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Abstract

This paper presents an additional credit channel for monetary policy that would arise in the presence of credit rationing. I formally examine a situation in which new entry firms have no choice but to borrow funds from a financial intermediary to cover entry costs, taking into account the fact that most of the small and young firms are bank dependent in practice. It turns out that the presence of nominal debt contracts allows the central bank to influence firm entry and thereby aggregate output through its effect on the severity of credit rationing even in the absence of price stickiness. This is because a decrease in the nominal interest rate reduces the cost of funds for lending, which enables financial intermediaries to extend credit to less creditworthy firms. This "credit rationing effect" is absent in the conventional balance-sheet channel, where loan rates are determined such that credit demand is equal to credit supply.

JEL Classification: E32, E44, E52

Keywords: credit channel, credit rationing, firm entry, monetary policy transmission.

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1 Introduction

The credit channel of monetary policy has traditionally been divided into two categories: the *bank lending channel* (Kashyap, Stein and Wilcox, 1993, Kashyap and Stein, 2000) and the *balance sheet channel* (Bernanke, Gertler and Gilchrist, 1999). The bank lending channel is a supply-driven channel in the sense that monetary policy has real effects through its influence on bank liquidity. If the central bank tightens monetary policy and the volume of bank liquidity available for lending is reduced, then financially constrained banks are forced to cut their lending. Since a decline in the amount of bank lending leads firms to get other relatively costly sources of funds, such as trade credit, those firms are expected to reduce capital investment and output. On the other hand, the balance sheet channel is a demand-driven channel in the sense that monetary policy has real effects through changes in the cost of borrowing, so called external finance premium. If the value of firms' net worth is reduced after a rise in the policy rate, then banks increase their lending rates since the relative size of external finance to the firm's net worth increases and extending credit thus becomes riskier. Such a rise in the borrowing costs weakens the firms' demand for external finance, which leads to a decline in investment and output.[1]

It is widely recognized that small and medium size enterprises (SMEs) are more susceptible to shifts in monetary policy compared to large firms (Gertler and Gilchrist, 1993, 1994, Bougheas et al., 2006). However, there seems to be less agreement about the reason why. From the point of view of the bank lending channel, SMEs' investments and output are more sensitive to monetary policy than larger firms' since SMEs do not have access to alternative sources of external finance such as CP or corporate bonds, which are mostly issued by large firms. This means that more SMEs will become unable to obtain external funds as the supply of bank loans decreases. Advocators of the balance sheet channel, on the other hand, argue that SMEs bear the brunt of a tightening of monetary policy since SMEs' external finance premium tends to be higher than large firms' after a rise in the policy rate (Bernanke, Gertler and Gilchrist, 1996). This reduces SMEs' demand for external funds to a larger extent than demand by large firms.

In this paper I present an alternative channel of monetary policy in which the central bank can affect the volume of bank lending by altering the degree of credit rationing. Although the role of credit rationing has been deemed a key factor in the context of the bank lending channel, its logic has been criticized since most financial institutions in practice can usually raise external funds from the financial market in various ways.[2] Ashcraft and Campello (2007) also point out that small banks that are affiliated with the same holding company can reallocate funds internally in response to monetary policy shocks. Ashcraft and Campello (2007) conclude that borrowers' creditworthiness is crucial in determining

[1] See Bernanke and Gertler (1995) for a survey of the literature on the credit channel.

[2] See, for example, Bernanke (2007).

the volume of bank loans. In Bernanke et al.'s (1999) "financial accelerator" model, on the other hand, the possibility of credit rationing is precluded for the purpose of solving the model, so that the credit market is always equilibrated. However, various kinds of data and empirical studies strongly support the existence of credit rationing, and some of them report that monetary policy influences the degree of credit rationing (e.g., Atanasova and Wilson, 2004).

Based on Bergin and Corsetti (2005), Ghironi and Melitz (2005) and Bilbiie et al. (2007, 2008), I explore the effect of monetary policy within a DSGE framework that incorporates endogenous firm entry.[3] As in those endogenous entry models, I assume that potential entrants have no net worth at the time of entry. It follows that every prospective entrant is required to raise funds to cover entry costs. The most important departure from these previous studies is that new entry firms have no choice but to get credit from a financial intermediary to finance entry costs, while the standard models allow new entry firms to issue equity. I consider a situation in which other sources of financing such as equity, commercial papers and corporate bonds are unavailable for prospective entrants.[4] In this environment, *every* prospective firm tries to enter the market as long as there is a positive probability of repayment since the expected profit is nonnegative due to the limited liability property of a debt contract. Accordingly, whether or not a potential firm enters the market depends fully on the availability of credit.

Following Williamson (1987), Bernanke et al. (1999) and others, financial intermediaries are required to incur auditing costs in order to reveal the state of defaulted firms (costly state verification). In the presence of auditing costs there would exist a threshold of loan rates above which the lender can no longer extend credit.[5] If the lending rate is determined at the threshold value, then some applicants will necessarily be unable to obtain credit. In fact, the analysis shows that credit rationing arises in equilibrium since prospective entrants continue to try to enter the market until the financial intermediary becomes unable to extend credit. The number of new firms is determined at a finite value even though the expected profits of entry are still positive.

It turns out that a change in the nominal interest rate has a significant impact on real output through its effect on bank lending as long as financial contracts are made in nominal terms. The intuition for this is as follows: suppose that the central bank cuts the nominal interest rate, which is the cost of funds for financial intermediaries. Since

[3]Devereux et al. (1996), Broda and Weinstein (2007) and Bernard, et al. (2006) show that net firm entry is procyclical and a significant fraction of output fluctuations is attributable to the creation of new products and the destruction of existing products.

[4]Jaffee and Stiglitz (1990) provide some reasons why bank lending tends to be the only source of financing for small firms.

[5]Another strand of literature, such as Stiglitz and Weiss (1981), focuses on adverse selection between lenders and borrowers as the source of credit rationing. See Jaffee and Stiglitz (1990), Tirole (2006) and Freixas and Rochet (2008) for a survey of the literature on credit rationing.

a zero profit condition should be met in nominal terms, a reduction in the nominal cost of funds will allow the financial intermediaries to take higher risks. This implies that a part of the prospective entrants who are otherwise unable to obtain credit become able to get credit. Therefore, an expansionary monetary policy enhances new firm entry and stimulates aggregate output. This "credit rationing channel" differs from the conventional bank lending channel in that rationing stems not from the lack of bank liquidity, but from the lack of borrowers' creditworthiness. In this sense, the credit rationing channel may be viewed as complementing the traditional balance sheet channel.

The analysis also shows that there arises a procyclicality of net entry and bank loans, and the countercyclicality of credit spread. Since the number of firms is allowed to vary over time, macroeconomic shocks have two sorts of impacts on real output: first, a favorable economic shock increases aggregate output by directly affecting existing firms' production (intensive margin). Second, it affects aggregate output by stimulating new firm entry (extensive margin). An increase in the number of firms expands aggregate output not only by directly adding new products, but also by indirectly stimulating incumbent firms' production. It turns out that the extensive margin has a larger influence on output than the intensive margin.

This paper shares its purpose with Blinder's (1987) seminal work. Blinder (1987) examines the role of credit rationing in monetary policy transmission within a system of ad hoc macroeconomic relations, while I construct a microfounded model with endogenous firm entry. The influence of monetary policy on firm dynamics is also explored by Bergin and Corsetti (2005) and Bilbiie et al. (2008), who assume that new entrants are able to issue equity to cover entry costs. In their models, a policy shift can affect each firm's entry decision through its influence on the firm's current value as long as price stickiness exists. In contrast, the real effect of monetary policy considered in this paper does not rely on the existence of sticky prices. Other studies related to this paper are De Fiore and Tristani (2008) and Stebunovs (2008). De Fiore and Tristani (2008) considered the role of nominal financial contract in a model without endogenous entry based on Bernanke et al.'s (1999) model. Stebunovs (2008) introduced endogenous entry into a DSGE model with banks, but he considered a situation in which banks' bargaining power is so strong that they can collect all the firms' profits without incurring auditing costs.

