Trade Credits, Corporate Finance, and The Business Cycle : A Theoretical Lightening

Frédéric Boissay *†

August 2000
Work in progress
(comments are welcome)

Abstract

I argue that the observation of US economic fluctuations during the last decade leads to question the existing theoretical macroeconomic models on the financial accelerator, to the extent that these models misrepresent the cyclical behavior of business sector's financial structure.
This paper develops a computable general equilibrium model in which endogenous variations of firms' financial structure within the cycle are consistent with the recent observations. The interactions between the financial structure and the business cycle give rise to a financial accelerator mechanism. I show that the relevance of this mechanism depends on the degree of substitutability between the available means of external financing, such as trade credits and bank loans.

1 Introduction

Financial constraints empirically play an important role in the determination of investments (see, *e.g.* Whited [1992], Bond & Meghir [1994]) and inventories (see, *e.g.* Carpenter, Fazzari & Petersen [1994]) especially for small business (see, *e.g.* Kashyap, Lamont & Stein [1994], Gertler & Gilchrist [1994]). Moreover, it is well-known that inventory and investment fluctuations account for much of the movement in aggregate output. The interactions between individual firms' financial structure and the aggregate economic activity have been recently theoretically studied within dynamic

*EUREQua (University of Paris I), CREST, and University of Marne-la-Vallée. Correspondence : CREST, Laboratoire de macro-économie. Timbre J360. 15, boulevard Gabriel Péri. 92245 Malakoff Cedex. France. e-mail : boissay@ensae.fr.

†I thank M. Poitevin for helpful comments on an earlier version of this paper. I have also benefitted from discussions with B. Crepon, S. Gilchrist, M. Guillard and with seminar participants at EUREQua and CREST. All remaining errors are mine.

general equilibrium models (Bernanke & Gertler [1989], Fuerst [1995], Carlstrom & Fuerst [1997], Bernanke, Gertler & Gilchrist [1999]). Considering banks (or equivalently Capital Mutual Funds) as the unique source of external financing, all these models exhibit the so-called "financial accelerator mechanism".[1] According to them, the fraction of internal funds in the total financing would rise during booms (collapse during slumps), thus leading banks to lower (raise) their debtor interest rates and magnifying the business fluctuations. Corollarily, the part of external financing in the total financing would be countercyclical. However, these key mechanisms are not observed, as the evolution of business sector's financial structure during the last decade in US shows. In figure 1, the part of internal funds seems to be countercyclical, whereas the part of bank loans appears to be procyclical. These recent observations tend rather to advocate the view that firms would cope with bank credit rationing by raising both retained earnings and the part of other sources of external financing in their total short term financing. It follows that a broader view of corporate finance is required to meaningfully capture the interactions between financing conditions and business fluctuations and, notably, to account for the fact that banks are far from being the only source of external financing in practise.

In particular, trade payables represent a major part of external financing at the individual firm level and probably have a great influence on short term macroeconomic fluctuations.[2] Although there is no evidence of that, the conventional view on the theme argues that trade credits may work to propagate shocks to the economy.[3] My conjecture is quite different. I argue that, as substitutes of short term bank credits, trade credits should go up during periods of tight credit (typically, during recessions) and thus smooth the macroeconomic fluctuations. In other words, I think that the importance of the financial accelerator mechanism is likely to depend on

[1]Endogenous developments in credit markets work to propagate and amplify shocks to the macroeconomy. When lenders are not well informed about borrowers' investment projects they may devise "second-best" contracts that induce the borrowers to reveal some information. Typically, these contracts entail collateral requirements or credit rationing. As a consequence, real investment and consumption become highly dependent on the borrowers' balance sheet position, *i.e.* on the value of their net assets. These models are based on the notion that, because of asymmetries of information, the firms' degree of external finance is not irrelevant for investment decisions. In some cases, the degree of external finance depends on the value of durable assets. Since this value is sensitive to the cyclical variability of aggregate demand and supply, there is an obvious reason why financial factors should play a central role in business cycle.

[2]As reported in the Federal Reserve Bank Flow of Funds Accounts, trade payables represented 37% of short-term liabilities, against 30% for bank loans in 1998 for nonfarm nonfinancial corporate business firms.

[3]According to this view, in an economy where firms produce, borrow and lend simultaneously, a sector-specific shock to the technology or net worth of firms would cause a chain reaction in which other firms get into financial difficulties, thus generating a large, persistent fluctuation in aggregate output.

the degree of substitutability between the available external means of short term financing —i.e. trade credits and bank credits.

Although how trade credits alter short term macroeconomic fluctuations appears to be a puzzle for the theorist, the area has been strikingly deserted by macroeconomists and the question remains open (see Kiyotaki & Moore [1997]). The objective of this paper is to theoretically explore the role of trade/bank credits upon macroeconomic fluctuations within an otherwise standard dynamic general equilibrium model. In contrast with existing models, mine assumes heterogenous firms *ex ante*, which have access to two sources of external financing (banks and suppliers) and may use some illiquid assets as guarantees against possible *ex post* insolvency.

At the microeconomic level, my model includes an informational asymmetry, which creates an adverse selection problem on the credit market. Briefly speaking, I develop the model in two steps. In the first step, I assume that banks are the only source of external financing at the firm level, *i.e.* trade credits are absent. Basically, the model is a version of Besanko & Thakor [1987] (hereafter B&T) and I find that credit rationing *à la* Stiglitz & Weiss [1981] (hereafter S&W) always arises at equilibrium. However, the absence of trade credits does not lead to the second-best equilibrium, to the extent that every bank-credit-rationed firm should be willing to get funds through her suppliers. In the second step, the basic framework is amended to account for the availability of trade credits. Trade credits are supposed costlier than bank credits, so that firms demand trade credits if and only if they are red-lined by their bank.[4] In contrast with B&T, no rationing is present at equilibrium, *i.e.* borrowers prefer to be partially financed with probability 1, rather than totally financed at random; I will call this "red-lining". The second-best financial contract implies that high quality firms are more likely to demand trade credits and pledge assets as collateral than low quality firms, to the extent that they may signal themselves by doing so. These results shed light on the controversial empirical findings of Kaplan & Zingales [1997] and even provide strong theoretical reasons for investment-cash flow sensitivities to decrease monotonically with the degree of financing constraints.[5]

[4]Many corporate finance textbooks (see, for example, Brealey & Myers [1984]) point out that firms routinely offer their products on terms called "2-10 net 30", which means that the buyer must pay within 30 days, but receives a 2% discount if payment occurs within 10 days. The 2% price increase over the remaining 20 days corresponds to a 37.24% implicit annual interest rate, that is much more than the short term annual bank interest rate! This figure should be compared with the average interest rate on small firms' overdrafts, which amounts to 15% in US. Petersen & Rajan [1994] have estimated the cost of trade credit on a 3404 US firms panel. They have found that the implicit annual commercial interest rate is above 22.1 percents. This is higher than 99.8 percents of the loans in their sample.

[5]See also the passage of arms between Kaplan & Zingales [1995] and Fazzari, Hubbard

graphe

Figure 1:

At the macroeconomic level, agency costs endogenously become less severe in periods of high output and thus lower the cost of borrowing. Basically, a supply-side force complements the demand-side force already present in the standard dynamic general equilibrium framework. Indeed, in the perfect information economy, a positive technology shock alters borrowers' behavior solely by increasing the demand for external funds. In the agency cost model, this demand force is still present, but there is also a supply-side force. Increases in output raise the level of collateralizable assets and the level of guarantees, thus enabling competitive banks to lower the level of credit red-lining. In the economy without trade credits, this does not only imply that firms —when financed— have access to better financing conditions, but also that more firms are financed and may undertake their project. Hence, my model predicts that, without trade credits, the financial accelerator mechanism exists and should be rather important. In contrast, when trade credits are available, a lower level of bank credit red-lining just implies that firms use less expensive trade credits. But the number of undertaking firms should not increase. It follows that, by substituting for bank credits, trade credits tend to act as a buffer within the business cycle.

