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Credit Market Imperfections and the Heterogeneous Response of Firms to Monetary Shocks

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Abstract

This paper assesses the *bank-lending channel* interpretation of evidence on the heterogeneous response of firms to monetary shocks. To do so I develop a quantitative general equilibrium model of the bank-lending channel with imperfect credit markets. The calibrated model's steady state supports a common identification strategy adopted in the literature: small firms are credit constrained and large firms are not. For some parameter values the model reproduces the cyclical observations viewed as supporting the lending view of the monetary transmission mechanism and for others it does not. The parameter values consistent with the lending view appear to be implausible.

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1. Introduction

Borrowing and sales by small firms falls significantly relative to large firms following a monetary contraction. Moreover, the spread between the interest rate on loans paid by "bank-dependent" firms compared to firms that use public debt markets for external finance rises during a monetary contraction.[1] This evidence has been interpreted as an implication of quantitatively important frictions in credit markets. Generally, there are two views about how imperfect credit markets influence the transmission of monetary shocks. One emphasizes the role of net-worth in the determination of the premium paid by borrowers for external finance. The other focuses on the ability of monetary policy to influence the supply of loanable funds at banks.[2] This latter view is often referred to as the bank-lending channel of the monetary transmission mechanism or, simply, the *lending view*. The objective of this paper is to assess the interpretation of the empirical evidence that says it reflects the lending view.

The foundation of the analysis is a general equilibrium model which embodies the friction conventionally employed to characterize the macroeconomic implications of imperfect credit markets. The model is designed to capture important features of the monetary transmission mechanism that have been attributed to the lending view and it has predictions for the responses of small and large firms and the spread between interest rates faced by bank-dependent versus non-bank-dependent firms to money supply disturbances. I use this model to evaluate the lending view in two ways. The first relies on the entire structure of the model. I calibrate parameters using long run features of the data and examine whether the model based on these parameters can replicate the key observations. I find that the model fails along this dimension – only with seemingly implausible parameters does it replicate the observations of interest. This is despite the fact that the steady state of the calibrated model does a good job at accounting for long run features of the data associated with the lending view.

These results could be sensitive to the details of the general equilibrium specification and in particular the assumptions underlying the monetary transmission mechanism. The second way I assess the lending view is an attempt to address this concern. The strategy here is to assume particular variables in the general equilibrium model are exogenous and study the resulting partial equilibrium model of the credit market. Parameter values are taken from those implied by the general equilibrium calibration procedure. However, instead of using the general equilibrium model's implications for how the exogenous variables respond to monetary shocks, I estimate their responses directly from US data. These estimates are then taken as given in the partial equilibrium model and the remaining parameter values are chosen to replicate the empirical observations. I find again that only for seemingly implausible parameters can the key observations be replicated. Thus the finding reached on the basis of the general equilibrium model does not depend on the assumptions underlying its treatment of the monetary transmission mechanism.

The extent to which these results cast doubt on the lending view interpretation of the empirical evidence depends on the model's success at capturing the main tenets of this view. As it is usually described, the lending view can be decomposed into two distinct elements.[3] First, the monetary authority must be able to influence the real supply of loanable funds. This idea is captured in the model using the limited participation assumption associated with Lucas (1990) and Fuerst (1992).[4] Second, frictions must exist that force some firms to depend on banks, rather than public debt markets, for external finance. As is conventional, I model this using the costly state verification framework introduced by Townsend (1979) and Gale and Hellwig (1985).[5] While the model captures these two elements of the lending view, there are several differences between it and the formulations implicit in much of the lending view literature. These differences and their implications for inference drawn from the findings presented here are discussed below. Also, it is important to recognize that, in order to focus on the lending view, net-worth is exogenous in the model. Therefore the findings do not have any implications for interpretations of the empirical evidence which rest on an important role for net-worth.

In the next section I develop the general equilibrium model. In section three I describe the calibration procedure and report features of the steady state. In section four I describe the findings based on the full structure of the model and in section five I report the findings based on the partial equilibrium methodology. The sixth and last section is devoted to discussing the extent to which the findings should be interpreted as evidence against the lending view interpretation of the empirical evidence.

2. A General Equilibrium Model of the Bank-Lending Channel

The model consists of households, goods producers and financial intermediaries (banks). Households consume a bundle of differentiated goods produced by Dixit and Stiglitz (1977) monopolistic competitive firms. These firms hire factors of production from households with predetermined internal funds and funds borrowed in the loan market from banks. Some fraction of goods producers have private information on their revenues which only banks can verify at a cost. Loan contracts are determined accordingly on a period-by-period basis. The source of funds for banks is household deposits and stochastic monetary injections which represent the model's only source of aggregate uncertainty.

In modeling the loan market I follow Fuerst (1994) by embedding in general equilibrium a static model of costly state verification due to Townsend (1978) and Gale and Hellwig (1985). I use this framework for several reasons. First, it has received considerable attention in the literature on the macroeconomic implications of credit market imperfections. As such it represents a prominent benchmark. Second, it has the desirable property that it delivers a standard debt contract as an equilibrium phenomenon. Third, from a quantitative perspective, the static loan environment is a natural place to start since it can be viewed as maximizing the distortion due to asymmetric information.[6] Finally, it is a parsimonious modeling environment.

In the remainder of this section I outline the decision problems of the agents in the model, describe the problem which determines the optimal loan contract between private information firms and banks, and then I describe a recursive equilibrium.

2.1. Households

The economy is populated by a continuum of households with unit measure. These households value alternative streams of a consumption good index and work effort according to

$$E_{x_t} \sum_{j=t}^{\infty} \beta^{j-t} \left[\ln c_j + \nu \ln(1 - h_j) \right], \quad 0 < \beta < 1, \nu > 0.$$

Here E_{x_t} is the conditional expectation operator with respect to information x_t, c_t is the amount of the consumption good index and h_t is work effort, both in period t. Dropping time subscripts, the consumption good index for household $j \in [0, 1]$ in an arbitrary period is given by

$$c_j = \left[\int_0^1 \phi_{ij} c_{ij}^{1/\psi} di \right]^{\psi}. \tag{1}$$

Here the ϕ_{ij}'s are preference shocks which are idiosyncratic across households and for each household idiosyncratic across individual goods $i \in [0, 1]$. Also c_{ij} denotes the consumption of good i by the j'th household. The preference shocks are realized at the beginning of every period and for household j are distributed according to Φ_j, an element of the family of distribution functions $\mathcal{F}$. I restrict $\mathcal{F}$ so that in equilibrium households are identical in terms of the consumption good index even though they differ in the allocation of consumption across goods. The only other source of uncertainty for households is the growth rate of the aggregate stock of money, x'.

The representative household divides beginning-of-period money holdings m between a constant transfer e to goods producers, deposits n with intermediaries and an amount to satisfy a cash-in-advance constraint on consumption goods.[7] The transfer to goods producers entitles the household to a share of their profits. Deposits with intermediaries must be made before observing x' and consequently the gross interest rate on deposits, R. All other choices are made after observing monetary growth.

Income for the household is derived from four sources. First, there is wage income, wh, where w denotes the nominal wage. Only wage income is available to pay for consumption goods in the period it is earned. All other income is received at the end of the period. Second, the household receives income rk from renting its constant endowment of capital k, where r is the rental rate on capital.[8] Third, the household is paid interest on its deposits $(R-1)n$. Finally, by virtue of its ownership of goods producers and intermediaries, the household receives nominal dividends which total π. The household does not face any idiosyncratic dividend risk. This amounts to assuming perfect insurance in the equity market.