2 SMEs' credit constraints and the real economy: The case of Japan

Before proceeding to a formal analysis, this section takes a brief look at the Japanese data regarding the condition of SMEs' external finance and its relation with the real economy.

2.1 Two types of credit rationing

In general, credit rationing arises for two reasons. One is the lack of borrower's creditworthiness. If a loan applicant is judged unable to yield a sufficient amount of profits in the future, then the expected net return of lending will be negative and the bank will not extend credit. Let us call this sort of rationing *type-D credit rationing* since it stems from a demand-side reason. The other possibility is that banks cannot extend credit even when the net expected return of lending is nonnegative. This situation arises either when banks cannot collect enough funds for lending, as the theory of bank lending channel insists, or when banks are constrained by the bank-capital requirements. Financial institutions that do not have enough capital are required to control the total amount of loans to meet bank capital requirements.[6] If this is the case, the source of SMEs' difficulty in external finance stems from banks' balance-sheet condition rather than applicants' credit worthiness. Let us call this type of rationing *type-S credit rationing* since it is caused by a supply-side factor.

A necessary condition for the theoretical analysis of this paper to be valid is that the size of type-D rationing is economically significant. It can be said that type-D credit rationing always exists in practice, while type-S rationing may be absent as long as banks have enough capital and the liquidity available for lending is abundant. However, it is beyond the scope of this paper to quantify to what extent actual SMEs are constrained by type-D rationing, although I show some evidence of its existence. The purpose of this paper is not to replace the widely recognized policy transmission mechanism, but to investigate the possibility of an additional channel of monetary policy transmission.

Examining the existence of credit rationing in a formal way is necessarily difficult since it requires an identification of loan demand. One possible way is to apply an econometric method that can be used for disequilibrium models (e.g., Madala and Nelson, 1974, Gersovitz, 1980). In this strategy, demand and supply functions for loans are estimated and the estimates are then used to figure out if credit rationing exists.[7] In the following, I instead show more direct evidence for the presence of rationing using survey data concerning Japanese SMEs.

2.2 Limited availability of credit for SMEs: Evidence from survey data

First of all, I show data taken from the *Basic Survey of Small and Medium Enterprises*, which is published by the Ministry of Small and Medium Enterprise Agency every year. Table 1 reports the proportion of SMEs for which the application of a bank loan has been

[6] Van den Heuvel (2006) investigates the effectiveness of monetary policy when a bank capital requirement matters.

[7] Atanasova and Wilson (2004) adopt this strategy using the UK data.

denied by their "main banks" in the past year.[8] It reveals that at least 6- 9.16% of loan applicants had their loan application refused or the amount of it reduced. One might think that this fraction is not significant, but there are at least two possibilities that this may be misleading. First, there is a strong possibility that there exists "discouraged borrowers", who did not apply for loans because they thought they would be rejected even though they needed funds. Unfortunately, precise data on the number of discouraged borrowers is not available regarding Japanese SMEs, but the *Survey of Small Business Finances (SSBF) 2003* in the US reports that 17.9% of SMEs turns out to be discouraged borrowers.[9] The proportion of discouraged borrowers would not be much smaller in Japan than in the US.

The second limitation of the above survey data is that young firms that have launched over the past few years are not included due to the unavailability of real-time information. For example, the sample firms included in *the Basic Survey of Small and Medium Enterprises 2008* are taken based on information available at *the Establishment and Enterprise Census 2006* published by the Ministry of Internal Affairs and Communications.[10] It is expected that younger and smaller firms are more financially constrained compared to older and larger SMEs. If this is the case, the extent of credit rationing will be more severe than the above data suggests. To examine this possibility, the difference in the fraction of SMEs that have some problems with external finance is shown in Table 2. It states that among the SMEs that are at the initial stage of firm growth, 38.7% of them answered that there is a problem with external financing. The corresponding fraction reduces to 2.6% for the most developed SMEs. This strongly suggests that the fraction of firms that have a problem obtaining funds shown in Table 1 is biased downward in that the *Basic Survey of Small and Medium Enterprises* does not include the youngest SMEs that are most likely to be financially constrained.

Next, let us look at some judgment surveys taken from TANKAN, which is published by the Bank of Japan on a quarterly basis. Figure 1 shows the judgment survey of SMEs on changes in the lending attitudes of financial institutions, lending rates and the easiness with which SMEs get external funds. According to these data, there is a strong correlation between the financial institutions' lending attitude and the easiness with which SMEs obtain external finance: an accommodative lending attitude makes it easier for firms to get external funds. This correlation could be viewed as supporting the conventional balance sheet channel as long as the ease of obtaining external finance stems from changes in the cost of borrowing. However, the figure reveals that SMEs' difficulty in external finance is not necessarily positively correlated to the level of lending rates, which implies that SMEs

[8]There can be various definitions of "main bank", but the *Basic Survey of Small and Medium Enterprises* directly asks each SME who its main bank is.

[9]SSBF 2003 also reports that 85.1% of loan applicants have always been approved and 10.3% have always been denied.

[10]This type of information lag varies each year since the *Establishment and Enterprise Census* is not conducted every year. The maximum lag is 4 years.

do not regard the cost of borrowing as the only source of financing difficulty. There must be another reason why SMEs have problems obtaining external finance. The time-varying severity of rationing is one possible factor that prevents the difficulty of external finance and cost of borrowing from moving in tandem.

As noted above, decomposing the observed rationing into type-S and type-D is beyond the scope of this paper, but some data appear to support the presence of type-D rationing. Table 3 reports that about 50% of SMEs that feel financial institutions' credit standard has been made more stringent attribute the reason to the fact that their profitability has deteriorated while 43.8% of SMEs answer that the increasing difficulty in obtaining external funds stems from financial institutions' problems. In addition, as is shown in Table 2, the fact that the fraction of SMEs that have some problems with external financing declines with firm age implies that the availability of credit depends largely on demand-side factors.

2.3 Loans from financial institutions and firms' entry and exit

If the source of credit rationing comes from the lack of SMEs' credit worthiness, then the ease of obtaining bank loans should be procyclical. From Figure 2, it appears that SMEs' net operating profits lead the ease of external finance, which implies that an increase in the current net profits makes it easier to obtain credit the following year. The coefficient of correlation between the current ease of finance and the one-year lag of net profits is 0.49, while the correlation coefficient between the current ease of finance and current net profits is 0.28.

Let us turn to the relationship between external finance and firms' entry and exit. If a certain fraction of SMEs cannot get credit and the severity of rationing is captured by the above judgment survey regarding the ease in finance, then the index is expected to have a positive correlation with the number of new firm entries since launching new firms usually requires external funds which are difficult to obtain in periods when the financial market is tight. Figure 3 shows this is indeed the case. There is a strong positive correlation between the number of newly launched firms and the ease of obtaining external finance. Figure 4 illustrates the ease in finance, the number of corporate bankruptcies and the growth rate of loans. It reveals that the number of bankruptcies has a close correlation both with SMEs' financing ease and with the growth rate of outstanding loans. While these figures do not exclude the possibility that changes in the difficulty in external financing is caused by the procyclical fluctuation of bank capital, any formal model that introduces credit rationing should be able to replicate such a pattern of firms' entries and exits.