This paper is organized as follows. In section 2, I depict the main features of the partial equilibrium model. I briefly remind B&T's results, and I then complete the model by allowing for trade credits. In section 3, the partial equilibrium models are embedded within a dynamic general equilibrium framework and the dynamics of the two economies are compared. Section 4 concludes.

2 The Partial Equilibrium Model

There are four types of rational infinite lived atomistic agents in the competitive economy: the banks, the intermediate good producers and the final good producers, who are risk neutral, and the households. There exist two types of final good producers, the "high-ability producers" and the "low-ability producers", endowed with a two-period production process, say periods $t-1$ and t. Every project requires b_t units of intermediate goods as early as period $t-1$. The high-ability firms achieve their project with higher probability than the low ability firms do, which will be referred to as the "riskiest" projects. For the moment, b_t is supposed fixed and exogenous.

I assume that the success probabilities are known by both the final good producers and their intermediate good suppliers, but not by banks; *per contra*, I assume that the suppliers incur specific management costs on account

& Petersen [1995].

receivables, whereas banks do not.[6] All agents freely observe project returns at the end of the production process. At the beginning of the production process, final good producers have no cash and have to borrow external funds, either from banks or, if conceivable, from their suppliers, in order to purchase the input (I will refer to these external funds as "overdrafts" and "trade credits" respectively).[7] Similarly, suppliers do not have liquidities and have to borrow as they extend trade credits. Under the law of large numbers, the representative supplier's trade receivables are perfectly diversified and she should not face credit rationing. In particular, she can afford to offer trade credits by raising external funds through banks at the exogenous riskless rate of interest, denoted by r_t. The total purchase cost of the intermediate good is then composed of the cash price plus the cost of external financing (*i.e.* the bank interests or the commercial interests).

To simplify, I will assume that one intermediate good is instantaneously produced with θ final goods, and that the final good is the numeraire, so that the equilibrium cash price of the intermediate good is equal to θ. I will also assume that management costs on account receivables are incurred in period $t-1$, each time a postponement of payment is granted, and are represented by parameter $\tau > 0$. Hence, the average production cost when selling on credit amounts to $(1+\tau)\theta$.[8] Parameter τ captures the degree of substitutability between trade credits and bank loans.

The timing of events is as follows (see figure 2). At the beginning of the production process (period $t-1$), a random move of nature determines the types of the final good producers, say L or H for low-ability firms and high-ability firms respectively. Final good producers have equal size; a fraction λ_L of them are of type L and λ_H of type H, with $\lambda_L + \lambda_H = 1$. Their project consists in investing the b_t units of intermediate goods in period $t-1$

[6]This simplifying assumption just stands for the fact that sellers-buyers productive relationships lead suppliers to glean private information about clients' ability to achieve their production process. This assumption is also made in Biais & Gollier [1997], and it has been empirically tested and accepted by Petersen & Rajan [1997] for US, and by McMillan & Woodruff [1999] for Vietnam. Admittedly, banks also incur some costs when lending. We normalize them to zero for simplicity insofar as they are likely to be lower for banks than for sellers, reflecting the specialization of the former in credit collection.

[7]It is unlikely that a firm will finance short-term project with long-term debt. Most of firms match the maturity of assets and liabilities. This is an argument for why we will only focus on the bottom of firms' balance sheet. Diamond [1991] presents rationales for this.

[8]In an intertemporal perspective, the final goods that enter the intermediate good producers production process have been produced in period t by the firms who began their production process in period $t-1$. Furthermore, the specification of the transaction cost on delayed payments is over-simple, and one would like it to be endogeneous. Nevertheless, think of this specification as a reduced form of a more realistic specification in which parameter τ would be, for instance, an agency cost on suppliers' bank loans (see appendix A).

that will yield $a_t b_t / \pi_j$ units of final goods in period t with probability π_j, $\pi_L < \pi_H$ and $\pi_j \in]0,1[, \forall j = L, H$ —or nothing otherwise. The term a_t is an exogenous technological parameter that can be time-varying. Incidentally, final good producers must borrow θb_t from their banks or (if conceivable) from their suppliers to invest.

In order to make the participation constrained of every firm satisfied, I will assume that $a_t > (1 + r_t)(1 + \tau)\theta$, $\forall t$. Final good producers are endowed with an exogenous asset, which is not liquid in period $t - 1$ but can be costlessly liquidated in period t. The asset-to-project-size ratio, denoted by C_t, is supposed sufficiently small that full collateralization is not possible: $C_t < 1 + r_t$. Once types are determined, banks and/or[9] borrowers simultaneously propose credit contracts.

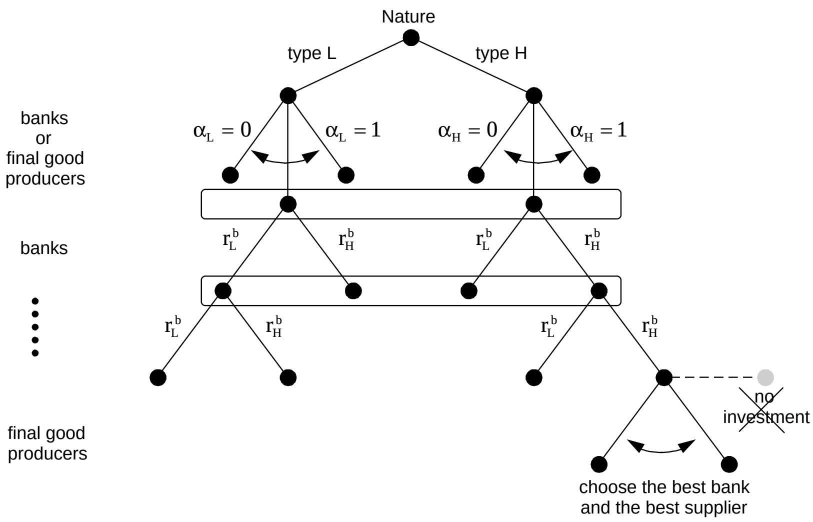

Figure 2: The extensive form of the game

[9]Microeconomists would say that the question of who proposes the contracts crucially matters in such models. Indeed, if financial contracts are offered by banks, then equilibrium may not exist; But we know that, if it exists, it implements the separating —unique— equilibrium (see Rothschild & Stiglitz [1976]). Anyway, the latter always represents a Riley [1979]'s reactive equilibrium. Conversely, if contracts are proposed by borrowers, then a signaling game arises, which, again, leads to the separating —unique— equilibrium, provided that Cho & Kreps [1987]'s refinement is adopted. As a result, the equilibrium implemented by the least-cost revealing/signaling contract appears to be the most meaningful, and the question of who proposes the contracts turns out to be of little interest for the macroeconomist. In the rest of the paper I leave out these issues and I focus exclusively on the least-agency-cost revealing/signaling financial contracts.

The financial contracts consist in the level of bank credit rationing in period $t-1$ (say α_{jt}), the fraction of the total asset collateralized (say γ_{jt}), and the bank interest rate, denoted by r_{jt}^b.[10] For simplicity I assume that a borrower can apply to only one bank during the period under consideration, and I focus only on Nash equilibria. Banks compete *ex ante* on the terms of these contracts, and borrowers, who compete on the final good market, choose the best financial contract for them.