The decision problem of the household can be summarized by the following dynamic program

$$\begin{aligned} V(m;x) &= \max_n \; E\left\{\max_{c_j,h} \; \{\ln(c_j)+\nu\ln(1-h)+\beta V(m';x')\} \mid x\right\} \\ &\quad \text{s.t.} \;\; \textstyle\int_0^1 p_i c_{ij} di \leq m-n-e+wh, \\ &\quad\quad\;\; (1+x')m' = m-n-e+wh+rk+Rn+\pi-\textstyle\int_0^1 p_i c_{ij} di, \\ &\quad\quad\;\; \text{and (1).} \end{aligned}$$

Here V is the household's value function and "$'$" denotes next period's value of a variable. Notice that I have retained the j subscript to emphasize the idiosyncratic nature of the consumption allocation. Finally, p_i denotes the nominal price of good i. The distribution of relative prices depends on current monetary growth, the underlying structure of preference shocks, and idiosyncratic productivity shocks to be introduced below. In solving its dynamic program the household understands the law of motion for growth in the aggregate stock of money and takes prices and dividends as given functions of the state.

This problem incorporates the limited participation assumption. Limited participation is meant to capture the idea that households are inflexible in their financial planning relative to firms and intermediaries. In the current context this amounts to assuming that n is chosen before observing the monetary injection and that e is a constant. Firms and intermediaries are more flexible since all their decisions are made after the current realization of the monetary injection. My assumption that e is a constant is made for simplicity, but it nevertheless captures a realistic aspect of the determination of internal funds for firms. Namely, that decisions affecting the level of internal funds, such as choices regarding dividends, are inflexible relative to ongoing interaction with intermediaries.

2.2. Goods Producers

The continuum of distinct nonstorable goods $i \in [0,1]$ are produced by monopolistic competitors. Goods indexed by $i \in A \equiv [0,\lambda]$ are produced by type a firms and goods indexed by $i \in B \equiv (\lambda, 1]$ are produced by type b firms. Producers are buffeted by idiosyncratic productivity and demand disturbances. Only one feature of the environment distinguishes the two types of firm: type b firms have private information on their demand and productivity shocks while type a firms do not.

Each period for a producer involves four stages. First, after the monetary injection, loan contracts with banks are determined and factors of production are hired. After this, production takes place with the realization of the productivity disturbance determining final product. Third, the demand shock is realized, prices are set and sales are made. In the last stage, accounts are settled with the banks and any surplus from operations are returned to households. I now describe the specifics of the environment.

Production is determined according to

$$\omega_i \left[F(k_i, h_i) - \xi_i \right], \tag{2}$$

where $F(k,h) \equiv k^\alpha h^{1-\alpha}$, $0 < \alpha < 1$, $\xi_i = \xi^a$ for $i \in A$ and $\xi_i = \xi^b$ for $i \in B$, and ω_i is the idiosyncratic productivity shock. Also, k_i and h_i are capital and labor inputs, respectively. Given internal funds e_i and external funds l_i, cost minimization for good producer i implies

$$k_i = \frac{\alpha}{r}(l_i + ve_i) \quad \text{and} \quad h_i = \frac{1-\alpha}{w}(l_i + ve_i). \tag{3}$$

Here $e_i = e^a$ for $i \in A$ and $e_i = e^b$ for $i \in B$, where e^a and e^b are constants satisfying $\lambda e^a + (1-\lambda)e^b = e$. The parameter v is the fraction of internal funds that are available for financing current production.

Demand for each good depends on the choices of households and the resource costs of state verification by banks. Household demand for each good is derived from the representative household's problem. Given that the demand of any one household is small relative to the total demand for a good we have that $\phi_{ij} \perp p_i$ for all goods i and all households j. In addition, throughout I use the normalization that $E_j \phi_{ij}^{\psi/(\psi-1)} = 1$ for each relevant agent j. Then, demand for good i by household j is given by $c_{ij} = c_j(\phi_{ij}p/p_i)^{\psi/(\psi-1)}$, where $p = \left[\int_0^1 p_i^{1/(1-\psi)} di\right]^{1-\psi}$ is the aggregate price index. I assume the resource costs of state verification are accommodated by the same index of goods that applies to households. The verification costs are assumed to be proportional to the real size of the loan outstanding. Thus, for firm j with outstanding loan l_j the real resource cost is $\mu l_j/p = \left[\int_0^1 \phi_{ij}\mu_{ij}^{1/\psi} di\right]^{\psi}$, $\mu > 0$. Here for each firm j the ϕ_{ij}'s are distributed according to $\Phi_j \in \mathcal{F}$. Cost minimization implies $\mu_{ij} = (\mu l_j/p)(\phi_{ij}p/p_i)^{\psi/(\psi-1)}$.

Total demand for good i, y_i, is the sum of total household demand and total demand due to verification costs. As will be explained below, only a fraction, $G(\gamma)$, of type b firms will actually be monitored in any given period. Thus total demand is

$$y_i = \int_0^1 c_{ij} dj + \int_{\lambda}^{\lambda+G(\gamma)(1-\lambda)} \mu_{ij} dj = \phi_i Y^* \left(\frac{p}{p_i}\right)^{\psi/(\psi-1)} . \tag{4}$$

Here Y^* denotes aggregate demand for goods, which is the sum of aggregate consumption demand and aggregate verification costs. Also, $\phi_i \equiv E_i \phi_{ij}^{\psi/(\psi-1)}$, where the expectation is with respect to both households and monitored firms. Notice that I have indexed type b firms so that the monitored firms are assigned the lowest indices.

Combining (2), (3) and (4), total revenues for good producer i are given by

$$p_i y_i = q\theta_i \left[z(l_i + ve_i) - \xi_i\right]^{1/\psi} ,$$

where $z \equiv (\alpha/r)^{\alpha}((1-\alpha)/w)^{1-\alpha}$, $\theta_i \equiv \phi_i^{1-1/\psi}\omega_i^{1/\psi}$ and $q \equiv pY^{*(\psi-1)/\psi}$. I assume that θ_i is distributed uniformly according to $G(\cdot)$ with support $[\underline{\Theta}, \overline{\Theta}]$, a mean of unity and standard deviation σ_θ.

I now describe the determination of loan size. Consider type a firms first. Since all their operations are common knowledge, contracts can be written on a state contingent basis. Thus, loan size is determined by the point at which the expected marginal revenue from a loan equals its marginal cost. Assuming symmetric behavior of these firms, we have

$$\frac{1}{\psi} zq \left[zl^a - \hat{\xi}^a \right]^{1/\psi - 1} = R, \tag{5}$$

where l^a is the size of the loan granted and $\hat{\xi}^a \equiv \xi^a - zve^a$ are *net fixed costs* for type a firms.

Now consider type b firms. Each bank is assumed to hold a sufficiently large and diversified portfolio of loans to achieve perfect risk pooling of loans to type b producers. Their opportunity cost of funds is the gross interest rate in the deposit market, R. Recall that loans are fixed before θ_i is observed and banks can verify θ_i by paying the verification cost. Finally, note that, as good producers, type b firms have a one-period planning horizon.[9] Now, if we assume that banks can commit to a monitoring strategy and that stochastic monitoring is not feasible then the optimal loan contract is a standard debt contract. First, the firm pays $R^b l$ if it is solvent, and defaults otherwise, where R^b is the gross interest rate on the loan. Second, the bank monitors only in the event of default. Finally, when default occurs the bank appropriates all the revenues from the firm. Since verification only occurs in the event of bankruptcy, I will follow convention and refer to the resources used up in verification as bankruptcy costs.