3 The Model

The model economy consists of a representative household, good-producing firms, a financial intermediary, a central bank, and the government. The representative household consumes a variety of consumption goods while supplying labor service in the goods sector. Since the number of firms is allowed to vary over time, goods firms can be classified into two groups: incumbents and new entrants. New entry firms have to employ a fixed amount of labor in order to make preparations for production at the beginning of the period. The required cost of hiring labor can be viewed as a barrier to entry. In order to cover this entry cost, new entrants have to raise funds in the financial market before producing goods. I consider a situation in which new entrants can borrow funds only from a financial intermediary. Unlike the previous endogenous entry models, new entrants are not allowed to issue equity. Since additional borrowing is not available at the end of the entry period, they go bankrupt if they fail to earn enough profits to repay the principal plus interest to the financial intermediary. Specifically, firms will go bankrupt if they are hit by an idiosyncratic productivity shock that is smaller than the endogenously determined threshold. The sequence of events is shown in Figure 4.

3.1 Households

The one-period utility function of a representative household is given as

$$U_t = \log C_t - \eta \int_{i\in\Omega_t} \frac{L_t(i)^{1+\phi}}{1+\phi} di - \tilde{\eta} \int_{j\in\Omega_t^e} \frac{f_t(j)^{1+\tilde{\phi}}}{1+\tilde{\phi}} dj, \quad \phi, \tilde{\phi}, \eta, \tilde{\eta} > 0$$

where $C_t \equiv \left[\int_{i\in\Omega_t} C_t(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$, and $C_t(i)$ and $L_t(i)$ are the consumption of differentiated good i and hours worked for the production of consumption good i, respectively. $\theta\,(>1)$ denotes the elasticity of substitution between the variety of goods. $\Omega_t \subset \Omega$ is the set of total variety of goods available in period t. $\Omega_t^e \subset \Omega_t$ denotes the set of production variety produced by new entrants. The mass of total firms including new entrants is denoted by N_t, while the mass of new entrants is denoted by N_t^E. $f_t(j)$ represents hours worked at new entry firm j in preparation for production. The optimization of the allocation of consumption goods yields the aggregate price index $P_t \equiv \left[\int_{i\in\Omega_t} P_t(i)^{1-\theta} di\right]^{\frac{1}{1-\theta}}$, where $P_t(i)$ denotes the price of good i.

The household needs to use cash to purchase consumption goods. At the beginning of period t, the amount of cash available for the purchase of consumption goods is $M_t + \int_{j\in\Omega_t^e} \tilde{W}_t(j) f_t(j) dj - S_t$, where M_t is the nominal balance held from period $t-1$ to t, and $\int_{j\in\Omega_t^e} \tilde{W}_t(j) f_t(j) dj$ represents the total nominal preparatory-labor wage paid by new entrants at the beginning of period t. The production-labor wage $\int_{i\in\Omega_t} W_t(i) L_t(i) di$ is paid after production has started. The household also makes a one-period deposit S_t

at the beginning of the period, the interest on which, R_t, is paid at the end of the period. Accordingly, the following cash-in-advance (CIA) constraint must be satisfied at the beginning of period t:[11]

$$P_t C_t \leq M_t + \int_{j \in \Omega_t^e} \tilde{W}_t(j) f_t(j) dj - S_t.$$

The household's budget constraint is given by

$$M_{t+1} = M_t + \int_{j \in \Omega_t^e} \tilde{W}_t(j) f_t(j) dj - S_t - P_t C_t + R_t S_t + \int_{i \in \Omega_t} W_t(i) L_t(i) di + \Pi_t - T_t$$

where Π_t denotes the sum of profits transferred from firms and the financial intermediary, and T_t is a lump-sum tax. Since the CIA constraint holds with equality in each period as long as there is an opportunity cost of holding cash, the budget constraint can be rewritten as:

$$P_t C_t + S_t = \int_{j \in \Omega_t^e} \tilde{W}_t(j) f_t(j) dj + R_{t-1} S_{t-1} + \int_{i \in \Omega_{t-1}} W_{t-1}(i) L_{t-1}(i) di + \Pi_{t-1} - T_{t-1}.$$

Due to the CIA constraint, the production-labor wage income in period t, $\int_{i \in \Omega_t} W_t(i) L_t(i) di$, cannot be used until period $t+1$ while the preparatory-labor wage income, $\int_{j \in \Omega_t^e} \tilde{W}_t(j) f_t(j) dj$, can be spent in period t.

The first-order conditions for the household's optimization problem are

$$R_t^{-1} = E_t \frac{\beta P_t C_t}{P_{t+1} C_{t+1}}, \tag{1}$$

$$\frac{\tilde{W}_t}{P_t} = \tilde{\eta} C_t f_t^{\tilde{\phi}}, \tag{2}$$

$$\beta E_t \frac{W_t(i)}{P_{t+1} C_{t+1}} = \eta L_t^{\phi}(i), \tag{3}$$

where β and E_t are the subjective discount factor and the expectations operator conditional on information in period t. I assume that the amount of labor required for the preparation of production is independent of production level and is identical across firms ($f_t(j) = f_t > 0, \forall j$). Accordingly, the nominal wage $\tilde{W}_t$ turns out to be identical across new firms. The first two conditions are fairly standard. Eq. (3) says that current disutility of labor must equal to the real wage evaluated in terms of future price level and future marginal utility of consumption. This is because the production-labor wages cannot be spent until the next period while the household incurs disutility of labor today. Using the Euler equation (1), this relation can be rewritten as

$$\frac{W_t(i)}{P_t} = \eta R_t C_t L_t^{\phi}(i). \tag{4}$$

[11] It is assumed that financial markets open before the goods market.

Eq. (4) is a labor supply condition that equates the real wage to the marginal rate of substitution between consumption and leisure. However, unlike the standard case, the nominal interest rate R_t also appears in the relation. The presence of R_t represents the distortion stemming from the time lag between the earning and spending of wage income. As will be seen below, the nominal interest rate has a real impact on the economy due to this time-lag. An intuitive reason for the appearance of the nominal interest rate in (4) is as follows. In the optimal equilibrium, the current disutility of labor must equal to "future real wage", $W_t(i)/P_{t+1}$, times future marginal utility of consumption, C_{t+1}^{-1}. On the one hand, the difference between the current real wage, $W_t(i)/P_t$, and "future real wage" is given by the rate of inflation. On the other hand, the Euler equation (1) suggests that the difference between the current and the future marginal utility of consumption is given by the real rate of interest. Therefore, when optimality condition (3) is expressed exclusively by time-t variables, inflation terms offset each other and only the nominal interest rate term remains.

3.2 Goods sector

Each goods firm produces a differentiated product after observing productivity shocks. The production function takes a form of a constant-returns-to-scale function:[12]

$$Y_t(i) = (Z_t + z_t(i))L_t(i), \tag{5}$$

where $Y_t(i)$, Z_t and $z_t(i)$ denote output, a common productivity shock and an idiosyncratic productivity shock, respectively. Z_t takes a positive value for all t.

There are three economic agents who consume goods: the household, the government and the financial intermediary. The financial intermediary is a consumer of goods since auditing costs take the form of consumption spending. All agents have an identical elasticity of substitution between differentiated goods, which means that they will demand the same consumption basket. It follows that the goods demand function is simply given by

$$Y_t(i) = \rho_t^{-\theta}(i)Y_t, \tag{6}$$

where $\rho_t(i) = P_t(i)/P_t$ and $Y_t = C_t + G_t + \xi_t$. G_t and ξ_t denote the consumption baskets purchased by the government and the financial intermediary, respectively. In the following, I assume that the government spending is determined such that $C_t = \gamma Y_t$ and hence $G_t + \xi_t = (1-\gamma)Y_t$, where $\gamma \in (0,1)$. This implies that fluctuations in ξ_t are completely absorbed by the corresponding shift in the government spending so as to keep the household's consumption a constant fraction of aggregate output. The reason for imposing this assumption is twofold: first, it is natural to consider that the contribution of auditing costs

[12]The essential results below will not change even when we allow for the possibility of decreasing returns to scale.

incurred by financial institutions to GDP is negligible compared to that of household consumption and government spending. Second, this simplification enables us to analytically prove the existence and the uniqueness of the financial market equilibrium. Without this assumption, there arise trivial second and higher order effects of a change in ξ_t on output. This is because ξ_t depends on firms' profits, which depend on aggregate output, which depends on ξ_t, and so forth.