2.1 Credit Market Equilibrium Without Trade Credits

The partial equilibrium model is a simplified version of B&T, with costless collateral and without opportunity cost to the investors of undertaking the risky project. The only difference —which is not fundamental— concerns the distribution of final good producers' returns.[11] Since banks are the only source of external funds, the end-of-period t expected profit for types j is equal to

$$\widetilde{\Pi}_{jt}^{final} = \alpha_{jt}\left[a_t - \pi_j(1+r_{jt}^b)\theta - (1-\pi_j)\gamma_{jt}\theta C_t\right] b_t \tag{1}$$

and the end-of-period t expected profit for the representative bank, with a type j borrower, is equal to

$$\widetilde{\Pi}_{jt}^{bank} = \alpha_{jt}\left[\pi_j(1+r_{jt}^b) + (1-\pi_j)\gamma_{jt}C_t - (1+r_t)\right]\theta b_t \tag{2}$$

The representative bank raises funds at the riskless rate of interest, and is aware of the fact that low–ability clients are inclined to cheat by telling they are high–ability ones. Under asymmetric information, two distinct incentive compatible contracts will be traded (see constraint (3a) below) and the competitive equilibrium credit policy $(\alpha_{jt}^*, \gamma_{jt}^*, r_{jt}^{b*})$, $j \in \{L, H\}$ is a solution

[10] We may have: $r_{jt}^b = r_t^b$, $\gamma_{jt} = \gamma_t$, and $\alpha_{jt} = \alpha_t$, $\forall j = L, H$.

[11] In B&T's notations, one would have $\beta = 1$ and $b = 0$. The Mean Preserving Spread (MPS) specification is just aimed at making the dynamic general equilibrium model as familiar as possible. As noted in B&T, this may raise the following issue: If the level of output is observable *ex post*, the MPS specification should permit sorting with costless contingent contracts. I cope with this issue by simply assuming that only whether the projects succeeded or not is observable, not returns.

to[12]

$$\begin{cases} Maximize\ \lambda_L \widetilde{\Pi}^{final}_{Lt} + \lambda_H \widetilde{\Pi}^{final}_{Ht} \\ s.t. \\ \quad (3a)\ \ \widetilde{\Pi}^{final}_{it}(\alpha_{it}, \gamma_{it}, r^b_{it}) \geqslant \widetilde{\Pi}^{final}_{it}(\alpha_{jt}, \gamma_{jt}, r^b_{jt})\ ,\ \forall i = L, H \\ \\ \quad (3b)\ \ \widetilde{\Pi}^{bank}_{jt} = 0\ ,\ \forall j = L, H \\ \\ \quad (3c)\ \ (\alpha_{jt}, \gamma_{jt}) \in [0,1]^2 \end{cases} \tag{3}$$

Condition $(3b)$ is implied by the perfect competition on the credit market, *i.e.* interest rates must just cover loan costs. This means that low-ability borrowers must pay higher interest rates than high-ability borrowers and must, therefore, be deterred from choosing the contract designed for high-ability types. The equilibrium, stated in proposition 1, implements the least-cost revealing/signaling contract.

Proposition 1: When trade credits are not available, the *separating* credit market equilibrium is given by

$$\begin{cases} \alpha^*_{Lt} = 1 \text{ and } \alpha^*_{Ht} = \frac{a_t - (1+r_t)\theta}{a_t - (1+r_t)\theta + \frac{\pi_H - \pi_L}{\pi_H}[1 + r_t - C_t]\theta} \\ \\ 1 + r^{b*}_{Lt} = \frac{1+r_t}{\pi_L} \text{ and } 1 + r^{b*}_{Ht} = \frac{1+r_t}{\pi_H} - \frac{(1-\pi_H)C_t}{\pi_H} \\ \\ \gamma^*_{Lt} = 0 \text{ and } \gamma^*_{Ht} = 1 \end{cases}$$

Proof : See B&T's proposition 3. □

Because collateral is costless, it is insufficient to deter low-ability borrowers from choosing the high-ability contract. The bank responds to this incentive compatibility problem by reducing the probability of extending credit to a high-ability borrower, thereby randomizing the credit policy (this is S&W rationing). The high-ability contract is still acceptable by a high-ability borrower because interest rate is low. This lower interest rate is of lesser value to a low-ability borrower because the probability of actually paying it is lower. Thus, low-ability borrowers are coaxed away from the high-ability contract.

The probability of being financed in period $t-1$ positively depends on the —expected— value of next-period assets (C_t) and high-ability firms are more rationed by banks than low-ability firms. This result may explain the empirical conclusions of Kaplan & Zingales [1997], who found that financially constrained firms, *i.e.* "firms facing a wedge between the internal and

[12] I take the existence and the uniqueness of the separating equilibrium for sure. See the brief discussion in footnote 9. Note that: $\widetilde{\Pi}^{final}_{it}(\alpha_{jt}, \gamma_{jt}, r^b_{jt}) = \alpha_{jt}\left[a_t - \pi_i(1 + r^b_{jt})\theta - (1-\pi_i)\theta\gamma_{jt}C_t\right] b_t$.

external costs of funds" (types L in our model), exhibit significantly lower sensitivities to collateral than firms that appear less financially constrained. Proposition 1 establishes the relation between the —expected— aggregate level of the economic activity and the financing conditions at the individual firm level. Moreover, corollary 1 establishes the relation between financing conditions at the individual firm level in period $t-1$, α_{Ht}^{*}, and the aggregate level of output of final goods in period t, denoted by y_t.

Corollary 1: In absence of trade credits, the aggregate level of output of final goods in period t is equal to $y_t = (\lambda_L + \lambda_H \alpha_{Ht}^{*}) a_t b_t$.

2.2 Credit Market Equilibrium With Trade Credits

In presence of trade credits, proposition 1 does not describe the second best equilibrium because every firm whose bank denied credit is willing to get funds through her suppliers. In this paragraph, I amend the model presented in paragraph 2.1 in order to account for the availability of trade credits. It is now useful to distinguish the notion of red-lining from the notion of S&W rationing: red-lining occurs when there is a partial and different bank financing of borrowers who exhibit different features. I show in appendix B that contracts including S&W rationing are suboptimal in presence of trade credit. Instead, α_{jt}^{*} must be interpreted as the fraction of bank overdrafts in the total short term financing for a type j firm rather than interpreted as the probability of being funded. In other words, when trade credits are available, firms prefer to be partially financed by banks with probability 1, rather than totally but randomly financed. This result, which strongly departs from B&T or Bester [1985], is very intuitive. When firms are red-lined, the assets-to-bank-loan- size ratio (*i.e.* $\frac{Ct}{\alpha_{jt}}$) is higher than when they are S&W rationed (C_t), so that financing conditions are relatively better.[13]

I will denote by r_{jt}^{s} the period $t-1$ implicit interest rate on trade credits for the final good producers of type j ($j = L, H$), which is equal to the price of the final good when paid on credit minus one (the price of the final good). The end-of-period t expected profit of the representative intermediate good producer, $\widetilde{\Pi}_t^{inter}$, is equal to

$$\widetilde{\Pi}_t^{inter} = \sum_{j=L,H} (1-\alpha_{jt}) \lambda_j \left[\pi_j (1 + r_{jt}^{s}) - (1 + r_t)(1 + \tau) \right] \theta b_t \qquad (4)$$

In the intermediate good market equilibrium, the intermediate good suppliers do not make strictly positive expected profits, so that the equilibrium debtor interest rates on trade credits are $1 + r_{jt}^{s*} = \frac{(1+\tau)(1+r_t)}{\pi_j}, \forall j = L, H$.

[13] Compare the debtor interest rate in proposition 2 with the equilibrium debtor interest rate in appendix B.

