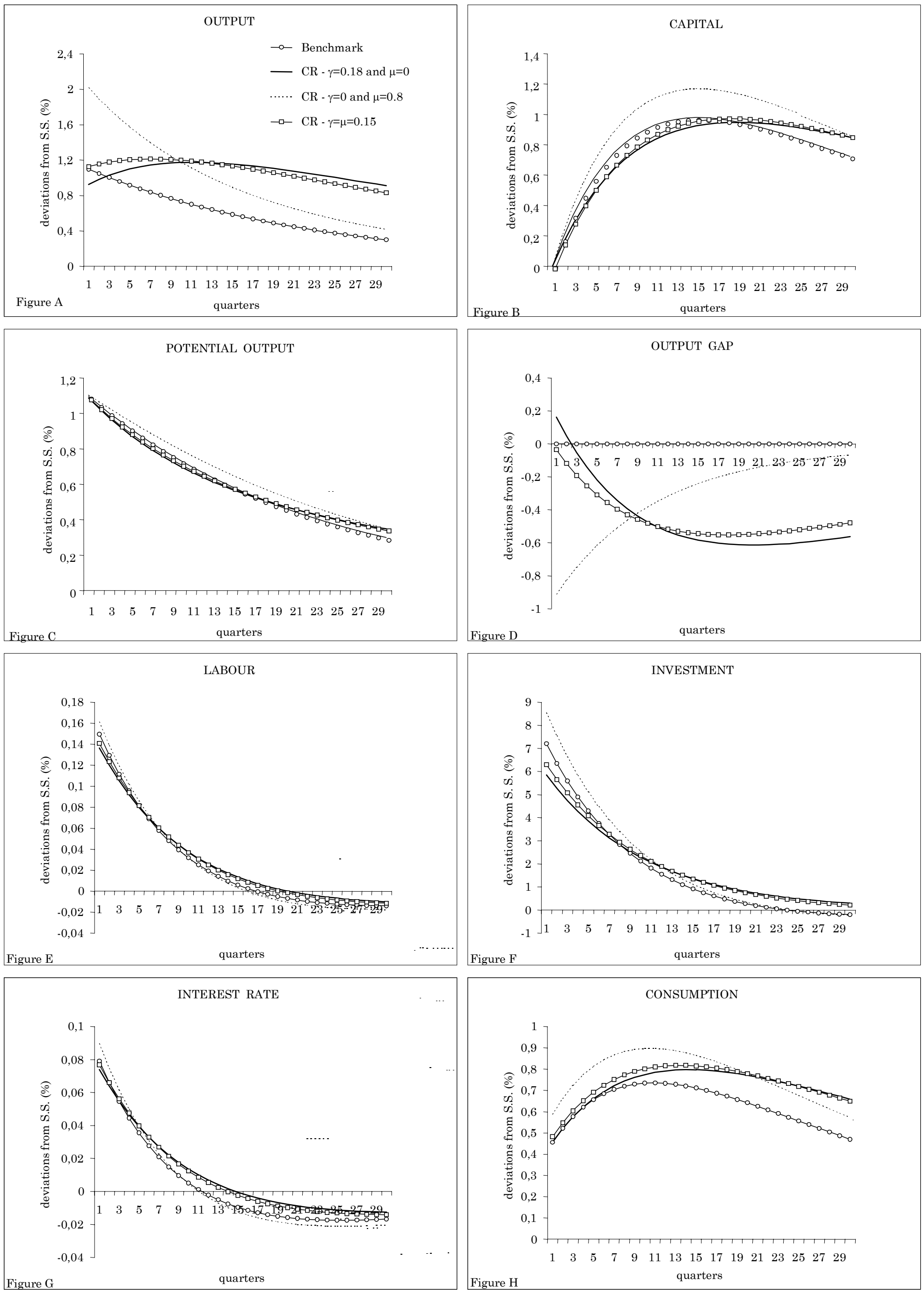


Figure 1: Benchmark and Credit Rationing

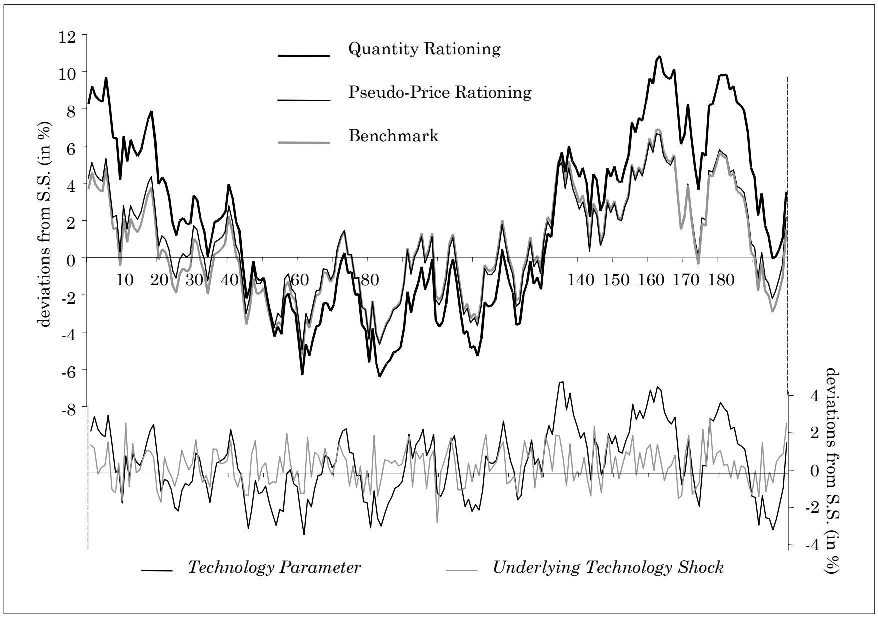
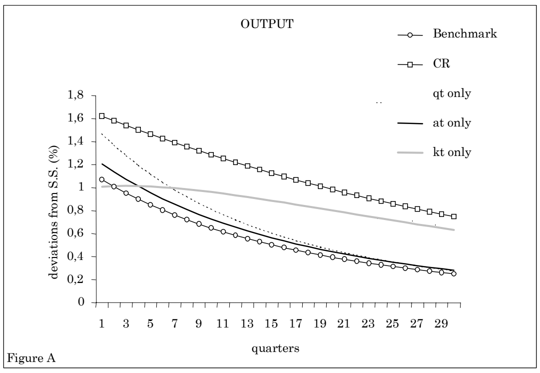