The optimal contract maximizes the expected profits of a type b firm subject to the constraint that the representative bank earns at least its opportunity cost of funds. Assume symmetric behavior for type b firms so that they all receive a loan of size l^b. Then, as described in appendix A, the optimal contract solves

$$\max_{\{l^b \geq \hat{\xi}^b/z, \underline{\Theta} \leq \gamma \leq \overline{\Theta}\}} \quad q\left[zl^b - \hat{\xi}^b\right]^{1/\psi}\left[1 - \Gamma(\gamma)\right] \tag{6}$$

subject to

$$\frac{q\left[zl^b - \hat{\xi}^b\right]^{1/\psi}}{l^b}\Gamma(\gamma) + (1-v)\frac{e^b}{l^b} - \mu G(\gamma) \geq R.$$

Here γ denotes the realization of θ_i below which default occurs, $\Gamma(\gamma) \equiv \int_{\underline{\Theta}}^{\gamma} \theta dG(\theta) + \gamma[1 - G(\gamma)]$ and $\hat{\xi}^b \equiv \xi^b - zve^b$ is the net fixed costs of a type b firm. Note that $R^b = (\gamma q\left[zl^b - \hat{\xi}^b\right]^{1/\psi} + (1-v)e)/l^b$. Implicit in the statement of this problem is that a fraction $(1-v)$ of internal funds is available for use as collateral.[10] Given a solution (l^b, γ) to the contract problem, aggregate bankruptcy costs are $\mu G(\gamma)(1-\lambda)l^b/p$.

When firms make their production plans they expect to charge the same price. However, because of the idiosyncratic nature of productivity and demand, actual prices differ in equilibrium. Prices are set by firms to ensure that no output goes unsold. These prices are given by[11]

$$p_i = q\left(\frac{\phi_i/\omega_i}{\left[zl_i - \hat{\xi}_i\right]}\right)^{1-1/\psi}.$$

This expression illustrates the importance of incorporating two sources of idiosyncratic uncertainty in the goods producers' environment. To see this, note that when assessing the revenues of a type b firm, a bank knows the price of its good, l^b, z, q and $\hat{\xi}^b$. Thus, if any one of the idiosyncratic disturbances were absent or were common knowledge, then the bank could use prices to uncover the entire structure of demand and supply among goods producers it had financed. It could then use this information to infer the revenues of all these firms – there would not be any private information in this economy.

2.3. Intermediaries

Intermediaries accept deposits from households and are the conduit for cash injections. The loans they make are constrained by the sum of deposits and the cash injection. In the aggregate, then,

$$\lambda l^a + (1-\lambda) l^b \leq n + x'. \tag{7}$$

The first term on the left hand side of (7) is the total of loans granted to type a firms and the second term is the total of loans granted to type b firms. After paying interest to depositors the dividends paid by intermediaries equal $(R-1)x'$. The law of motion for the growth rate of the aggregate stock of money is

$$x' = (1-\rho)\bar{x} + \rho x + \epsilon, \quad \epsilon \sim \mathbf{N}(0, \sigma_\epsilon^2). \tag{8}$$

Here, $\bar{x}$ is the unconditional mean of monetary growth, x equals last period's growth rate and $\rho \in (-1, 1)$.

2.4. Market Clearing and Equilibrium

In equilibrium all markets clear. The market clearing conditions are:

$$\lambda k^a + (1-\lambda) k^b = K, \tag{9}$$

$$\lambda h^a + (1-\lambda) h^b = H, \tag{10}$$

$$rK + wH = n + x' + ve, \tag{11}$$

$$Y^* = \left[\lambda (F(k^a, h^a) - \xi^a)^{1/\psi} + (1-\lambda)(F(k^b, h^b) - \xi^b)^{1/\psi}\right]^\psi, \tag{12}$$

$$m = m' = 1, \tag{13}$$

and (7) holding with equality. Conditions (9) and (10) say that the total demand for capital and labor for the two types of firm equal the aggregate stock of capital K and aggregate supply of labor H, respectively. Implicit in these conditions is that firms of a given type have identical factor demands. Condition (7) holding with equality and (11) summarize loan market clearing. Goods market clearing is given by (12), which says the aggregate demand for goods equals its aggregate supply.[12] Note that measured aggregate output, Y, is just equal to aggregate consumption. Finally, (13) is the money market clearing condition.

A recursive equilibrium can be defined in the usual way. It consists of time invariant aggregate allocation and price functions of the relevant state such that given these rules agents' optimization satisfies market clearing. With the exception of deposits n, which depends on last period's monetary growth x only, all price and allocation rules are functions of both x and x'. In Fisher (1996) I describe how the equilibrium can be characterized in terms of the solution to a system of two functional equations in the allocation rules for n and l^a. This system is solved numerically using methods described in Judd (1992). An advantage of these methods is that the solutions are virtually exact so approximation error is not a concern.

3. Parameter Values and the Steady State

I choose parameter values so that the steady state of the model is consistent with direct and indirect evidence on various long-run average and cross-sectional features of the US data. The procedure is used to calibrate a baseline set of parameter values and it also plays a role when I explore the parameter space more generally. In the remainder of this section I describe how the baseline parameter set is constructed and the strategy I use to explore the parameter space more generally. The section concludes with a brief description of the steady state.

3.1. Parameter Values

I need to identify the following parameters:[13]

$$
\begin{aligned}
\text{Preferences:} &\quad \beta, \nu, \psi; \\
\text{Production:} &\quad \alpha, \xi^a, \xi^b, \lambda; \\
\text{Finance:} &\quad \upsilon, e^a, e^b, \mu, \sigma_\theta; \\
\text{Monetary Policy:} &\quad \bar{x}, \rho, \sigma_\epsilon.
\end{aligned}
$$

The endowment of capital is normalized to 10 throughout.

With the exception of λ, I follow convention to identify all the preference and production parameters. I assume a period in the model corresponds to a quarter of a year and select the discount rate so that the mean of the real interest rate is 3% at an annual rate. I select ν so that work effort accounts for 30% of the time endowment in steady state, and α is chosen to equate an estimate of the average share of capital in income with its steady state value in the model. The mark-up ψ is set to a value suggested by recent empirical work. Hall (1995), in response to results reported in Burnside, Eichenbaum and Rebelo (1995) and in references they cite, argues that mark-ups are probably quite modest and I choose ψ accordingly. Finally, I choose ξ^a and ξ^b so that in steady state economic profits are zero for goods producers, as in Rotemberg and Woodford (1992). Here this amounts to equating the rate of return on equity in the two types of firm, e^a and e^b, with the rate of return on their closest substitute, deposits.

The proportion of type a firms in the aggregate index for goods, λ, does not appear in conventional quantitative general equilibrium studies. I follow the lead of Gertler and Gilchrist (1994) to identify this parameter. In their analysis of manufacturing firms they identify a class of 'credit constrained' firms by sales. The smallest firms in their sample with 30% of total sales are classified as credit constrained, while all other firms are classified as non credit constrained. Thus, I choose λ so that the credit constrained firms in the model, that is type b firms, account for 30% of aggregate sales in steady state.

Now consider the parameters governing the financial structure of the model. I use empirical evidence on the average leverage ratio, d, to identify e^a and e^b.[14] Obviously leverage ratios vary considerably across firms. However, since the model has no predictions along this dimension, I assume the leverage ratio for each type of firm equals the economy-wide average. This value is probably close to 0.4 for the US economy.[15] Since the results are more favorable to the lending view interpretation of the empirical evidence if this ratio is higher, I use 0.5 as the baseline value of this parameter.

I identify μ using empirical evidence on the ratio of bankruptcy costs to assets for bankrupt firms.[16] Several studies examine the size of bankruptcy costs with estimates ranging from 1% to 25% of assets.[17] The main findings reported here are insensitive to the particular value used for μ. Nevertheless, I use the relatively large cost share of 20% to select my baseline μ. As a basis for comparison I also consider versions of the model without any monitoring costs, *i.e.* $\mu = 0$.