It will be assumed that these equilibrium interest rates are common knowledge, but also that banks do not know whether a given final good producer is financed at r^{s*}_{Lt} or at r^{s*}_{Ht} by her supplier.[14]

Given the agency costs due to the postponement of payments, it is clear that these debtor interest rates are higher than those given in proposition 1. That is why borrowers would prefer to be totally financed by their bank. However, the asymmetry of information may lead banks to red-line credit (with fraction $1-\alpha_{jt}$) so that type j final good producers are forced to demand postponement of payments to their suppliers as complementary financing. Hence, type j final good producers' end-of-period t expected profit is equal to

$$\begin{aligned}\widetilde{\Pi}^{final}_{jt} &= a_t b_t - \alpha_{jt}\left[\pi_j(1+r^b_{jt}) + (1-\pi_j)\gamma_{jt}\tfrac{C_t}{\alpha_{jt}}\right]\theta b_t \\ &\quad -(1-\alpha_{jt})(1+\tau)(1+r_t)\theta b_t\end{aligned} \tag{5}$$

The end-of-period t expected profit for the representative bank, with a type j borrower, is now equal to

$$\widetilde{\Pi}^{bank}_{jt} = \alpha_{jt}\left[\pi_j(1+r^b_{jt}) + (1-\pi_j)\gamma_{jt}\frac{C_t}{\alpha_{jt}} - (1+r_t)\right]\theta b_t \tag{6}$$

and the equilibrium credit policy $(\alpha^*_{jt}, \gamma^*_{jt}, r^{b*}_{jt})$, $j \in \{L, H\}$ is stated in proposition 2.

Proposition 2: In presence of trade credits, the *separating* credit market equilibrium is given by

$$\begin{cases} \alpha^{**}_{Lt} = 1 \text{ and } \alpha^{**}_{Ht} = \frac{\tau\pi_H + (\pi_H - \pi_L)\frac{C_t}{(1+r_t)}}{\tau\pi_H + \pi_H - \pi_L} \\ 1 + r^{b**}_{Lt} = \frac{1+r_t}{\pi_L} \text{ and } 1 + r^{b**}_{Ht} = \frac{1+r_t}{\pi_H} - \frac{(1-\pi_H)C_t}{\pi_H \alpha^{**}_{Ht}} \\ \gamma^{**}_{Lt} = 0 \text{ and } \gamma^{**}_{Ht} = 1 \end{cases}$$

[14] Suppose that banks could observe the interest rate on trade payables. Then, the informational structure would be symmetric. One can also justify this assumption by the fact that some buyers may potentially make strictly positive expected profits, that entails there is scope for potential collusion between final good and intermediate good producers against the representative bank. For example, intermediate good suppliers could be tempted to extend little trade credit at rate $\frac{1+r_t}{\pi_H}$ to their clients of type L, in order to make the representative bank (a) believe these clients are of type H and (b) provide them complementary financing at rate $\frac{1+r_t}{\pi_H}$ instead of $\frac{1+r_t}{\pi_L}$. Then the value extracted from the bank could be shared between final good and intermediate good producers — and thus compensate the sellers for risk taking.

Proof : Solve program (3) for the least-cost revealing/signaling contract.[15] The equilibrium contract corresponds to the menu (S_L, S_H) drawn in figure 3. The single crossing property of types L and H's isoprofit curves ensures that the revealing contract always exists. □

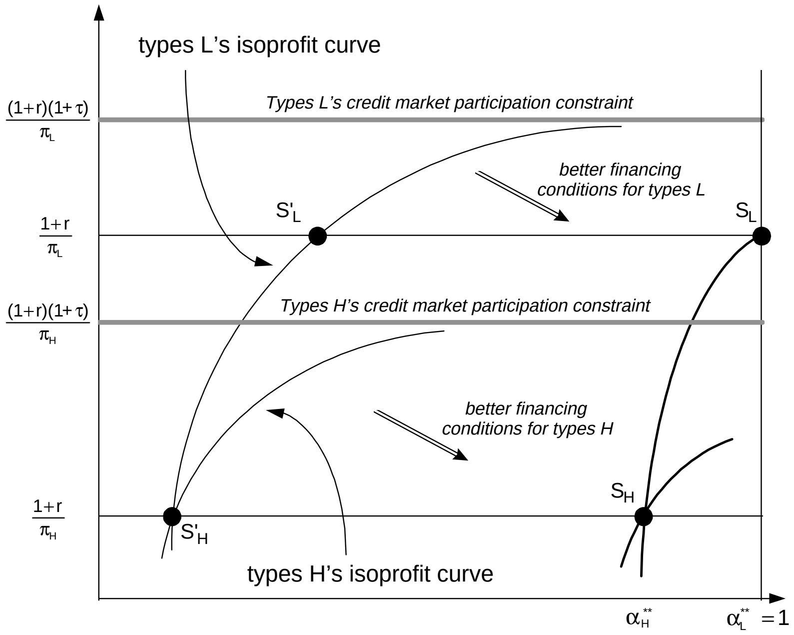

Figure 3: The equilibrium contract

This new revealing/signaling device is of the same vein as the one described in proposition 1. In the separating equilibrium, high-ability borrowers are ready to get costly trade credits simply because it allows them to distinguish themselves from low-ability borrowers and receive a lower bank interest rate. At the equilibrium, bad final good producers obtain the same expected profits (and even sign the same contract) as under symmetric information, while the good ones loose expected profits due to asymmetric information.[16]

Corollary 2: When trade credits are available, the aggregate level of output of final goods in period t is equal to $y_t = a_t b_t$.

[15] With: $\widetilde{\Pi}^{final}_{it+1} = \left[a_{t+1} - \alpha_{jt}\pi_i(1 + r^b_{jt+1})\theta - (1 - \alpha_{jt})(1 + r_{t+1})(1 + \tau)\theta - (1 - \pi_i)\theta\gamma_{jt}C_{t+1}\right] b_{t+1}$.

[16] I leave it to the reader to show that suppliers are neither interested in rationing their trade credit offer nor collateralizing their trade payables. This is consistent with the widespread claim of corporate managers that if they had not extended trade credits they would not have been able to sell.

Because I assumed that $a_t > (1 + r_t)(1 + \tau)\theta$ and there is no alternative investment, every firm is always interested in undertaking her project, even if she must raise expensive complementary funds from her suppliers. Hence, the availability of trade credits may avoid a wide range of firms from withdrawing from the market (compare corollaries 1 and 2), and the level of the activity is higher with trade credits than without. As trade credits and bank credits become highly substitutable (*i.e.* as τ tends to 0), agency costs due to the asymmetry of information vanish and the impact of credit red-lining on the level of the economic activity diminishes. This result may help to already perceive why the presence of trade credits may smooth aggregate economic fluctuations. In the next section, I close the model in order to embed this mechanism within a computable dynamic general equilibrium framework.

3 The Financial Accelerator Mechanism

In this section I develop a computable dynamic general equilibrium model derived from the partial equilibrium model described above. For tractability I assume that there is enough anonymity in financial markets that only one-period contracts between borrowers and lenders are feasible.[17] Then, I analyze the dynamics of the economy.

3.1 The General Equilibrium Framework

The revealing/signaling game is repeated infinitely. The sequence of events over periods t and $t+1$ is described in the first paragraph. The decentralized equilibrium is solved and the general equilibrium conditions are derived in the second paragraph.

3.1.1 The sequence of decisions in time period t

The decisions taken in period t concerns the production of period $t+1$. The timing is quite standard, save a production lead time exists: Inputs engaged in period t produce (with probability π_L or π_H) $a_{t+1}b_{t+1}$ units of final goods in period $t+1$. There are two inputs: capital k_{t+1} and labor l_{t+1}, whose combination

$$b_{t+1} \equiv k_{t+1}^{\eta} l_{t+1}^{1-\eta}$$

is the maximal quantity of intermediate goods the final good producers whose project has begun in period t are able to process in period $t+1$.

In period t, two groups of final good producers coexist with unit size: the final good producers who entered their production process in $t-1$, and those

[17] A similar assumption is made in Carlstrom & Fuerst [1998].

who are just entering it. The former are heterogenous with respect to their ability to carry out their project successfully (some are of type H, and some others of type L), while the latter are not heterogenous yet (see the time line in figure 4).

1. At the beginning of period t, households, who own the firms, choose how much to invest in new capital goods, say i_t. This decision determines the level of capital stock they will equally share among the entrepreneurs at the end of period t:

$$k_{t+1} = (1-\delta)k_t + i_t \tag{7}$$

where δ is the rate of depreciation of capital. This capital stock is made of newly accumulated capital goods and used capital goods, purchased on the secondhand market at price q_t. I will show later that the old capital goods are less profitable than the new ones ($q_t < 1$) owing to the credit market imperfections. The investment decision taken at the beginning of period t is assumed irrevocable, capturing thus the idea that physical assets are not as liquid as financial assets (like deposits).