Figure 2: Output's Dynamics and Credit Rationing



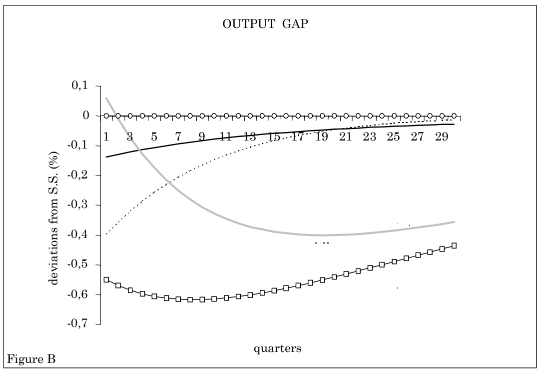


Figure 3: Accelerator and "Dynamic Multiplier"

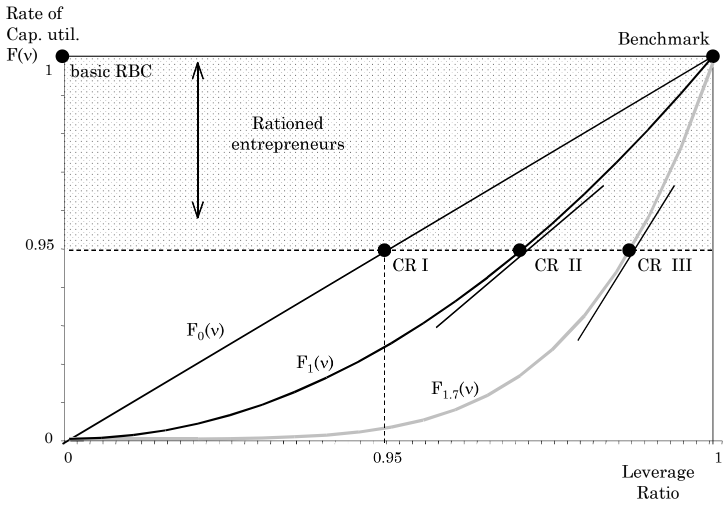


Figure 4: Some Risk Distributions

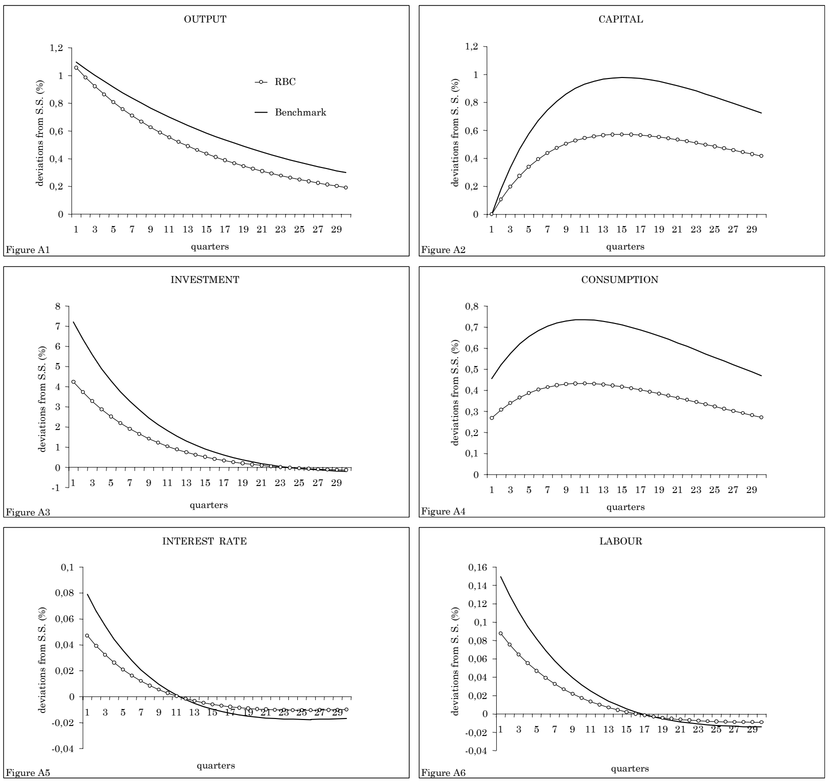


Figure A: The RBC Model and the Benchmark

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