The parameter σ_θ controls the steady state spread between the interest rates paid by the two types of firm. Accordingly, I use evidence on this spread to identify σ_θ. Berger and Udell (1992) report that the average premium paid on bank loans relative to US Treasury bills over the period 1977-1988 is about 4 percentage points. Since their sample involves historically high interest rate spreads and since it is very rare for any firm to borrow at Treasury bill rates, I work with the baseline value of 3 percentage points to identify σ_θ. Note that the main findings are insensitive to alternative assumptions for the spread.

The remaining financial parameter, v, determines the 'relative velocity of equity.' I am not aware of any independent evidence on this parameter. I use 0.5 as my baseline for v. This value of v along with the baseline leverage ratio imply that internal funds account for a relatively small fraction of total finance compared to evidence reported in Fazzari, Hubbard and Peterson (1988). Increasing v and reducing d to increase this fraction would only harm the model's implications in terms of the lending view interpretation of the empirical evidence. This is discussed further below.

The monetary policy parameters govern the mean, autocorrelation and standard deviation of growth in the money stock. I adopt the values used by Christiano and Eichenbaum (1992) for these parameters. In particular I use $\bar{x} = 0.012$, $\rho = 0.30$ and $\sigma_\epsilon = 0.014$ throughout the analysis. These values are based on properties of the US monetary base.

The baseline parameters associated with versions of the model with and without monitoring costs are summarized in table 1 under the heading 'Baseline.' In this table and below 'AI' refers to asymmetric information ($\mu > 0$) and 'PI' refers to perfect information ($\mu = 0$). Below I discuss results from exploring the parameter space more generally. These results are based on alternative assumptions for selecting v, d, and ψ. When I consider alternative values for these parameters I choose the remaining parameters according to the criteria set out above. The other columns in table 1 refer to these alternative parameter sets.

3.2. The Steady State

In the columns under the header 'Baseline' in table 2 I report values of selected variables in steady state for the baseline parameter sets associated with the AI and PI versions of the model. We can use the steady state predictions of the model to gauge the empirical plausibility of the baseline parameters. To this end, consider the steady state predictions of the baseline AI version of the model for the bankruptcy rate, bankruptcy costs, liabilities of failed firms and firm size. (The other entries in this table are discussed below).

In steady state the bankruptcy rate is about 2%. The mapping between the model and the data along this dimension is not obvious since firms may be subject to substantial reorganization due to financial distress and not actually declare bankruptcy. In addition firms may declare bankruptcy as a legal manoeuver and continue operating. Neither of these facts are modelled here. The Dun and Bradstreet Corporation attempts to take these and other similar considerations into account when compiling their measure of business failures. Using their measure we find the failure rate for US businesses over the period 1984-1994 was roughly 1%. Thus the model does not appear to be too far from the data along this dimension.

The ratio of bankruptcy costs to output in steady state is 0.1%. While I am not aware of any estimate of this magnitude, it does not seem unreasonable. The ratio of liabilities of failed firms to aggregate output in steady state is roughly 0.8%. To assess the plausibility of this magnitude we can compare it to the mean of the corresponding ratio computed using the Dun and Bradstreet measure of failure liabilities and US GDP. Over the period 1984-1994 this is roughly 0.1%. Given that the Dun and Bradstreet measure may be biased downwards because their sample contains a relatively small number of unincorporated small firms, the model's steady state implications along this dimension also seem reasonable.

Finally, notice that in steady state type b firms, who face the credit constraint, are only 1/3 the size of type a firms who do not face the constraint. In addition, we see from table 1 that type b firms account for almost 50% of the total number of firms in the economy. These facts are consistent with the identification of small firms as credit constrained by Gertler and Gilchrist (1994) and the view that a substantial fraction of firms in the US economy are credit constrained.

In summary, when considered in conjunction with the criteria used to identify the baseline parameter set, the steady state implications of the model seem to capture key long-run features of the data associated with the lending view. The assumed monitoring costs are non-trivial and imply apparently reasonable values for the failure rate, bankruptcy costs and liabilities of failed firms. In addition, a large fraction of firms in the economy are credit constrained and these firms are considerably smaller than their non-credit constrained counterparts. The question of whether the cyclical predictions of the model also conform to the lending view interpretation of the empirical evidence remains. This is the focus of the next two sections.

4. General Equilibrium Results

In this section I analyze the cyclical properties of the model. The objective is to provide a quantitative evaluation of the lending view interpretation of the empirical evidence described in the introduction. The main finding reported in this section is that imperfections in credit markets as they are modelled here can only account for the empirical evidence if we assume implausible mark-ups and leverage ratios.

The empirical evidence concerns the responses of variables to measures of monetary disturbances. We can analyze the predictions of the model in this regard by studying how variables respond to innovations in money growth. I focus on the impact effects of these innovations, rather than entire dynamic responses. This is because the model lacks an internal propagation mechanism and so the effects of the model's frictions essentially last one period only.[18] The discussion that follows begins with the model's predictions based on the baseline parameters. I then outline the implications of perturbing the values of key parameters.

4.1. Baseline Responses of the Main Aggregates

In table 3 I report impact responses following an unanticipated 1 percentage point reduction in money growth of variables of interest for the AI and PI versions of the model. The entries corresponding to the baseline parameter set are shown under the 'Baseline' header. Consider first the behavior of the aggregate variables Y, H and R shown in the first three rows. We see that output and hours fall and the deposit interest rate rises in both the AI and PI versions of the model. Thus the model is consistent with conventional views on the behavior of the economy in a monetary contraction.

These results can be explained as follows. With households' nominal savings fixed before the monetary disturbance, firms and intermediaries must absorb the entire amount of the monetary contraction. Funds are at a premium because less cash is in the money market than anticipated. Since firms require funds to finance their ongoing operations, they are willing to pay the premium. The premium they are willing to pay is large enough that it dominates the Fisher anticipated inflation effect and interest rates rise following the contraction. With higher operating costs, firms cut back on production and hours worked falls.[19] Notice that the responses of these variables are virtually identical in the two versions of the model so that monitoring costs do not amplify the non-neutrality introduced by limited participation.[20]

4.2. Baseline Responses of the Lending View Variables

The impact of an unanticipated monetary contraction on the activities of type b firms relative to type a firms is indicated in the last five rows of table 3. In the baseline PI case type b firms are identical in all respects to type a firms so there is no difference in how their activities respond to an unanticipated monetary contraction. In the baseline AI case the relative amount of debt flowing to type b firms *rises* by more than 1.8%. In addition sales by type b firms actually rise in a contraction while they fall for type a firms and the interest rate spread drops. These results clearly contradict the lending view interpretation of the empirical evidence. Notice as well that in the AI case the bankruptcy rate falls by over 6% which seems inconsistent with the lending view as well.

To understand these findings it is helpful to consider the contract problem, (6), in isolation from the rest of the general equilibrium model. That is, assuming the aggregate variables q, z, and R are exogenous. We will analyze the responsiveness of loans to changes in R implied by the contract problem compared to the PI case by studying the interest rate elasticities of loan size, η_R^b and η_R^a, respectively. In comparing the two elasticities, I decompose the effect of a change in R on l^b into two parts: the direct effect on l^b holding the bankruptcy cut-off, γ, constant and the indirect effect via changes in γ induced by the change in R.

Consider the direct effect first. We can derive the direct elasticity, $\hat{\eta}_R^b$, using the bank's rate of return constraint in (6), which is binding in equilibrium. Using (5) to compute η_R^a we find

$$\hat{\eta}_R^b = \frac{\Delta R}{1 - \frac{\psi}{\psi-1}\Upsilon^b + \frac{\Delta}{\psi-1} \cdot \frac{(1-v)e^b}{l^b}} \eta_R^a, \tag{14}$$

where $\Delta \equiv 1/\left[R + \mu G(\gamma)\right]$ and $\Upsilon^b \equiv \hat{\xi}^b/(zl^b)$ is the *effective overhead ratio* for type b firms. Here I have assumed that AI and PI firms are identical in all respects except for the credit market imperfection.