Goods prices are flexible. The relative price of good i is then given as

$$\rho_t(i) = \left(\frac{\theta}{\theta-1}\right)\frac{W_t(i)}{P_t(Z_t + z_t(i))}. \tag{7}$$

Using (4) - (7) and the relation $Y_t = \left[\int_{i\in\Omega_t} Y_t(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$, the aggregate output can be expressed as

$$\begin{aligned} Y_t &= \left[\left(\frac{\theta}{\theta-1}\right)\gamma\eta R_t\right]^{\frac{-1}{1+\phi}} \left[\int_{i\in\Omega_t} (Z_t + z_t(i))^{\alpha} di\right]^{\frac{1}{\alpha}} \\ &= \left[\left(\frac{\theta}{\theta-1}\right)\gamma\eta R_t\right]^{\frac{-1}{1+\phi}} N_t^{\frac{1}{\alpha}} \left[\int_0^{z_u} g(z)(Z_t + z)^{\alpha} dz\right]^{\frac{1}{\alpha}}, \end{aligned} \tag{8}$$

where $\alpha \equiv (\theta-1)(1+\phi)/(1+\theta\phi)$, and $g(z)$ denotes the density function of idiosyncratic shock $z \in (0, z_u)$. As is clear from the equation, an increase in the mass of firms will expand the aggregate output, and a reduction in the nominal interest rate will also have a positive impact on output. As I mentioned above, the latter effect simply comes from the time lag between the payment and the usage of production-labor wages.

Let $d_t(i)$ denote the real profit of firm i. When i denotes a new entry firm, $d_t(i)$ corresponds to the real profit prior to the repayment to the financial intermediary.[13] The diversity in $d_t(i)$ among firms can be expressed solely by the difference in idiosyncratic shocks:

$$\begin{aligned} d_t(i) &= \frac{1}{\theta} Y_t(i)^{\frac{\theta-1}{\theta}} Y_t^{\frac{1}{\theta}} \\ &= \frac{1}{\theta}(Z_t + z_t(i))^{\alpha} \left[\left(\frac{\theta}{\theta-1}\right)\gamma\eta R_t\right]^{\frac{-1}{1+\phi}} N_t^{\frac{1-\alpha}{\alpha}} \tilde{Z}_t^{1-\alpha}, \end{aligned} \tag{9}$$

where $\tilde{Z}_t \equiv [\int_0^{z_u} g(z)(Z_t + z)^{\alpha} dz]^{\frac{1}{\alpha}}$. Whether or not a rise in N_t leads to an increase in the profits depends on the parameter $(1-\alpha)/\alpha$. This is because firm entry has two opposite effects on the demand for each good. While a rise in N_t expands aggregate output and thus stimulates the demand for each individual good, it also has an effect of diluting the demand for individual goods. α is shown to be smaller than unity under the baseline parameter values described below, which generates a widely observed procyclicality of profits.

[13] New entrants pay the right amount of wages to workers before paying back to the financial intermediary. Note that this is always possible since $d_t(i)$ is nonnegative.

As in Ghironi and Melitz (2005) and Bilbiie et al. (2007, 2008), incumbent firms suffer from a "death shock" with probability δ at the end of each period. Those firms hit by a death shock will go out of business immediately. On the other hand, new entry firms exit the market if they fail to repay the loan amount to the financial intermediary. Thus, the dynamics of the mass of firms are given as

$$N_t = N_t^I + N_t^E, \tag{10}$$

$$N_t^I = (1-\delta)N_{t-1}^I + (1-x_{t-1})N_{t-1}^E, \tag{11}$$

where N_t^I denotes the mass of incumbent firms in period t, which is a state variable in period t. x_t represents the probability of default.

Every new entry firm is required to hire a fixed amount of labor, f_t, at the beginning of the period. As in Ghironi and Melitz (2005) and Bilbiie et al. (2007, 2008), the labor needed to build new firm is expressed as $f_t = f_E/Z_t$. f_E is assumed to be constant since the effect of entry regulation or deregulation is not of interest here. This specification suggests that the required labor cost at the time of entry will decrease as common productivity improves.

3.3 Financial intermediary

Let us turn to the financial contract between new entry firms and the financial intermediary. Before observing idiosyncratic productivity shocks, but after a common productivity shock is realized, each prospective entrant borrows funds from the financial intermediary in order to pay entry cost $\tilde{W}_t f_t$. They cannot raise capital in other ways such as equity, trade credits, corporate bonds, commercial paper, etc.

Here, I consider a situation in which a debt contract is made in nominal terms. The lending rate, R_t^l, is determined according to the following risk-neutral no-arbitrage condition:

$$(1-x_t)R_t^l\tilde{W}_t f_t + (1-\mu)\int_0^{\bar{z}_t} g(z)P_t d_t(z)dz = R_t\tilde{W}_t f_t, \quad \mu \in (0,1) \tag{12}$$

where $\bar{z}_t$ denotes the threshold of idiosyncratic productivity shocks below which firms go into bankruptcy. As in Williamson (1987) and Bernanke et al. (1999), the financial intermediary has to incur auditing costs in order to reveal the state of defaulted firms. As is well known, in the presence of such costs, there would arise a threshold of idiosyncratic shocks above which the lender can no longer extend credit. This is because a rise in the threshold will increase the probability of default and thereby increase the expected cost of auditing while a rise in the threshold has a direct positive effect on its revenue through a rise in the lending rate. Following Bernanke et al. (1999), I assume that the auditing costs take a form such that the financial intermediary spends a certain fraction of its revenue on

final goods consumption. This leads to $\xi_t = \mu \int_0^{\bar{z}_t} g(z) d_t(z) dz$.[14] Since prospective entrants are ex ante identical, the financial intermediary assigns an identical loan rate to all firms.

There exists at least two sorts of financial market imperfections here. One is the presence of auditing costs, $\xi_t > 0$. The other is the unavailability of additional liquidity at the end of each period. If financial markets were perfect, then the financial intermediary would try to avoid having firms default by extending additional credit since the firms would continue to earn a positive amount of profits as long as they are alive. In such situations, new entrants could get the same amount of external funds as their discounted value of expected profits, and the financial market structure of this model will basically be the same as that of the standard endogenous entry models. This model does not allow such a possibility of additional borrowing since firms are forced to go bankrupt before financial markets reopen. One possible rationale of this situation is that financial institutions do not have accurate information about the future profitability of new entrants. This unavailability of additional credit will keep the mass of new entrants below the efficient level.[15]

Since the central bank injects money into the financial intermediary at the beginning of each period, the financial market equilibrium condition is given as

$$N_t^E \tilde{W}_t f_t = S_t + \Delta M_{t+1},$$

where $\Delta M_{t+1} \equiv M_{t+1} - M_t$. Accordingly, the profits of the financial intermediary are $R_t \Delta M_{t+1}$, which are transferred to the household at the end of the period.

As a preparation for analyzing equilibrium dynamics, let us express eq. (12) in terms of threshold $\bar{z}_t$ and the mass of total firms N_t. First of all, the threshold of default is defined implicitly as

$$P_t d_t(\bar{z}_t) = R_t^l \tilde{W}_t f_t. \tag{13}$$

It follows that the probability of default, x_t, can be given as

$$\begin{aligned} x_t &= Prob(P_t d_t(z_t) < R_t^l \tilde{W}_t f_t) \\ &= Prob(z_t < \bar{z}_t) \\ &= G(\bar{z}_t), \end{aligned}$$

where $G(\cdot)$ denotes the cumulative distribution function of idiosyncratic shocks. Then, eq.

[14] An advantage of this specification of auditing costs is that the financial intermediary always has an incentive to audit since auditing is always beneficial.