2. Once investment is chosen, a macroeconomic shock occurs on the technological parameter a_t. This shock alters the productivity of the projects began in period $t-1$ (y_t), but it does not change the size of these projects (b_t). Among the entrepreneurs whose project began in period $t-1$, some fail and cannot pay back their loan, while the others succeed and make strictly positive profits. The latter reimburse their bank, pay the wages, the dividends and give the used machines ($(1-\delta)k_t$) back to households. Then, the banks pay back deposits plus the interest rates to households.

3. Given the technological shock, households supply labor (l_{t+1}) to the entrepreneurs who are entering their production process, consume c_t final goods, make new deposits (d_{t+1}) and invest in new capital goods according to what they previously decided at the beginning of the period. Every entrepreneur is endowed with the same quantity of capital goods.

4. Given the technological shock and the endowment of capital goods, entrepreneurs hire labor, that determines the maximal quantity of intermediate goods they will be able to handle in period $t+1$ (b_{t+1}). As a result, they have to borrow θb_{t+1} from banks and (if possible) from suppliers.

5. An idiosyncratic shock occurs, which makes entrepreneurs of type L or H. Then, the credit market opens and different financial contracts are

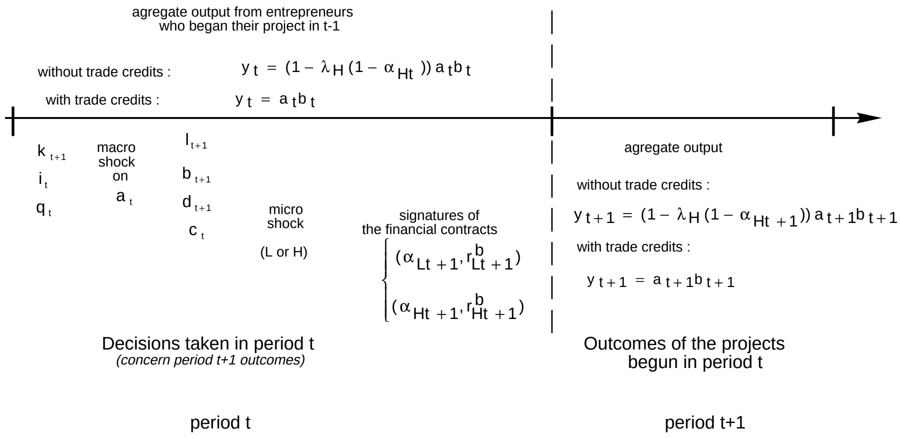

Figure 4: The sequence of decisions in time period t

signed (see propositions 1 and 2). At the aggregate level, final good producers borrow the quantity $(\lambda_L + \lambda_H \alpha_{Ht+1})\theta b_{t+1}$ of final goods from banks. In the economy with trade credits, they further borrow the quantity $\lambda_H(1 - \alpha_{Ht+1})\theta b_{t+1}$ of final goods from their suppliers since every entrepreneur invests. In this case, suppliers borrow the amount $\lambda_H(1 - \alpha_{Ht+1})(1 + \tau)\theta b_{t+1}$ from banks in order to cope with the postponement of payments and the management-induced-costs.

6. The final good and intermediate good markets, the labor market and the loanable fund market close and period t ends up.

As seen in section 2, entrepreneurs may be interested in pledging their illiquid assets as collateral. It is assumed that the collateralizable assets correspond to the most recent capital goods, *i.e.* the last investment i_t. Hence, the collateral-to-project-size ratio is equal to

$$C_{t+1} = \frac{(1 - \delta) q_{t+1} i_t}{\theta b_{t+1}} \tag{8}$$

This assumption captures the idea that lenders generally value used machines at a lower price than borrowers do, simply because they are likely to incur valuation costs or transaction costs when liquidating. A simplifying assumption is made here: there is no liquidation costs on last investment and infinite liquidation costs on older capital goods. As a result, borrowers pledge only their new capital goods as collateral (see figure 5).[18]

[18]In case of failure, entrepreneurs keep $q_{t+1}(1 - \delta)^2 k_t$ by them. Note that I could have

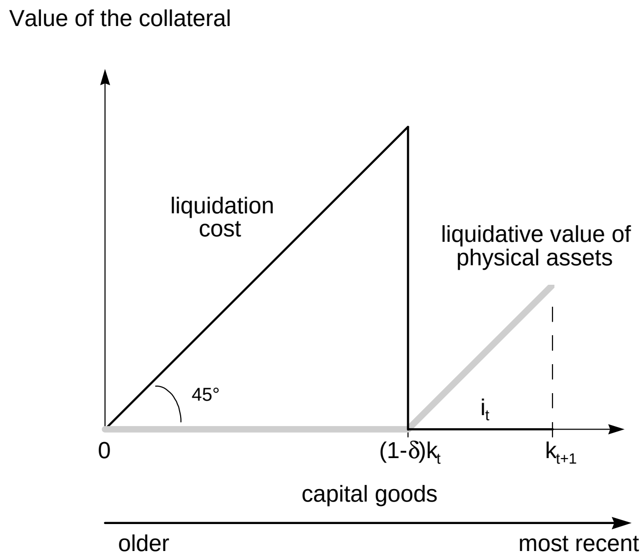

Figure 5: The liquidative value of assets

3.1.2 General Equilibrium

I assume that the representative household maximizes his intertemporal utility function:

$$\max_{\{i_h\}_{h=t,\dots,+\infty}} \mathbb{E}_{t-1} \max_{\{l_{h+1},d_{h+1},c_h\}_{h=t,\dots,+\infty}} \mathbb{E}_t \sum_{h=t}^{h=\infty} \beta^t \left\{\ln(c_h) + \nu(1-l_h)\right\}$$

where $\mathbb{E}_t \equiv \mathbb{E}\left(. \mid a_t, k_{t+1}\right)$ denotes the expectation operator conditional on the realization of the macroeconomic shock and the level of capital stock decided at the beginning of period t and $\beta \in (0,1)$ is the personal discount factor, under her intertemporal budget constraint:

$$c_t + i_t + d_{t+1} \leqslant (1+r_t)d_t + \widetilde{\Pi}_{jt}^{final}$$

with $\Pi_{jt}^{final} \equiv \widetilde{\Pi}_{jt}^{final}$ and under equation (7). General equilibria in the economy without trade payables and in the economy with trade payables are mainly described by the following equations.

taken more than one lag on past investment. Given the standard calibration of dynamic general equilibrium models, these assumptions will ensure that full collateralization is not possible. Capital goods are no longer homogeneous to the extent that old capital goods cannot be collateralized while new capital goods can. As a result, the price of old capital goods will be lower than the price of the new capital goods (which is equal to 1), unless one assumes that private agents take the equilibrium interest as given (see below).