The indirect effect is usually small relative to the direct effect so we can use (14) to examine whether loan size is more sensitive to interest changes under AI compared to the PI case. For example, if fixed costs are zero and there is no equity participation ($e^a = e^b = 0$), then $\hat{\eta}_R^b < \eta_R^a$. That is, loans are more sensitive to interest rate changes for PI firms relative to AI firms. As (14) suggests, this result will not hold in general so it is certainly possible that the contract problem is consistent with the hypothesis that AI firms exhibit excess interest rate sensitivity of loan size relative to PI firms.

It turns out that the magnitudes of the effective overhead ratios in the two cases, Υ^a and Υ^b, are crucial factors determining whether AI firms are more sensitive to exogenous disturbances than PI firms. The larger are these overhead ratios the more likely it is that AI firms will exhibit excess sensitivity.[21] This is due to the impact overhead ratios have on the relative loan size elasticities of average and marginal revenues. Other things equal, the larger are these overhead ratios the more elastic are marginal revenues and the less elastic are average revenues. Less elastic average revenues for AI firms imply l^b must change by more to keep the bank's rate of return constraint binding, which tends to increase the direct effect of changes in R on l^b. Similarly, the more elastic are marginal revenues for PI firms then the less l^a must respond to maintain equality in (5).

The relative debt flow result can now be explained. Given the baseline parameter values, the partial equilibrium interest rate elasticity of loan size is *smaller* for type b firms than for type a firms. Also, limited participation in general equilibrium leads to a reduction in the real supply of loanable funds. Intuition from static demand analysis suggests, then, that firms with the more elastic loan schedules will respond greatest in per cent terms to the reduction in the supply of loanable funds.

4.3. Evaluating Robustness to Parameter Selection

The question naturally arises whether this finding is sensitive to the choices made when constructing the baseline parameter set. To address this question recall that the relative flow of debt to type b firms is more likely to fall after a monetary contraction the greater are the effective overhead ratios for the two types of firm, Υ^a and Υ^b. For the baseline parameter set these overhead ratios are actually negative (see table 2) and so serve to increase the sensitivity to monetary shocks of type a firms relative to type b firms.

The reasons for this are threefold. First, overhead costs, ξ^a and ξ^b, are small (see tables 2 and 3). Given that the baseline mark-up is quite modest (5%), only small overhead costs are needed to make profits zero in steady state. Second, the baseline setting for the leverage ratio implies a considerable amount of internal funds are available to finance ongoing operations and this tends to reduce effective overhead ratios. Third, the positive velocity of equity also tends to reduce effective overhead ratios.

The foregoing suggests that to evaluate the robustness of the findings based on the baseline parameters we should focus on d, ψ and v. Consider the relative debt flow result. It turns out the velocity of equity has only a small impact on relative debt flows so it is sufficient to consider perturbations in the mark-up and the leverage ratio only. The implications of varying the mark-up and the assumed leverage ratio are illustrated in the two graphs of figure 1. Figure 1A shows that increasing the mark-up indeed improves the predictions of the model. However, even with $\psi = 2$ the finding of a relative increase in funds flowing to type b firms following a monetary contraction holds.

In figure 1B the impact of increasing the leverage ratio given $\psi = 1.5$ (solid line) and $\psi = 2$ (dashed line) is shown. Note that these results are based on $v = 1$ since for lower values of this parameter interior solutions to the contract problem do not exist.[22] We see from figure 1B that only with close to 90% of total finance coming from debt and $\psi = 2$ is even the qualitative nature of the empirical findings replicated. It is important to emphasize that extreme values for the mark-up and leverage ratio are needed to replicate the empirical results even if we allow for counterfactually large values for steady state monitoring costs and the interest rate spread, or if we introduce increasing returns to scale in the monitoring technology.

An example of the predictions of the model when the mark-up and leverage ratio are at extreme values is shown in table 3 under the heading 'Excess sensitivity I' (see table 1 for the corresponding values for the remaining parameters and table 2 for the corresponding steady state). Notice that not only is the relative debt flow empirical finding replicated, but so are the sales and interest rate spread findings. Even the bankruptcy rate rises sharply in this case.

To summarize, limited participation and monitoring costs deliver findings consistent with empirical work on how broad aggregates respond to a monetary contraction, and results consistent with empirical work that describes the heterogeneous response of firms to monetary contractions. Given that the firms in the model that face the credit constraint are smaller than the firms that do not, the results are broadly consistent with the Gertler and Gilchrist (1994) findings on the behavior of sales and outstanding debt for small versus large firms. The findings are also consistent with the empirical evidence on how interest rate spreads behave in monetary contractions. However, the lending view interpretation of these findings is in question now, given that these results only emerge when we assume implausible values for the mark-up and leverage ratio.

5. Partial Equilibrium Results

If we assume q, z, and R are exogenous then the contract problem (6) can be solved independently of the general equilibrium (GE) model. A difficulty with the GE model in terms of assessing the lending view interpretation of the empirical evidence is that it takes a strong stand on the exact nature of how these variables respond to a monetary disturbance. This may be problematic because the model's implications for the pattern of responses for these variables may be counterfactual and distort the predictions of the credit market model embedded within it.

To understand why this is so it is helpful to begin by considering comparative statics for the contract problem (6). These are summarized in table 4. In this table single entries for an endogenous variable indicate that the comparative static result is independent of the mark-up, ψ. For cases with multiple entries, the first is for low mark-ups ($\psi \leq 1.1$) and the second is for high mark-ups ($\psi \geq 1.5$). Notice that the comparative statics of the interest rate spread and the likelihood of bankruptcy depend on the mark-up ψ, while loan size and sales do not.

Now, consider the response of the aggregate demand index, q, and the marginal product of a loan, z, in the baseline parameterization of the AI version of the general equilibrium model indicated in table 3. Notice that q drops (due to the fall in output and a fall in the aggregate price index) and z increases (due to wage and rental rate declines). According to the comparative statics these responses have implications for how l^b responds to a monetary shock. The fall in q tends to reduce l^b and the rise in z tends to increase l^b. Thus the response of l^b under the baseline parameterization may be excessively small if these responses are of counterfactual magnitudes. Similar considerations apply to the other variables of interest. This could mean that the rejection of the lending view interpretation of the empirical evidence on the basis of the GE model is misleading.

To explore this possibility I adopt the following strategy. I estimate from US data the responses to monetary policy disturbances of the aggregate variables that are now taken as exogenous, namely q, z, and R. I use a conventional VAR methodology for this, the details of which are outlined in appendix B. Using these estimates and parameter values calibrated as outlined in section 3, I examine the predictions of the contract problem, (6), and the condition for determining type a loans, (5), for the variables of interest. Note that the steady state of the GE model is consistent with a large class of models that potentially involve very different assumptions about the exact nature of the monetary transmission mechanism. Thus this evaluation of the lending view involves much weaker assumptions than before.

Two examples of applying this procedure are illustrated in figure 2. In figures 2A-2C the estimated responses of R, z and q, respectively, are displayed. Note that the measure of q depends on assumptions regarding the mark-up. Thus in figure 2C two responses are displayed: one for $\psi = 1.2$ (solid line) and one for $\psi = 1.5$ (dashed line). The responses of l^b/l^a implied by feeding the aggregate variables through the contract problem are reported in figure 2D, where for these examples I assume $v = 0.5$ and $d = 0.8$. Here we see that for $\psi = 1.2$ the response of l^b/l^a is in the wrong direction (using the baseline parameter set the response is even further in the wrong direction). Only when the mark-up is increased to $\psi = 1.5$ do we observe the response suggested by the lending view. While not shown here, the responses of sales, the interest rate spread and the bankruptcy rate also conform to the lending view in this latter case. The complete list of parameter values for the $\psi = 1.5$ case are indicated in the columns under the 'Excess sensitivity II' header in table 1. Also, the predictions of the GE model for the usual list of variables are shown in table 3 under the same header. Notice that for the parameterization that implies a lending-view-favorable response of l^b/l^a using the partial equilibrium approach implies counterfactual responses in the GE model.