[15] Although this paper does not specify a particular microfounded rationale for why the financial intermediary refuses to continue to extend further credit to firms in default, various reasons were proposed in the previous studies. For instance, Stiglitz and Weiss (1983) insisted that a credible threat of cutting off credit will reduce the likelihood that the borrowers undertake risky projects. Jaffee and Stiglitz (1990) provide a brief review of studies on this topic.

(12) leads to

$$(1-G(\bar{z}_t))d_t(\bar{z}_t)+(1-\mu)\int_0^{\bar{z}_t} g(z)d_t(z)dz=\frac{R_t\tilde{W}_t f_t}{P_t},$$

Or, owing to the absence of aggregate uncertainty, the financial contract can be expressed in a more simple form by eliminating terms that are common to both sides of the equation.

$$(1-G(\bar{z}_t))(Z_t+\bar{z}_t)^{\alpha}+(1-\mu)\int_0^{\bar{z}_t} g(z)(Z_t+z)^{\alpha}dz=\theta\tilde{\eta}\gamma f_t^{1+\tilde{\phi}}\tilde{Z}_t^{\alpha}R_tN_t. \tag{14}$$

Note that the "time-lag effect" regarding the wage income has no impact on this financial contract since the term $R_t^{-\frac{1}{1+\phi}}$ appears in every term of eq. (12) and they cancel out each other. For later use, let us define $\Gamma(\bar{z}_t;Z_t)$ as follows:

$$\Gamma(\bar{z}_t;Z_t)\equiv(1-G(\bar{z}_t))(Z_t+\bar{z}_t)^{\alpha}+(1-\mu)\int_0^{\bar{z}_t} g(z)(Z_t+z)^{\alpha}dz.$$

This can be interpreted as the "quasi-expected revenue" from an individual loan.

4 Firm dynamics and the role of credit rationing

4.1 Firm entry

Now, let us consider the dynamics of firm entry and exit. There is an infinite mass of prospective entrants. Since the prospective entrants have never produced goods before entering the market, they have no net worth at first. Those entrants will try to enter the market if and only if the following condition is satisfied:

$$(1-G(\bar{z}_t))\left[\int_{\bar{z}_t}^{z_u}\frac{g(z)}{1-G(\bar{z}_t)}d_t(z)dz-\frac{R_t^l\tilde{W}_t f_t}{P_t}+V_t\right]>0,$$

where V_t denotes the discounted value of expected profits from period $t+1$ onward. Notice that since entrants have nothing to lose, their net benefit is zero in the case of default. We obtain the following proposition:

Proposition 1 *Prospective firms will try to enter the market if N_t is positive finite and $\bar{z}_t<z_u$.*

Proof: The expected profit conditional on repayment is always nonnegative since the following inequality holds:

$$\int_{\bar{z}_t}^{z_u}\frac{g(z)}{1-G(\bar{z}_t)}d_t(z)dz\geq d_t(\bar{z}_t)=\frac{R_t^l\tilde{W}_t f_t}{P_t}.$$

From eq.(9), this inequality holds strictly if N_t is finite and $\bar{z}_t<z_u$. Since the sum of expected discounted profits from period $t+1$ onward is nonnegative, the proposition is proven.

This proposition implies that firm entry continues as long as bank credit is available and there is a positive probability of repayment. The question is: how can the mass of firms be determined at a finite value? We will see in the next section that there arises credit rationing in equilibrium, and thereby N_t and N_t^E are uniquely determined at finite values.

4.2 Equilibrium credit rationing

The discussion above implies that the total demand for funds is basically infinite since an unbounded mass of prospective firms tries to enter the market. Therefore, the determination of the mass of new entrants, N_t^E, depends fully on the financial intermediary's supply of funds. In other words, there is always room for an "effective supply" of funds as long as N_t^E is finite.[16]

In order to see how N_t^E is determined, we have to see eq. (14) in more detail. First of all, in order to exclude a trivial situation in which the probability of default is one, the LHS of (14), $\Gamma(\bar{z}_t; Z_t)$, must have a global maximum at $\bar{z}_t = \bar{z}_t^* < z_u$. If this is not the case, it is optimal for the financial intermediary to set $\bar{z}_t$ at z_u so that no firm will be able to survive. In fact, whether this is the case or not depends on the distribution of idiosyncratic shocks.[17] In the following, I assume that idiosyncratic shocks are uniformly distributed over $(0, z_u)$.

The first-order differentiation of $\Gamma(\bar{z}_t; Z_t)$ with respect to $\bar{z}_t$ leads to

$$\begin{aligned} \Gamma'(\bar{z}_t; Z_t) &= (Z_t + \bar{z}_t)^{\alpha} \left[\alpha(1 - G(\bar{z}_t))(Z_t + \bar{z}_t)^{-1} - \mu g(\bar{z}_t)\right] \\ &= (Z_t + \bar{z}_t)^{\alpha} \left[\alpha(1 - \frac{\bar{z}_t}{z_u})(Z_t + \bar{z}_t)^{-1} - \frac{\mu}{z_u}\right]. \end{aligned} \tag{15}$$

It follows that $\Gamma(\bar{z}_t; Z_t)$ attains the global maximum at

$$\begin{aligned} \bar{z}_t &= \frac{\alpha z_u - \mu Z_t}{\alpha + \mu} \\ &\equiv \bar{z}_t^*. \end{aligned} \tag{16}$$

Recall that the bank will lend funds as long as the equilibrium condition (14) is satisfied. This implies that more and more firms will be entering the market in the situation in which (14) would be still satisfied even after the firms' entry is included in N_t. Consequently, the equilibrium is attained at $z_t = \bar{z}_t^*$. The probability of default turns out to be less than one since $\bar{z}_t^* < z_u$ implies $\mu(z_u + Z_t) > 0$, which holds as long as there is a positive auditing cost. In the absence of auditing costs, z_u becomes identical to $\bar{z}_t^*$ and all the new entrants will go bankrupt. On the other hand, $\bar{z}_t^*$ must be greater than zero to ensure $x_t > 0$, which requires $Z_t < \alpha z_u / \mu$. Let us summarize the results as follows:

[16] The practical importance of "effective supply" was stressed by Blinder (1987).

[17] Bernanke et al. (1999) assumed that the distribution of idiosyncratic shocks has a decreasing-hazard property in order to eliminate the situation in which the probability of default is one in equilibrium.

Proposition 2 *If $\mu \in (0, \alpha z_u/Z_t)$, then the equilibrium probability of default lies between 0 and 1, and N_t is uniquely determined at a positive finite value.*

Figure 6 illustrates the equilibrium relation. Depending on the size of the common shocks realized at the beginning of period t, there are two possible cases prior to the adjustment of N_t. The first situation is that the "quasi-cost of funds", RHS of (14), lies below the maximum of quasi-expected revenue, $\Gamma(\bar{z}_t^*; Z_t)$ (CC). In this case, a financial contract would be made at B provided that the mass of total firms were unchanged.[18] In fact, the mass of total firms will instantly increase until the quasi-cost line reaches $\Gamma(\bar{z}_t^*; Z_t)$. The equilibrium value of N_t equalizes the quasi-cost of funds with $\Gamma(\bar{z}_t^*; Z_t)$.

CC in figure 6 corresponds to the situation in which the financial intermediary can increase its credit supply due either to a decline in the cost of funds or to an increase in the expected revenue (after subtracting auditing costs). In either case, the default risk will be reduced prior to the start of firm entry, so that the financial intermediary becomes able to extend more credit than before until credit rationing arises. Another possible situation is that the cost of funds is greater than the expected revenue (DD). In this case, no prospective entrants can get funds, so that the mass of total firms must decline relative to the previous period's level.