$(i)\ c_t = \beta \mathbb{E}_t(1 + r_{t+1})/c_{t+1}$

$(ii)\ k_{t+1} = (1 - \delta)k_t + i_t$

$(iii)\ b_t = k_t^{\eta} l_t^{1-\eta}$

$(iv)\ y_t = c_t + i_t + \mathbb{E}_t\left(d_{t+1}\right)$

The model in absence of trade credits

$$(v)\ \mathbb{E}_{t-2}\Big([1 - \lambda_H(1 - \alpha^*_{Ht})]\,[a_t - (1 + r_t)\theta]\,\eta \tfrac{b_t}{k_t} + (1 - \delta)q_t - (1 + r_t)q_{t-1} - \psi(\alpha^*_{Ht})\tfrac{\eta(1-\delta)q_t i_{t-1}}{k_t}\Big) = 0$$

$$(vi)\ \mathbb{E}_{t-1}\Big([1 - \lambda_H(1 - \alpha^*_{Ht})]\,[a_t - (1 + r_t)\theta]\,(1 - \eta)\tfrac{b_t}{l_t} - \nu c_t - \psi(\alpha^*_{Ht})\tfrac{(1-\eta)(1-\delta)q_t i_{t-1}}{l_t}\Big) = 0$$

$$(vii)\ \alpha^*_{Ht} = \mathbb{E}_{t-1}\left(\frac{a_t-(1+r_t)\theta}{a_t-(1+r_t)\theta+\frac{\pi_H-\pi_L}{\pi_H}\theta\left[1+r_t-\frac{(1-\delta)q_t i_{t-1}}{\theta b_t}\right]}\right)$$

$(viii)\ \ d_t = [1 - \lambda_H(1 - \alpha^*_{Ht})]\,\theta b_t$

$(ix)\ y_t = [1 - \lambda_H(1 - \alpha^*_{Ht})]\,a_t b_t$

$(x)\ q_t = 1 - \mathbb{E}_{t-1}\left(\psi(\alpha^*_{Ht+1})\frac{(1-\delta)q_{t+1}}{1+r_{t+1}}\right)$

where $\psi(\alpha^*_{Ht}) = \frac{\lambda_H(\pi_H-\pi_L)\alpha^{*2}_{Ht}}{\pi_H}$

The model in presence of trade credits

$$(v)\ \mathbb{E}_{t-2}\left(\left[a_t - (1 + r_t)(1 + \overline{\psi})\theta\right]\eta\frac{b_t}{k_t} + (1 - \delta)q_t - (1 + r_t)q_{t-1}\right) = 0$$

$$(vi)\ \mathbb{E}_{t-1}\left(\left[a_t - (1 + r_t)(1 + \overline{\psi})\theta\right](1 - \eta)\frac{b_t}{l_t} - \nu c_t\right) = 0$$

$$(vii)\ \alpha^{**}_{Ht} = \frac{\tau\pi_H+(\pi_H-\pi_L)\frac{(1-\delta)q_t i_{t-1}}{(1+r_t)\theta b_t}}{\tau\pi_H+\pi_H-\pi_L}$$

$(viii)\ \ d_t = [1 + \tau\lambda_H(1 - \alpha^{**}_{Ht})]\,\theta b_t$

$(ix)\ y_t = a_t b_t$

$(x)\ q_t = 1 - \mathbb{E}_{t-1}\left(\overline{\psi}\frac{(1-\delta)q_{t+1}}{1+r_{t+1}}\right)$

where $\overline{\psi} = \frac{\tau\lambda_H(\pi_H-\pi_L)}{\tau\pi_H+\pi_H-\pi_L}$

The representative household accumulates two assets: capital goods (physical/non liquid assets) and deposits (financial/liquid assets). The total amount of assets is given by Euler's equation (i). The optimal structure of the representative household's portfolio is given by equation (v), which means that the representative household purchases capital goods until the marginal rate of profitability of the latter equals the rate of profitability of deposits (r_t). In the equilibrium, the representative household is indifferent between consume one more final good and make one new deposit. Hence, the amount of deposits is determined residually through the loanable funds market equilibrium ($viii$). Equation (iii) determines firms' optimal demand for labor. The financing conditions of the economy are described by equation (vii) and depend on the last investment. Equation (ix) defines the aggregate level of output and equation (x) corresponds to the price of capital on the secondhand market. This price is strictly inferior to 1 because old capital goods cannot be pledge as collateral, unlikely to new ones. In particular, for the same price, households always prefer to accumulate new capital goods rather than olds. It turns out that the secondhand market of capital goods clears if and only if old capital goods are priced beneath recent capital goods (whose price is equal to 1): $q_t < 1$. Moreover, it is worth to notice that q_t depends negatively on the degree of imperfection on the credit market. A rise in the degree of credit market imperfection (*e.g.* in parameter τ) tends to increase the demand for new capital goods relatively to the demand for used capital goods.

- In the model without trade credits, the financial role of investments, mainly described by equations (v)-(vii), is the core of a financial accelerator mechanism in the model. A rise in investment in period t stimulates bank credit supply in t (α^*_{Ht+1} goes up) and thereby raises the marginal productivities of both labor and capital.
- In the model with trade credits, the financial role of investment is much weaker to the extend that a rise in investment in period t just allows entrepreneurs to substitute cheap bank loans to expensive trade credits (compare equations (v) and (vi) and (ix) in both models).

3.1.3 Model Dynamics

In this paragraph, I analyze the effects of an unanticipated autoregressive aggregate technological shock on a_t, that raises the marginal productivities of both factors and intermediate goods as well as the expected returns on the projects beginning in period t.[19] The parameters of the model are given in the table below.

[19] The technological parameter increases by 1% above its steady state value. Its logarithm follows a $AR(1)$ process, whose parameter is set equal to 0.95.

Parameters[20]

δ	β	ν	a	θ	η	λ_H	π_L	π_H	τ
0.025	0.98	4	2	1	0.35	0.95	0.5	0.95	0.15

In the economy, 95% of final good producers are of type H and have a probability equal to 0.95 to achieve their production process (against 0.5 for types L). I further assume that the management costs induced by the postponement of payments are equal to 15% of the amount of trade credits. These parameters entail the following values for the steady state:

The steady state

Information	r	y	c	i	α_H^{**}	α_H^{*}	C	q
symmetric	0.02	1.16	0.47	0.11	–	–	–	1
asymmetric I (without trade credits)	0.02	0.75	0.29	0.08	–	0.69	0.12	0.82
asymmetric II (with trade credits)	0.02	1.14	0.41	0.10	0.36	–	0.16	0.90

The information is symmetric when either $\pi_L = \pi_H$ or $\tau = 0$. In the steady state of the economy without trade credits, only 69% of type H entrepreneurs get funds and undertake their project. This implies that 29% of the factors of production are not used at the aggregate level.[21] In the steady state of the economy with trade credits, type H entrepreneurs choose a mixed financing with 36% of bank loans and 64% of trade credits. The implied aggregate deadweight loss represents 4.6% of output.[22] As a result, the productivity loss due to the informational asymmetry on the credit market is much lower in presence of trade credits than in absence of trade credits.

The responses of the linearized economy to an unanticipated autoregressive technological shock on a_t are drawn in Figure F.

- When the information is symmetric (SI), the response of the economy is very closed to the response of the King, Plosser & Rebelo [1988]'s canonical economy. The only difference, which appears in period t, is due to the production lead time: factors and output adjust from period $t+1$ and the 1% rise in output in period t is purely exogenous.

[20] One can verify that $\beta a > (1+\tau)\theta$ and $\beta C < 1$, so that constraints on endogenous variables should remain satisfied for small deviations in the neighborhood of the steady state.

[21] $\lambda_H(1-\alpha_H^{**}) = 0.29$.

[22] $\tau\lambda_H(1-\alpha_H)\theta/a = 0.046$.

graphe

Figure 6:

- When the information is asymmetric (AI) and trade credits are not available, the response of the economy sharply differs from the SI model. To benefit from the rise in factor productivity as much as possible, the representative household is willing to purchase new capital goods in period $t+1$. The rise in period $t+1$ investment is much larger than in the SI economy because new capital goods also enable firms to raise their probability to get funds in period $t+1$ (cf. points A and B). Corollarily, this would reduce the under-utilization of factors in period $t+2$. Then, the demand for final goods goes up in period $t+1$, as well as the demand for intermediate goods in period t. In period t, final good producers borrow from banks in order to purchase more intermediate goods. The excess demand on the loanable funds market pushes the riskless interest rate up (point C), thus incitating the representative household to reduce his period t consumption (point D).