In summary, using the partial equilibrium approach we still require counterfactually large mark-ups and leverage ratios to replicate even the qualitative response of relative debt flows. (This fact holds up when alternative VAR estimates are considered – see appendix B). This finding suggests that the main conclusion regarding the predictions of the credit market model hold up when we allow the data to speak about the monetary transmission mechanism rather than taking the strong stand implied by working with the GE model in isolation.

6. Concluding Remarks

The formalization of the lending view described here reproduces the empirical evidence emphasized in the introduction only for seemingly implausible parameters. One conclusion that could be drawn from this finding is that interpreting the small-large firm empirical evidence as an indication of an active bank-lending channel is problematic. The extent to which this conclusion is warranted depends on the model's success at capturing the main tenets of the lending view. As modelled here the key feature of the lending channel is the presence of a credit market imperfection which influences the equilibrium determination of debt for firms which face the imperfection relative to firms which do not. While this is a commonly emphasized feature of the lending view, there are several differences between the model of this paper and the formulations implicit in much of the lending view literature. In this concluding section I outline these differences and discuss their implications for interpreting the results.

One difference with descriptions of the lending view in the literature regards the specification of the monetary transmission mechanism. For example, Bernanke and Blinder (1988) and Kashyap and Stein (1994) emphasize a traditional sticky-price transmission mechanism in their descriptions of the bank-lending channel. The general equilibrium model described in section 2 clearly does not have this feature. For example, prices are perfectly flexible and traditional aggregate demand effects that operate through investment are not present. However, the partial equilibrium analysis in section 5 suggests that the details of the monetary transmission mechanism are not crucial for the main findings. This conclusion follows as long as proposed alternative specifications are consistent with the steady-state calibration and reproduce the estimated responses of aggregate variables to a monetary disturbance.

Another difference concerns the specification of factor demand in the model. Firms are relatively flexible in adjusting factor inputs here. A related concern is the absence of a role for inventories, specifically the need for firms to finance inventories. These facts imply the demand for loanable funds is quite responsive to changing aggregate conditions. As described in the literature, the lending view often involves firms facing commitments to pay factors which make it difficult for them to adjust their borrowing requirements in the short-run. The connection between these commitments and observed borrowing by small and large firms is not direct. However, to the extent that model features which make adjusting payments to factors difficult are missing from the model, it is possible that important components of the lending view have been ignored. Incorporating these features may lead to findings more supportive of the lending view.

Kashyap and Stein (1995) emphasize a role in the lending view for credit market imperfections faced by banks. Key to their analysis is the imperfect substitutability of securities and loans in banks' portfolios, which makes it possible for the central bank to influence the supply of loanable funds. The mechanism for influencing the supply of loanable funds is different in the general equilibrium model of this paper, where banks are not subject to such imperfections. Incorporating this missing feature could enhance the effects of monetary contractions on the supply of loanable funds in the model. It is less clear whether doing this would help explain the observed borrowing of small versus large firms. For this to be the case, the subset of banks which may be subject to the credit market imperfections described by Kashyap and Stein must be the principle source of funds for small firms.

Finally, the way the credit market imperfection was modelled here may bias the results against the lending view. The approach taken was to assume a sequence of one-period contracts, thereby eliminating any dynamic role for net-worth in the analysis. In the sense of Townsend (1982) this assumption maximizes the distortion due to asymmetric information. Another advantage of this approach is that it permits a clear distinction between the lending view and theories which emphasize a key role for net-worth. However, this distinction, while consistent with the literature, may be overly restrictive. In fact it may be the case that the lending view and net-worth theories of the monetary transmission mechanism are tied together in important ways. To get a sense of the potential for net-worth dynamics to overturn the results presented here, consider perturbing internal funds in the contract problem. Clearly, the level of internal funds influences the size of the loan granted. If internal funds are allowed to vary systematically then presumably loan size for credit constrained firms could become more sensitive to disturbances in the credit market.[23]

Appendix A: Derivation of the Contract Problem

In this appendix I derive (6), the problem characterizing the optimal contract for loans to type b firms described in section 2. Recall, the optimal contract maximizes the expected profits of a type b firm subject to the constraint that the representative bank earns at least its opportunity cost of funds.

To eliminate R^b from the objective and the constraint of the contract problem, notice that, for the marginal solvent firm, the principal plus interest for the loan exactly equals the revenues plus the collateral put up for the loan:

$$R^b l^b = \gamma q \left[z l^b - \hat{\xi}^b \right]^{1/\psi} + (1-v)e^b.$$

Keeping in mind the fact that type b firms lose everything, including their collateral, if they cannot repay their loan, expected profits are derived as follows:

$$\begin{aligned}
& q \left[z l^b - \hat{\xi}^b \right]^{1/\psi} \int_{\gamma}^{\overline{\Theta}} \theta dG(\theta) + [1 - G(\gamma)]\,(1-v)e^b - [1-G(\gamma)]\, R^b l^b \\
= \;& q \left[z l^b - \hat{\xi}^b \right]^{1/\psi} \int_{\gamma}^{\overline{\Theta}} \theta dG(\theta) + [1 - G(\gamma)]\,(1-v)e^b - [1-G(\gamma)]\,(1-v)e^b \\
& - [1-G(\gamma)]\,\gamma q \left[z l^b - \hat{\xi}^b \right]^{1/\psi} \\
= \;& q \left[z l^b - \hat{\xi}^b \right]^{1/\psi} \left[\bar{\theta} - \Gamma(\gamma) \right].
\end{aligned}$$

The no arbitrage condition for intermediaries says that payments of solvent firms, plus collateral and accounts receivables of insolvent firms, minus the monitoring costs for the insolvent firms, are greater than or equal to the opportunity cost of the funds loaned. That is

$$[1 - G(\gamma)]\, R^b l^b + q \left[z l^b - \hat{\xi}^b \right]^{1/\psi} \int_{\underline{\Theta}}^{\gamma} \theta dG(\theta) + G(\gamma)(1-v)e^b - \mu G(\gamma) l^b \geq R l^b.$$

Simplifying and rearranging this expression delivers the constraint for the contract problem.

Appendix B: Impulse Response Function Estimation

In this appendix I describe the procedure used to estimate the impulse response functions depicted in figure 2. It is based on a conventional VAR methodology. I estimate a six variable vector auto-regression, or VAR, in the order Y, q, $PCOM$, R, $NBRX$ and z. With the exception of PCOM, the data is taken directly from or is derived from variables in Citibase. Except for $PCOM$ all variables are in logs. The sample is 1964:1-1992:4 and four lags were used.

The variables were measured as follows: Y is real GDP (Citibase GDPQ), q is defined as in the main text with the GDP deflator (GDPD) as the aggregate price index and Y proxying for Y^*, $PCOM$ is the index of commodity prices used by Christiano, Eichenbaum and Evans (1996), R is the Federal funds rate (FYFF), $NBRX$ is the ratio of non-borrowed reserves (FMRNBC) to total reserves (FMRRA) and z is measured as in the main text. To compute z we need measures of the nominal wage and rental rates. I use Citibase variable LEH to measure the nominal wage (average hourly earnings of production or nonsupervisory workers on private nonagricultural payrolls). I impute a measure of the rental rate as follows. Denote the measure of capital's income share described in the notes to table 2 as α_t, then the rental rate is computed as $r_t = \alpha_t GDP/K_t$. Here GDP is nominal GDP from Citibase and K_t denotes an imputed capital stock based on assuming a 10% annual rate of depreciation on real gross fixed private investment (GIFQ).