In the literature, this type of credit rationing is called "*pure credit rationing*" (Jaffee and Stiglitz, 1990) or "*type-II credit rationing*" (Keeton, 1979), where some people can get the full amount of credit they demand while apparently identical people cannot.[19] In the model, the presence of the excess demand for funds can be confirmed by the fact that N_t is finite and $\bar{z}_t < z_u$, in which case the entry condition is still satisfied with strict inequality. It follows that the *effective supply* of liquidity to those prospective entrants who cannot obtain credit is a key to stimulating aggregate output. Notice that the source of rationing is not related to the financial intermediary's financial position. This is a situation in which the financial intermediary can obtain external funds as much as it wants, and there is no regulation for the volume of loans. Hence, this situation corresponds to the type-D credit rationing defined in section 2.

An interesting feature concerning firm dynamics is that the response of N_t to common economic shocks is asymmetric, depending on the size of the shocks. To see this, recall that N_t is expressed as the sum of N_t^E and a state variable N_t^I. This implies that N_t^I is a lower bound for N_t since N_t^E is nonnegative. Therefore, if the size of an unfavorable shock is sufficiently large so that $\theta\tilde{\eta}\gamma f_t^{1+\tilde{\phi}} \tilde{Z}_t^{\alpha} R_t N_t^I > \Gamma(\bar{z}_t^*; Z_t)$, then the mass of new entrants will necessarily be zero. Moreover, such a situation may persist for some periods until the equality (14) is restored. In contrast, as far as favorable shocks are concerned, the

[18] Note that the right intersection does not make sense since the financial intermediary can earn positive profits by lowering the threshold.

[19] In contrast, the presence of a binding collateral constraint is an example of *type-I* rationing, where some agents cannot get the desired amount of credit.

equilibrium can always be attained at $\bar{z}_t = \bar{z}_t^*$ since there is no upper bound for N_t^E. I will later discuss the implications of this asymmetric feature in more detail.

5 Equilibrium dynamics

5.1 Equilibrium equations

In the following, I solve the model by focusing on nine endogenous aggregate variables $N_t, N_t^I, N_t^E, x_t, \bar{z}_t, Y_t, R_t^l, d_t(\bar{z}_t), \tilde{W}_t/P_t$. The rest of the endogenous aggregate variables, such as the real interest rate, can be determined residually. Table 4 summarizes the equilibrium equations that are used to solve for the nine endogenous variables. As for the process of exogenous shocks, I employ the following simple autoregressive process:

$$\begin{aligned} Z_t &= Z_{t-1}^{\rho_z} Z^{1-\rho_z} \epsilon_t^z \\ R_t &= R_{t-1}^{\rho_r} R^{1-\rho_r} \epsilon_t^r, \end{aligned}$$

where Z and R denote the steady state values of common productivity shock and the nominal interest rate, respectively. ϵ_t^i, $i = z, r$ represent temporary shocks to the corresponding variable.

If one focuses on the nine endogenous variables listed above, the model can be solved analytically without relying on linearization technique because there is no expectation term in the related equilibrium equations. Steady states of those variables are summarized in Appendix.[20]

5.2 Impulse response

5.2.1 Calibration

The baseline parameter values are as follows: as for the utility parameter, $\phi = 2$, $\tilde{\phi} = 1$, $\eta = \tilde{\eta} = 1$, and $\beta = .99$. R is set at $1/.99$. The consumption-GDP ratio, γ, is .6 and the mean of common productivity shocks is set at 1. Following Bilbiie et al. (2007, 2008), I employ $\theta = 3.8$, and f_E is determined such that it equals to the steady state individual production labor, $Y/[(Z + z_u/2)N^{\theta/(\theta-1)}]$. This leads to $f_E = 2.977$.[21] Bilbiie et al. (2007, 2008) set δ at .025 to match the U.S. data for job destruction, which is 10% per year. In

[20] Since the process of nominal interest rate is exogenously given, the aggregate price level will be indeterminate as long as the public forms rational expectations (Sargent and Wallace, 1975). Nevertheless, the public's expectation formation is left unspecified in obtaining the solutions for the above nine endogenous variables, so that the price level is not necessarily indeterminate if the public's expectation formation is not rational.

[21] In fact, this procedure is possible only if $\phi \neq \tilde{\phi}$. This is why I set $\tilde{\phi}$ at a value lower than ϕ. Setting $\phi < \tilde{\phi}$ does not change qualitative results. However, imposing a high value of $\tilde{\phi}$ will create an extremely large amplification of productivity shocks. This is because the extent of reduction of the entry cost in response to a positive productivity shock increases with $\tilde{\phi}$.

this model, however, there are two exit rates, δ and x. The total exit rate in the steady state is $N^E/N = \delta/(1-x+\delta)$. I set the values of δ and z_u such that $N^E/N = .025$, introducing the assumption that the default probability of new entrants is twice as high as incumbent firms. It results in $\delta = .024$ and $z_u = .130$.[22] The auditing cost parameter, μ is set at .12, following Bernanke, et al. (1999). With these parameter values, the steady state credit spread, defined as $R^l - R$, is .025 per annum. The AR coefficients ρ^z and ρ^r are both set at .9.

5.2.2 A common productivity shock

Figure 7 provides a graphical illustration of the impact of a positive common productivity shock. The effect is twofold. First, a rise in Z_t decreases the quantity of each firm's demand for funds by reducing the preparatory labor needed for entry, f_t. This is reflected by a downward shift of the horizontal line (DD$\rightarrow$ EE). While a rise in Z_t also has an effect of increasing $\tilde{Z}_t^{\alpha}$, this effect is relatively smaller compared to the decrease in f_t. Second, a positive productivity shock also moves $\Gamma(\cdot)$ upward, which corresponds to an improvement in the profitability of borrowers. Consequently, after a positive common productivity shock hits the economy, there arises room for the mass of firms to rise. The new equilibrium is attained at C since firm entry continues until the horizontal line is tangent to $\Gamma(\cdot)$. The value of $\bar{z}$ that maximizes $\Gamma(\cdot)$ is shifted leftward, so that the equilibrium probability of default is lowered.

Figure 8 illustrates impulse responses to a positive (annualized) one-percent deviation of the common productivity shock from the steady state. The path of each variable is shown in terms of the deviation from the corresponding steady state. The figures shows that an improvement in the common productivity increases the mass of firms, the aggregate and per-firm output and the average profit. In particular, the procyclicality of profits and the number of firms has been confirmed by some previous studies such as Devereux et al. (1996), Bergin and Corsetti (2005) and Bilbiie et al. (2007) for the US data. The model is also able to replicate a positive relationship between the volume of loans and firm entry, which is neglected by the standard entry models.

There is also a negative relationship between the credit spread and N_t. To understand this, recall that the loan rate is determined according to the relation $R_t^l = d_t(\bar{z}_t)/(\tilde{W}_t f_t/P_t)$, which represents the ratio of the threshold profit to the amount of loan. It is straightforward to show that this ratio is decreasing in N_t. This states that an increase in the mass of firms will increase the amount of each loan relative to the threshold profit due to a rise in the labor cost. Other things being equal, this leads to a deterioration in the creditworthiness of borrowers. In order to maintain a certain degree of default risk, the financial intermediary has to cut the loan rate so as to keep the borrowers' burden unchanged. Provided R_t is

[22] Setting $\delta = x$ generates virtually the same results.

constant, this will reduce the credit spread.

5.2.3 A monetary policy shock and the credit rationing channel

Next, let us examine the effects of monetary policy shocks. Since goods prices are flexible, the standard interest channel of monetary policy through the Euler equation does not work here. Instead, there are two alternative channels: first, a change in R_t influences the household's labor supply decision, (4), because there is a time lag between the payment and the usage of production-labor wages. Second, a shift in R_t affects the financial intermediary's loan supply by changing the cost of funds. Since a financial contract is made in nominal terms, a change in the nominal cost of funds can change the total amount of loans that can be extended to prospective entrants.