  As period $t+2$ aggregate output is concerned, two opposite effects are at stake. On the one hand, the rise in period $t+1$ investment diminishes the intensity of credit rationing in period $t+1$. Hence, more projects are funded in period $t+1$ and more firms produce in period $t+2$ (α^*_{Ht+2} goes up, point E). On the other hand, the autoregressivity of the technological shock lowers the productivity of labor and tends to reduce the *per capita* output. At the aggregate level, the former effect outweighs the latter: output goes on raising from period $t+1$ to period $t+2$ (point F) despite the decrease in labor (point G). As a result, the economy exhibits a hump-shaped response for output, which is closely linked to the financial role of investment. This is a version of the financial accelerator mechanism described by the proponents of the large credit channel (*e.g.* Bernanke & Gertler [1989]).

- When the information is not symmetric but trade credits are available, the response of the economy gets back closer to the perfect information economy. Households still raise their period $t+1$ investment in order to improve firms' financing conditions in period $t+1$ by substituting (cheap) bank loans to (expensive) trade credits in period $t+1$ (α^{**}_{Ht+2} goes up). As a result, the financing conditions have little effect on the real activity because the inefficiencies due to credit market imperfections are not very strong. The financial accelerator mechanism is still perceptible, but it is much lower than in the economy without trade credits.

4 Conclusion

In this paper, I argue that credit rationing is responsible for the widespread use of trade credits in the economy despite the fact that it is an expensive means of short-term financing. A theoretical gap has been bridged between the well documented literature on optimal financial contracting and the recent literature on the financial accelerator.

I have also developed a computable general equilibrium analysis of the interactions between the financial and the real sectors, which is consistent with what has been observed in US since the late eighties. Our main result is that, by substituting for bank loans, trade payables tend to act as a buffer within the business cycle and to limit the business cycle fluctuations due to credit market imperfections. Consequently, the importance of the financial accelerator mechanism is likely to depend on the degree of substitution between bank credits and trade credits.

References

BERNANKE, B. & M. GERTLER [1989]: "Agency costs, net worth and business fluctuations", *American Economic Review, p.* 14 − 31.

BERNANKE, B., GERTLER, M. & S. GILCHRIST [1999]: "The financial accelerator in a quantitative business cycle framework", in *Handbook of Macroeconomics, chapter 21,* Edited by J.B. Taylor and M. Woodford.

BESANKO, D. & A. THAKOR [1987]: "Collateral and rationing: sorting equilibria in monopolistic and competitive credit market", *International Economic Review, p.* 671 − 689.

BESTER, H. [1985]: "Screening *vs* Rationing in Credit Markets with Imperfect Information", *American Economic Review, p.* 850 − 855.

BHATTACHARYA, S. [1980]: "Nondissipative signaling structures and dividend policy", *Quarterly Journal of Economics, p.* 1 − 24.

BIAIS, B. & C. GOLLIER [1997]: "Trade credit and credit rationing", *The Review of Financial Studies*, n°4.

BOND, S. & C. MEGHIR [1994]: "Dynamic investment models and the firm's financial policy", *The Review of Financial Studies*, n°61.

BREALEY, R. & S. MYERS [1984]: "Principles of corporate finance", *McGraw-Hill, 2nd ed.*

CARLSTROM, C. & T. FUERST [1997]: "Agency costs, net worth, and business fluctuations: a computable general equilibrium analysis", *American Economic Review, p.* 893 − 910.

CARLSTROM, C. & T. FUERST [1998]: "Agency costs and business cycles", *Economic Theory*, n°12, *p.* 583 − 597.

CARPENTER, R., FAZZARI, S. & B. PETERSEN [1994]: "Inventory investment, internal-finance fluctuations, and the business cycle", *Brookings Papers on Economic Activity*, n°2.

CHO. I-K. & D. KREPS [1987]: "Signaling games and stable equilibria", *Quarterly Journal of Economics, p.* 179 − 221.

DIAMOND, D. [1991]: "Debt maturity structure and liquidity risk", *Quarterly Journal of Economics*, n°56.

EMERY,G. [1987]: "An optimal financial response to variable demand", *Journal of Financial and Quantitative Analysis*, n°22.

FAZZARI, S., HUBBARD, G. & B. PETERSEN [1995]: "Financing constraints and corporate investment: response to Kaplan and Zingales", *NBER Working Paper,* n°5462.

FERRIS, J. [1981]: "A transaction theory of trade credit use", *Quarterly Journal of Economics*, n°94.

FUERST, T. [1995]: "Monetary and financial interactions in the business cycle", *Journal of Money, Credit and Banking*, n°4, *p.* 1321 – 1337.

GALE, D. & M. HELLWIG [1985]: "Incentive compatible debt contracts: The one-period problem", *Review of Economic Studies*, *p.* 647 – 663.

GERTLER, M. & S. GILCHRIST [1994]: "Monetary policy, business cycle and the behavior of small manufacturing firms", *Quarterly Journal of Economics*, *p.* 309 – 340.

KAPLAN, S. & L. ZINGALES [1995]: "Do financing constraints explain why investment is correlated with cash flow?", *NBER Working Paper* n°5267.

KAPLAN, S. & L. ZINGALES [1997]: "Do investment-cash flows sensitivities provide useful measures of financing constraints?", *Quarterly Journal of Economics, p.* 169 – 215.

KASHAYAP, A., LAMONT, O. & J. STEIN [1994]: "Credit conditions and the cyclical behavior of inventories", *Quarterly Journal of Economics, p.* 565 – 592.

KEETON, W. [1979]: "Equilibrium credit rationing", *New-York, Garland Press eds.*

KING, R., PLOSSER, C. & S. REBELO [1988]: "Production, growth and business cycles I.", *Journal of Monetary Economics, p.* 196 – 232.

KIYOTAKI, N. & J. MOORE [1997]: "Credit chains", *Mimeograph.*

MCMILLAN, J. & C. WOODRUFF [1999]: "Interfirm relationships and informal credit in Vietnam", *Quarterly Journal of Economics, p.* 1285 – 1320.

MIAN, S. & C. SMITH [1992]: "Extending trade credit and financing receivables", *Journal of Applied Corporate Finance*, *p.* 75 – 84.

MIAN, S. & C. SMITH [1992]: "Account receivables management policy: theory and evidence", *Journal of Finance*, *p.* 169 – 200.

NADIRI, M. [1969]: "The determinants of trade credit in the U.S. total manufacturing sector", *Econometrica, vol.* 37,n°3.

PETERSEN, M. & R. RAJAN [1994]: "The benefits of lending relationships: Evidence from small business data.", *The Journal of Finance*, n°1.

PETERSEN, M. & R. RAJAN [1997]: "Trade credit: theories and evidence", *The Review of Financial Studies*, n°3.

RILEY,J-G. [1979]: "Informational equilibria", *Econometrica, vol.* 47.

ROTHSCHILD, M. & J. STIGLITZ [1976]: "Equilibrium in competitive insurance markets: an essay in the economics of imperfect information", *Quarterly Journal of Economics, vol.* 90.

SCHWARTZ, R. [1974]: "An economic model of trade credit", *Journal of Financial and Quantitative Analysis*, n°9.

SCHWARTZ, R & D. WHITCOMB [1979]: "The trade credit decision", *Handbook of Financial Economics*, J. Bicksler eds, North Holland.

SMITH, J. [1987]: "Trade credit and informational asymmetry", *The Journal of Finance*, *p.* 863 − 872.

STIGLITZ, J. & A. WEISS [1981]: "Credit rationing in markets with imperfect information", *The American Economic Review*, *p.* 393 − 410.

TIROLE, J. [1997]: "Lecture notes on corporate finance", *mimeograph.*

TOWNSEND, R. [1979]: "Optimal contracts and competitive markets with costly state verification", *Journal of Economic Theory, p.* 265 − 293.

WHITED, T. [1992]: "Debt, liquidity constraints, and corporate investment: evidence from panel data", *Journal of Finance, n*°4.

WILSON, C. [1977]: "A model of insurance market with incomplete information", *Journal of Economic Theory, vol.* 16.