Monetary policy disturbances are measured as orthogonalized innovations to R. Thus figures 2A-2C contain impulse response functions to a one-standard deviation innovation in the Federal funds rate. See Christiano, Eichenbaum and Evans (1996) for a discussion of this approach to measuring monetary policy disturbances.

I have not shown standard errors in figures 2A-2C to prevent cluttering the figures. The response of R is significant to about 6 quarters after an innovation and the responses of the price indices are significant only after about a year. Note that the results are robust to alternative orderings as long as the factor price index z is placed after the monetary variables in the ordering. If it is placed before the monetary variables (R, $NBRX$) then the responses of Y, q and $PCOM$ are all unconventional. The findings are robust to using another measure for wages (LEHM) as well. Finally, based on the estimation underlying figure 2, the imputed response of real factor costs (the response of $1/z$ divided by the response of the GDP deflator) is negative. That is real factor costs decline after a negative innovation in the Federal funds rate. This result is consistent with results reported in Christiano and Eichenbaum (1995) for the real wage.

Estimated responses of q, R and z are interpreted as per cent deviations from an undisturbed path. For given per cent deviation x_t I compute the relevant level response that can be fed into the partial equilibrium model as $X_t = (1 + x_t) \cdot \bar{X}$, where $\bar{X}$ is the steady state value of a given variable and X_t is the level response of the variable.

Notes

[1]Gertler and Gilchrist (1994) report the first two findings using data for manufacturing firms. Christiano, Eichenbaum and Evans (1996) report similar results in terms of relative debt flows for non-corporate versus corporate firms. Berger and Udell (1992) find the spread between commercial bank loan rates and Treasury bill rates increases in a 'credit crunch'. Kashyap, Wilcox and Stein (1992) report a similar finding for the spread between the prime bank lending rate and a commercial paper rate.

[2]See Bernanke and Gertler (1995) for a recent discussion of these views and the related empirical evidence.

[3]See for example Bernanke (1993), Bernanke and Blinder (1992), Bernanke and Gertler (1995) and Kashyap and Stein (1994, 1995).

[4]Christiano, Eichenbaum and Evans (1996) report evidence from the Flow of Funds accounts that generally supports this assumption.

[5]The costly state verification framework has been the predominant method of articulating aspects of both the 'net-worth channel' as well as the bank-lending channel. Examples include Bernanke and Gertler (1989), Carlstrom and Fuerst (1995), Fuerst (1993), Gertler and Gilchrist (1991), and Williamson (1986, 1987).

[6]This view follows from the well known fact that dynamic interaction between borrowers and lenders may mitigate agency costs associated with asymmetric information (see Townsend, (1982)).

[7]Note that to write the household's problem in recursive form all nominal variables are normalized by the per household stock of money.

[8]Incorporating capital accumulation does not change any of the main results as long as we adopt Christiano (1991)'s 'sluggish capital' assumption. The assumption that households

own the capital stock is made for simplicity.

[9]As long as we assume sufficient anonymity in transactions this assumption is consistent with firms surviving for multiple periods. Alternatively we can view firms as surviving for one period only.

[10]I only consider interior solutions to the contract problem. Fuerst (1994) analyses a related problem. His model does not have fixed costs, internal funds or collateral, but it does allow for increasing returns in the monitoring technology. He focuses on corner solutions to the contract problem in which extensive margin rationing occurs (interior solutions to the current problem involve intensive margin rationing in the sense that at the given R^b firms desire larger loans than specified by the contract.) As the analysis in section 5 indicates, corner solutions only occur in the current model for extreme values of the parameters. Also, allowing for increasing returns to monitoring does not alter the main conclusions of this paper.

[11]To understand this expression consider the case of a firm with an average productivity disturbance, but an above average demand disturbance. In this case the price is higher than the average, as you would expect. Notice that the only role played by $\mathcal{F}$ is to determine the distribution of relative prices. Thus as long as the distribution of consumption across goods is not a main concern we do not need to exactly specify $\mathcal{F}$.

[12]As described in Fisher (1996), for this condition to be satisified we must assume $E\phi_i^{1-1/\psi} = E\phi_i^{-1/\psi}$.

[13]This list does not include $\mathcal{F}$. As long as the elements of $\mathcal{F}$ are consistent with the normalizations and assumptions put on them in the previous section, we need not specify it to infer the predictions of the model for the variables of interest.

[14]The leverage ratio is defined as the ratio of debt to the sum of debt and equity.

[15]See Benninga and Protopapadakis (1990) and the references they cite.

[16]In the model, the assets of a bankrupt firm include its collateral and accounts receivables.

[17]See for example Altman (1984), Guffey and Moore (1991), and Warner (1977).

[18]The differences between models with limited participation and without are almost entirely confined to the period of the monetary shock. This is discussed in Christiano (1991).

[19]If the limited participation assumption is dropped (so that nominal savings are chosen after the realization of the monetary disturbance), then output and hours rise and interest rates fall following the negative innovation. These are standard results for cash-in-advance economies which arise because of the dominating influence of anticipated inflation effects. See Christiano (1991) for more details on this.

[20]This limitation of the model could be overcome if the limited participation assumption were extended to cover multiple periods along the lines analyzed by Christiano and Eichenbaum (1992).

[21]This is most easily seen by comparing η_R^a and $\hat{\eta}_R^b$ for the case of no equity participation.

[22]In these cases extensive margin rationing in which some type b firms do not receive any external finance arises. As indicated by these examples, extensive margin rationing only occurs in this model for extreme parameter values.

[23]This potential is explored in the recent paper by Cooley and Quadrini (1997).

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Table 1
Parameter values and conditions for their identification

Parameter	Identification condition	Baseline PI	Baseline AI	Excess Sensitivity I PI	Excess Sensitivity I AI	Excess Sensitivity II PI	Excess Sensitivity II AI
v	fixed *a priori*	0.5	0.5	1	1	0.5	0.5
d	average leverage ratio	0.5	0.5	0.9	0.9	0.8	0.8
ψ	average mark-up	1.05	1.05	2	2	1.5	1.5
μ	average bankruptcy costs:assets ratio	0	0.13	0	0.20	0	0.20
σ_θ	average interest rate spread	0	0.41	0	0.06	0	0.14
λ	type a firms' share of total sales	0.70	0.48	0.70	0.68	0.70	0.66
ξ^a	zero profits for type a firms	0.03	0.05	0.42	0.44	0.29	0.30
ξ^b	zero profits for type b firms	0.03	0.04	0.42	0.43	0.29	0.29
e^a	leverage ratio for type a firms	0.41	0.59	0.08	0.08	0.16	0.17
e^b	leverage ratio for type b firms	0.41	0.24	0.08	0.07	0.16	0.14
α	capital's share of total income	0.29	0.29	0.29	0.29	0.29	0.29
η	average work hours:total hours ratio	1.61	1.61	1.61	1.61	1.61	1.61

Notes to table 1. See sections 2 and 3 for parameter definitions. I use the methodology outlined in Cooley and Prescott (1995) to measure capital's share of total income. Unlike them I do not include government and the services from durable consumption goods in my measure of total income since the credit market imperfections modelled here do not seem to apply in these cases. I estimate the mean of capital's income share to be 0.31. This does not match the value for α due to the fact that I identify dividend income from intermediaries as capital income. See section 3 for a description of the column labels.