Figure 9 shows impulse responses to a (annualized) one-percent cut in the nominal interest rate. As output and profits are affected by the wage-lag effect as well as a change in N_t, the figure also shows impulse responses under no wage-lag effects.[23] It is shown that the relative importance of the wage-lag effects is limited in the case of aggregate output, while per-firm output and average profit are largely affected by such an effect. This is in part because per-firm profit and average profit are little influenced by changes in N_t when the parameter $(1-\alpha)/\alpha$ is very small.[24]

The figure suggests that the credit rationing channel of monetary policy may play a significant role in the policy transmission mechanism. It turns out that a shift in monetary policy can have significant real effects through its effect on credit supply. A cut in the nominal interest rate will lead the financial intermediary to increase credit by reducing the cost of funds. The intuition is that a reduction in the cost of funds allows the expected (nominal) revenue of each lending to decrease, which enables the financial intermediary to extend credit to less creditworthy borrowers. This enlarges prospective entrants' opportunities to obtain credit and thus promotes firm entry, and consequently the level of loan rate decreases. Recall that a rise in the mass of total firms exacerbates the creditworthiness of prospective entrants by increasing the labor wage to a larger extent than expected profits.

The figure also reveals that the loan rate decreases more than proportionately in response to a decline in R_t so that credit spread declines. Provided that the credit spread remains unchanged, extending credit to less creditworthy borrowers necessarily increases the risk of default, but a reduction in the spread allows the default risk to remain constant. In other words, a reduction in the credit spread will rebalance the borrowers' burden by reducing the interest payment while increasing the principal component due to a rise in the labor cost.

[23] I do this by eliminating the interest terms appearing in the output equation (8) and profit function (9). Of course, the resultant equilibrium is not theoretically meaningful, but this is done just for measuring the pure effect of the credit rationing channel.

[24] $(1-\alpha)/\alpha$ is .024 under the baseline parameter values.

5.2.4 Intensive and extensive margin

I showed that changes in Z_t or R_t have significant influences on output. In fact, these real effects can be distinguished into two categories: intensive and extensive margins. By intensive margin I mean the extent to which the shift in output is generated by an expansion of existing products. On the other hand, extensive margin refers to the extent to which the output fluctuation is due to a change in the variety of products. If the extensive margin turns out to be significantly large, then it implies that firm dynamics will be a major contributing factor to business fluctuations. The effectiveness of the credit rationing channel will be most profound in such situations.

Figure 10 illustrates the output responses attributable to the intensive margin.[25] It also shows the total output responses so that we can figure out the extent of the extensive margin. It turns out that in both shocks, the intensive margin can explain only about one-third of total output fluctuations. Although a productivity shock has a direct influence on output through the production function, its impact is magnified by the presence of credit constraint.

In the case of a policy shock, the only source of the intensive margin is the wage-lag effect. Hence, the figure is essentially the same as the output response shown in Figure 9. As noted above, a change in N_t is quantitatively a more important source of output fluctuation than the wage-lag effect.

5.2.5 Credit crunch

Finally, let us consider the implication of the asymmetric feature in the adjustment of N_t. As briefly discussed above, the nonnegativity of N_t^E creates a lower bound for N_t, N_t^I. For this reason, there arises a possibility that the equilibrium condition (14) might not hold if a large negative productivity shock (or a large positive policy shock) hits the economy. If the negative shock is so large that N_t cannot decline enough to attain the equilibrium, then credit will not be supplied.

Figure 11 shows impulse responses to a (annualized) 20% negative deviation of Z_t from the steady state value. In the face of such a large negative shock, the mass of new entrants immediately takes the value of zero and it takes several periods until the mass of new entrants restores a positive value. During the zero-entry period, the mass of total firms decreases at a rate δ and output also declines along with this. Importantly, aggregate output is no longer positively correlated with the common productivity shock while per-firm output commoves with the shock. The aggregate output continues to decline even after the common productivity has started recovering. This will not be the case when the financial market is under normal conditions, where the amount of credit is always positive. Such discrepancy in movements between aggregate and per-firm outputs stems from a

[25] Impulse responses generated by intensive margin are obtained by fixing N_t at the steady state value.

persistent decline in the mass of firms. The mass of total firms continues to decline until the financial intermediary becomes able to extend a sufficient amount of credit, whereas each firm's output and profit may be improved with a common productivity shock provided the effect of N_t on individual profit, captured by $(1-\alpha)/\alpha$, is not so large. In this sense, the appearance of "credit crunch" prolongs the recession in terms of aggregate output, but this is not necessarily true for per-firm output and profit.

If such a credit crunch emerges, then the effectiveness of monetary policy will largely be undermined. This is because the credit rationing channel, which is a major source of the real effects of the nominal interest rate, disappears in the case of $N_t^E = 0$. Of course, such a situation could be avoided by decreasing the nominal interest rate to a level for which eq. (14) holds with equality. However, since there exists a zero-lower bound of nominal interest rates, any interest rate cut might not be enough to restore a positive value of N_t^E. If this is the case, given that the only policy instrument of the central bank is the nominal interest rate, then all the central bank can do is wait until the mass of incumbent firms (and the labor wage) declines to a level for which the relation $\Gamma(\bar{z}_t; Z_t) = \theta\tilde{\eta}\gamma f_t^{1+\tilde{\phi}} \tilde{Z}_t^{\alpha} N_t$ holds. Nevertheless, this does not mean that a cut in the nominal interest rate during the periods of credit crunch is ineffective. Although monetary policy is seemingly ineffective, keeping the interest rate at zero helps the credit market to promptly re-equilibrate.[26]

Figure 11 also shows that the credit spread takes negative values during the period of zero entry, but this is simply because the equilibrium condition (14) is not satisfied with equality. The credit spread during the zero-entry period should be interpreted as a "shadow credit spread", the level of credit spread that would attain eq. (14) with equality.

6 Concluding remarks

This paper explored a situation in which new entrants have to borrow funds from a financial intermediary in order to cover entry costs. I showed that credit rationing arises in equilibrium since the expected profits for prospective entrants are nonnegative. In this environment, the mass of entry firms depends on the volume of credit financial intermediaries can supply.

It turns out that a cut in the nominal interest rate leads to an increase in the credit supply as long as the debt contract is made in nominal terms. Since an improvement in the availability of credit enhances firm entry, it expands aggregate output as well as per-firm output and profits. A virtue of this credit rationing channel is that the source of rationing does not come from the lack of bank liquidity, but from the lack of borrower creditworthiness. In this sense, the transmission mechanism is not inconsistent with Ashcraft and Campello's (2007) empirical finding. In addition, the credit rationing channel does not rely on the presence of price stickiness. The presence of nominal debt contracts gives the

[26] Mishkin (2009) discusses the effectiveness of monetary policy during financial crises.

central bank the ability to affect the real economy since the nominal interest rate is a cost of funds for lending. The intuition is that a reduction in the cost of funds allows the expected (nominal) revenue of individual lending to decrease, which enables the financial intermediary to extend credit to less creditworthy borrowers.

The main differences in the transmission mechanism between the balance sheet channel, the bank lending channel and the credit rationing channel are summarized in Table 5.[27] The credit rationing channel and the balance sheet channel are similar in that the key policy variable is an interest rate and borrower creditworthiness plays a crucial role in policy transmission. On the other hand, the credit rationing channel and the bank lending channel share the property that the presence of rationing is a key to the policy transmission mechanism, while the sources of supply shortage are different.

The traditional balance sheet channel emphasizes that a shift in monetary policy has real effects through its influence on the borrowers' net worth. However, it only focuses on a demand-driven effect of monetary policy, neglecting the presence of financial market disequilibrium. If credit demand is greater than credit supply, then monetary policy can have real effects through a supply-side channel rather than a demand-side channel. This point will be quite important given the fact that it is necesarily difficult to exactly control long-term interest rates. In practice, financial institutions usually collect funds by issuing securities with short-term maturities, typically deposits, even when lending is based on longer-term contracts. The presence of such maturity transformation suggests that monetary policy will be more effective if the central bank can influence the economy by exploiting a supply-side channel rather than a demand-side channel.