Appendices

Appendix A

The model with τ endogenous

The aim of this appendix is to show how the transaction cost on the postponement of payments may be endogeneized without altering the results. Incidentally, I exhibit a "failure propagation mechanism", and I show how intermediate good suppliers and purchasers' financial structures may overlap. In this appendix, I will focus on periods t and $t+1$.

The basic idea behind this is that account receivables owned by intermediate good suppliers are likely to be imperfectly diversified in practice, so that some suppliers would be less repaid than expected — and would go bankrupt — while some others would be more. The key feature, then, is that the representative bank's portfolio does remain perfectly diversified, whereas the representative intermediate good supplier's one does not.

In the basic model, I implicitly supposed that (successful) final good producers are uniformly distributed among intermediate good suppliers at the end of period t. This means that each supplier's account receivables are effectively repaid by a fraction π_j of her type j clients and that each supplier's portfolio of account receivables is perfectly diversified. In this case, suppliers will finance trade credits by borrowing from the banks at the riskless interest rate. I now relax this assumption.

Assume that suppliers experience a lottery just before the date of repayment of account receivables, which split them into 2 groups: The group of the suppliers of type ℓ and the group of the suppliers of type h in proportion μ and $1-\mu$ respectively. These suppliers are identical in all respects save the number of account receivables effectively repaid: Type ℓ (respectively h) suppliers' trade credits are paid back by a fraction $\frac{\pi_j}{2\mu}$ (respectively $\frac{\pi_j}{2(1-\mu)}$) of type j clients, with $\mu \in [1/2, 1]$. When parameter μ is high, I will say that the "diversification" of account receivables is bad.[23]

In this context, final good producers' failures are expected to — and effectively do — lead a proportion μ of the intermediate good producers to go

[23] The simplicity of this specification is aimed at being tractable; Obviously, other specifications could be chosen. The only requirement is that it must be consistent with the basic model framework since the unconditionnal probabilities of being repaid by a type j client must still amount to μ^{π}

bankrupt. This is what I call “the failure propagation mechanism”. As a result, suppliers will finance trade credits by borrowing from the banks at a rate $\overline{r}_{t+1}$ higher than the riskless interest rate r_{t+1}.

Suppliers' types are unknown in period t, so that suppliers are identical *ex ante*. Only suppliers costlessly observe their own type at the end of period $t+1$. However, banks have got a costly monitoring technology at their disposal which enables them to observe the type of every supplier *ex post*; For one dollar lent, the banks' monitoring cost amounts to m dollars at the end of period $t+1$. A usual moral hazard problem with *costly state verification* arises (see Townsend [1979]).

As demonstrated by Gale & Hellwig [1985], the representative bank optimally offers a standard debt contract: In case of default every borrower is monitored, gives up her account receivables to the bank, and earns nothing; Otherwise, she has to repay her debt at the debtor interest rate $\overline{r}_{t+1}$.

The representative bank's expected profit on intermediate good suppliers, $\widetilde{\Pi}^{bank}_{inter,t+1}$, is written:[24]

$$\begin{aligned}\widetilde{\Pi}^{bank}_{inter,t+1} &= \underbrace{(1-\mu)\textstyle\sum_{j=L,H}(1-\alpha_{jt+1})\lambda_j(\overline{r}_{t+1}-r_{t+1})(1+\tau)\theta\, b_{t+1}}_{\text{(ex-post profits on types } h)} \\ &+\underbrace{\mu\textstyle\sum_{j=L,H}(1-\alpha_{jt+1})\lambda_j\left[\frac{\pi_j}{2\mu}(1+r^s_{jt+1})-(1+r_{t+1}+m)(1+\tau)\right]\theta b_{t+1}}_{\text{(ex-post losses on types } \ell)}\end{aligned}$$

The representative intermediate good supplier's expected profit is:

$$\begin{aligned}\widetilde{\Pi}^{inter}_{t+1} = (1-\mu)\textstyle\sum_{j=L,H}(1-\alpha_{jt+1})\lambda_j\Big[&\frac{\pi_j}{2(1-\mu)}(1+r^s_{jt+1}) \\ &-(1+\overline{r}_{t+1})(1+\tau)\Big]\theta b_{t+1}\end{aligned}$$

Competition on the intermediate good market and the credit market implies that these expected profits are equal to zero. Hence, one gets $1+r^{s*}_{jt+1} = \frac{(1+r_{t+1}+m\mu)(1+\tau)}{\pi_j}$ and $1+\overline{r}^*_{t+1} = \frac{1+r_{t+1}+m\mu}{2(1-\mu)}$ $\forall j = L, H$.

The bank debtor interest rate rises as diversification of account receivables lessens or as monitoring costs increase. Suppliers incur monitoring costs when borrowing, which are finally passed on the interest rate on trade credits. It is easy to show that a credit market *separating* PBNE always exists, which is unique and is the same as the equilibrium described in proposition 1, once τ replaced by $\widetilde{\tau}_{t+1} \equiv \tau + \frac{(1+\tau)m\mu}{1+r_{t+1}}$.

[24] In period t, the representative supplier's sells $((1-\alpha_{Lt+1})\lambda_L + (1-\alpha_{Ht+1})\lambda_H)\, b_{t+1}$ intermediate goods on credit. She pays the corresponding inputs thanks to a bank loan which amounts to $((1-\alpha_{Lt+1})\lambda_L + (1-\alpha_{Ht+1})\lambda_H)\,(1+\tau)\theta b_{t+1}$. Her account receivables on her type L (respectively H) clients amounts to $(1-\alpha_{Lt+1})\theta b_{t+1}$ (respectively $(1-\alpha_{Ht+1})\theta b_{t+1}$).

Here, the financial structure of the final good producers depends on the monitoring costs incurred by the suppliers. It is of interest to notice that the imperfect diversification of account receivables might justify why the commercial interest rate is high, insofar as even if the exogenous cost on the postponement of payments is null, one has: $1 + r^{s*}_{jt+1} = \frac{(1+r_{t+1}+m\mu)}{\pi_j} > 1 + r^{b*}_{jt+1}$.

Appendix B

Borrowers prefer to be red-lined rather than rationed

The aim of this appendix is to show that firms prefer to be partially financed by banks with probability 1, rather than entirely rationed at random. I compare the equilibrium stated in proposition 2, with the equilibrium that would arise whether partial financing were not possible, *i.e.* if banks randomized there credit policy (hereafter RCPWTP, for "randomized credit policy with trade payables"). In the latter case, the expected profit for the representative bank, with a —detected— type j borrower, is equal to (compare with (6))

$$\widetilde{\Pi}^{bank}_{jt} = \alpha_{jt}\left[\pi_j(1 + r^b_{jt}) + (1 - \pi_j)\gamma_{jt}C_t - (1 + r_t)\right]\theta b_t$$

After solving program (3) for the least-cost revealing/signaling contract $(\alpha^{***}_{jt}, \gamma^{***}_{jt}, r^{b***}_{jt})$, $j \in \{L, H\}$, one gets the following RCPWTP :

$$(RCPWTP)\begin{cases} \alpha^{***}_{Lt} = 1 \text{ and } \alpha^{***}_{Ht} = \frac{\tau}{\tau+\frac{\pi_H-\pi_L}{\pi_H}\left[1-\frac{C_t}{(1+r_t)}\right]} \\ \\ 1 + r^{b***}_{Lt} = \frac{1+r_t}{\pi_L} \text{ and } 1 + r^{b***}_{Ht} = \frac{1+r_t}{\pi_H} - \frac{(1-\pi_H)C_t}{\pi_H} \\ \\ \gamma^{****}_{Lt} = 0 \text{ and } \gamma^{****}_{Ht} = 1 \end{cases}$$

By comparing proposition 2 with $(RCPWTP)$, it is easy to verify that firms make higher expected profits when banks finance all firms partially $(\alpha^{***}_{Ht} < \alpha^{**}_{Ht})$. Hence, random credit rationing is not the best strategy for banks. □