Table 2
Features of the steady state in the Asymmetric Information and Perfect Information models

Variable	Description	Baseline PI	Baseline AI	Excess Sensitivity I PI	Excess Sensitivity I AI	Excess Sensitivity II PI	Excess Sensitivity II AI
$(1-\lambda)G(\gamma)$	bankruptcy rate	0	0.02	0	0.01	0	0.01
$\frac{\mu(1-\lambda)G(\gamma)l^b}{pY}$	bankruptcy costs:output ratio	0	0.001	0	0.002	0	0.002
$\frac{(1-\lambda)G(\gamma)l^b}{pY}$	failed firm liabilities:output ratio	0	0.008	0	0.009	0	0.009
$z\left(l^a+e^a\right)$	type a firm size	0.83	1.20	0.84	0.87	0.84	0.89
$z\left(l^b+e^b\right)$	type b firm size	0.83	0.48	0.84	0.79	0.84	0.74
$\xi^a/(zl^a)$	type a overhead ratio	0.03	0.04	0.50	0.50	0.30	0.33
$\xi^b/(zl^b)$	type b overhead ratio	0.03	0.08	0.50	0.54	0.30	0.39
Υ^a	type a effective overhead ratio	-0.94	-0.44	0.44	0.44	0.12	0.25
Υ^b	type b effective overhead ratio	-0.94	-0.38	0.44	0.49	0.12	0.31

Notes to table 2. All table entries are in levels. See table 1 for the parameter values underlying the different cases. The variables are defined in sections 2 and 4.

Table 3

Impact responses following an unanticipated 1 per cent reduction in money growth in the Asymmetric Information and Perfect Information models

		Baseline		Excess Sensitivity I		Excess Sensitivity II	
Variable	Description	PI	AI	PI	AI	PI	AI
Y	aggregate output	-0.26	-0.25	-0.40	-0.50	-0.32	-0.31
H	aggregate hours	-0.35	-0.35	-0.28	-0.28	-0.31	-0.31
R	intermediary cost of funds	225	226	262	293	237	242
q	nominal aggregate demand	-0.88	-0.89	-0.70	-0.61	-0.76	-0.78
z	marginal product of a loan	1.38	1.38	1.10	1.10	1.20	1.19
l^b/l^a	relative volume of type b loans	0	1.82	0	-0.08	0	0.22
$(1/p)\int_0^\lambda p_i y_i di$	sales of type a firms	-0.26	-0.62	-0.40	-0.38	-0.32	-0.38
$(1/p)\int_\lambda^1 p_i y_i di$	sales of type b firms	-0.26	0.60	-0.40	-0.48	-0.32	-0.20
$R^b - R$	interest rate spread	0	-20	0	154	0	-31
$(1-\lambda)G(\gamma)$	bankruptcy rate	0	-6.59	0	46.6	0	-11.5

Notes to table 3: All entries are in per cent except entries involving interest rates. These are measured in basis points at an annual rate. See table 1 for the parameter values underlying the different cases. The variables are defined in sections 2 and 4.

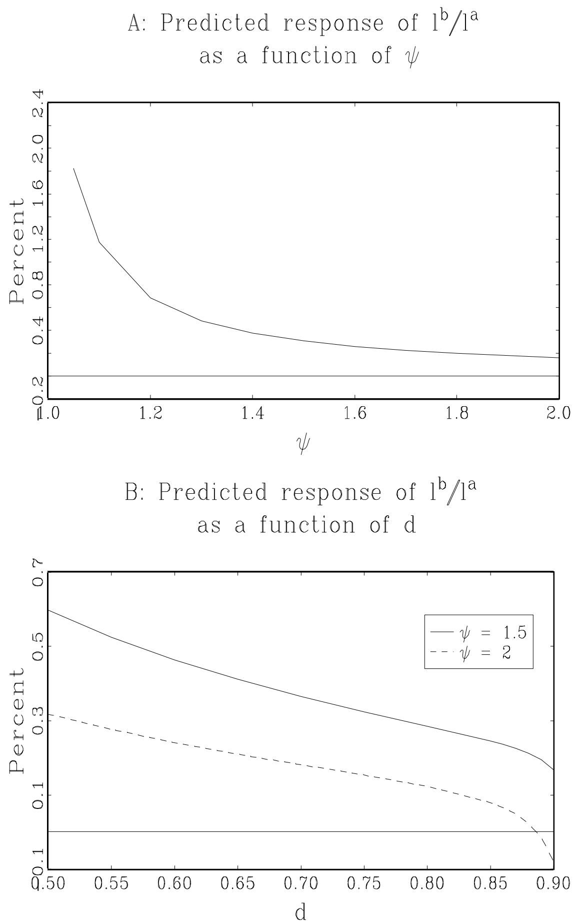
Table 4

Comparative Statics in the Contract Problem

Exogenous Variable	Endogenous Variable l^b	$R^b - R$	γ	sales
q	$+$	$+/-$	$+/-$	$+$
z	$+$	$+/-$	$+/-$	$+$
R	$-$	$-/+$	$+$	$-$

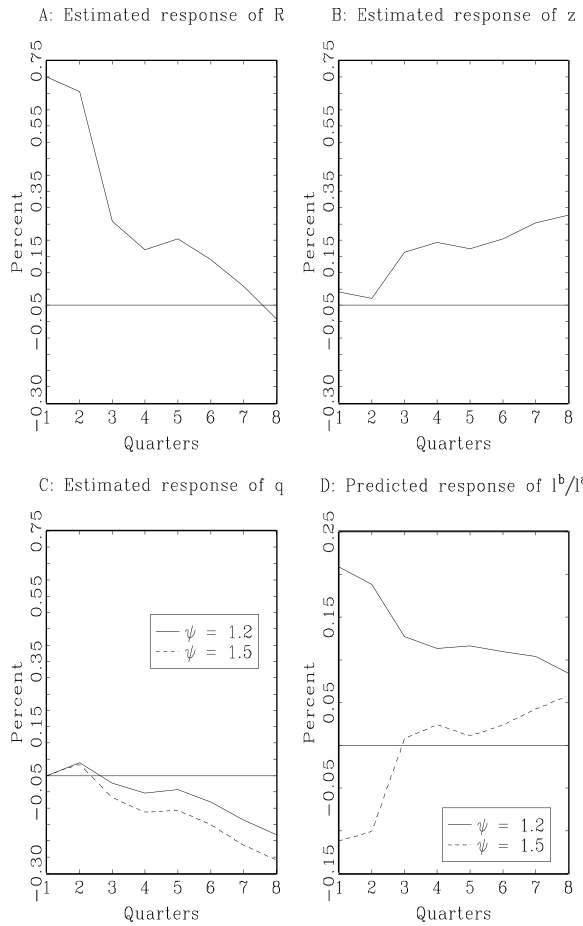
Notes to table 4: See section 2 for variable definitions. Entries in the table are the local dependence of the indicated endogenous variable to perturbations in the indicated exogenous variable. When one sign is shown for an endogenous variable this indicates the dependence does not depend on the mark-up. When two signs are shown for a given endogenous variable the first is for low markups ($\psi \leq 1.1$) and the second is for high markups ($\psi \geq 1.5$). All entries are for interior solutions to the contract problem.

Figure 1. General Equilibrium Predictions for l^b/l^a.



Notes to figure 1. The plots depict the impact response of relative debt flows to an unanticipated one percentage point reduction in monetary growth for the indicated parameter values. As the indicated parameters vary, the other parameters are re-calibrated according to the criteria described in section 4. ψ denotes the mark-up and d is the leverage ratio.

Figure 2. Partial Equilibrium Predictions for l^b/l^a.



Notes to figure 2. Figures 2A-2C are estimated responses of the indicated variables to a one standard deviation innovation to the interest rate. See Appendix B for details on the estimation. Figure 2D depicts the responses for the indicated variable as predicted by the partial equilibrium model, conditional on the estimated responses shown in figures 2A-2C. Finally, ψ denotes the mark-up.