The following topics should be addressed in future research: first, it is necessary to clarify the quantitative importance of the credit rationing channel. To do this, an empirical work will be needed to quantify the relative size of the two types of credit rationing: type-D and type-S. Second, price stickiness is absent in this paper. It would be useful to see how the introduction of price stickiness affects the relative importance of extensive margin to intensive margin in the presence of the credit rationing channel.

7 Appendix

The steady states of $N_t, N_t^I, N_t^E, x_t, \bar{z}_t, Y_t, R_t^l, d_t(\bar{z}_t), \tilde{W}_t/P_t$ can be obtained recursively as follows:

$$\begin{aligned} \bar{z} &= \frac{\alpha z_u - \mu Z}{\alpha + \mu} \\ x &= \frac{\bar{z}}{z_u} \\ N &= \frac{1}{R\theta\tilde{\eta}\gamma f^{1+\tilde{\phi}}\tilde{Z}^{\alpha}}\Gamma(\bar{z}; Z) \end{aligned}$$

[27] These are denoted by BS channel, BL channel and CR channel, respectively.

$$
\begin{aligned}
N^E &= \frac{\delta}{1-x+\delta}N \\
N^I &= \frac{1-x}{1-x+\delta}N \\
Y &= \left[\left(\frac{\theta}{\theta-1}\right)\gamma\eta R\right]^{\frac{-1}{1+\phi}} N^{\frac{1}{\alpha}}\tilde{Z} \\
d(\bar{z}) &= \frac{1}{\theta}(Z+\bar{z})^{\alpha}\left[\left(\frac{\theta}{\theta-1}\right)\gamma\eta R\right]^{\frac{-1}{1+\phi}} N^{\frac{1-\alpha}{\alpha}}\tilde{Z}^{1-\alpha} \\
R^l &= \frac{d(\bar{z})}{\tilde{\eta}\gamma f^{1+\tilde{\phi}}Y} \\
\frac{\tilde{W}}{P} &= \tilde{\eta}\gamma Y f^{\tilde{\phi}}.
\end{aligned}
$$

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Table 1: Availability of credit from the main bank

	2004	2005	2006	2007	2008
Credit application was refused or its amount reduced (among applicants)	8.6	8.8	6	6.8	9.2
Credit application was accepted with tightened borrowing conditions (among applicants)	18.1	17.8	15.8	15.9	17.2
Did not submit credit application in the past year	43	50.9	46.7	49.7	48.7

Source: *Basic Survey of Small and Medium Enterprises*, The Ministry of Small and Medium Enterprises Agency.

Table 2: Availability of credit according to the stage of firm growth

	initial stage	growing stage	stable stage	total
Have obtained funds as desired	61.3	87.9	97.4	93.9
Have not obtained funds as desired	38.7	12.1	2.6	6.1

Source: *White Paper on Small and Medium Enterprises in Japan 2009*, The Ministry of Small and Medium Enterprises Agency. The questionnaire was conducted by Tokyo Shoko Research Ltd.

Note: Only for SMEs that have an experience of R&D investment.

Table 3: What has made external finance difficult?

Financial institutions' problems	43.8
Deterioration in the business condition of the related industry	50.6
Deterioration in my company's profitability	46.4
Deterioration in the asset value of my company and/or the manager	14.2
Others	3.6

Source: *White Paper on Small and Medium Enterprises in Japan 2009*, The Ministry of Small and Medium Enterprises Agency. The questionnaire was conducted by Mizuho Research Institute.

Note: Based on the questionnaire to the SMEs that replied that loans from financial institutions have become tighter than before.

Table 4: Equilibrium equations

Threshold of z	$\bar{z}_t = \frac{\alpha z_u - \mu Z_t}{\alpha + \mu}$
Default probability	$x_t = G(\bar{z}_t)$
No-arbitrage condition	$(1 - x_t)(Z_t + \bar{z}_t)^\alpha + (1 - \mu)\int_0^{\bar{z}_t} g(z)(Z_t + z)^\alpha dz = \theta\tilde{\eta}\gamma f_t^{1+\tilde{\phi}} \tilde{Z}_t^\alpha R_t N_t$
Threshold of profit	$d_t(\bar{z}_t) = \frac{1}{\theta}(Z_t + \bar{z}_t)^\alpha \left[\left(\frac{\theta}{\theta - 1}\right)\gamma\eta R_t\right]^{\frac{-1}{1+\phi}} N_t^{\frac{1-\alpha}{\alpha}} \tilde{Z}_t^{1-\alpha}$
Output	$Y_t = \left[\left(\frac{\theta}{\theta - 1}\right)\gamma\eta R_t\right]^{\frac{-1}{1+\phi}} N_t^{\frac{1}{\alpha}} \tilde{Z}_t$
Preparatory-labor wage	$\frac{\tilde{W}_t}{P_t} = \tilde{\eta}\gamma Y_t f_t^{\tilde{\phi}}$
Lending rate	$R_t^l = \frac{d_t(\bar{z}_t)}{\tilde{W}_t f_t / P_t}$
Mass of incumbents	$N_t^I = (1 - \delta)N_{t-1}^I + (1 - x_{t-1})N_{t-1}^E$
Mass of new entrants	$N_t^E = N_t - N_t^I$

Table 5: Classification of the credit channels

	BS channel	BL channel	CR channel
key policy variable	interest rate	money supply	interest rate
effective supply?	no	yes	yes
source of rationing	n.a.	bank liquidity	creditworthiness

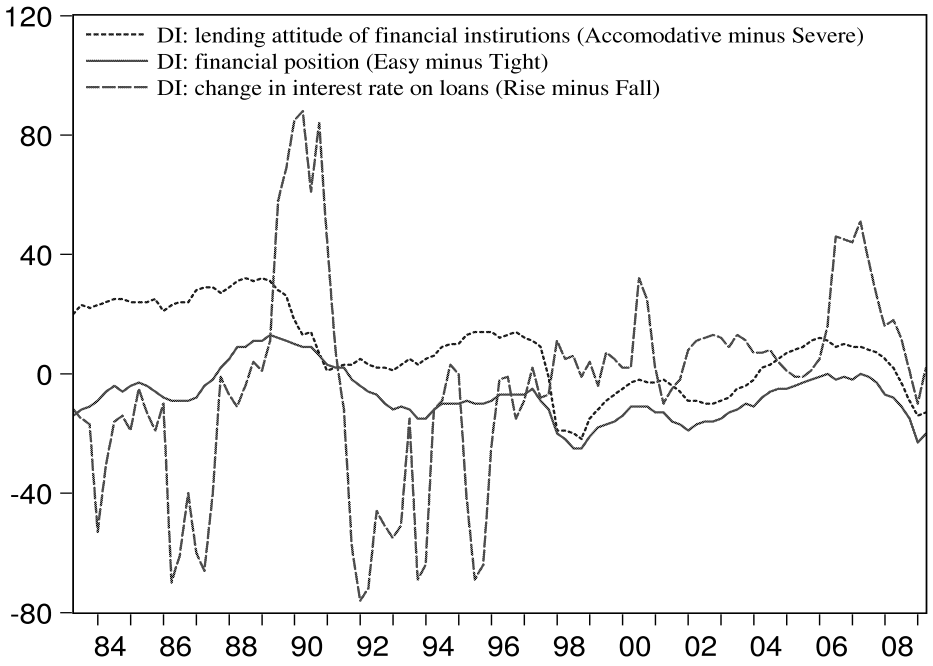

Figure 1: The behaviors of diffusion indices regarding external finance conditions (Source: *TANKAN*, Bank of Japan)

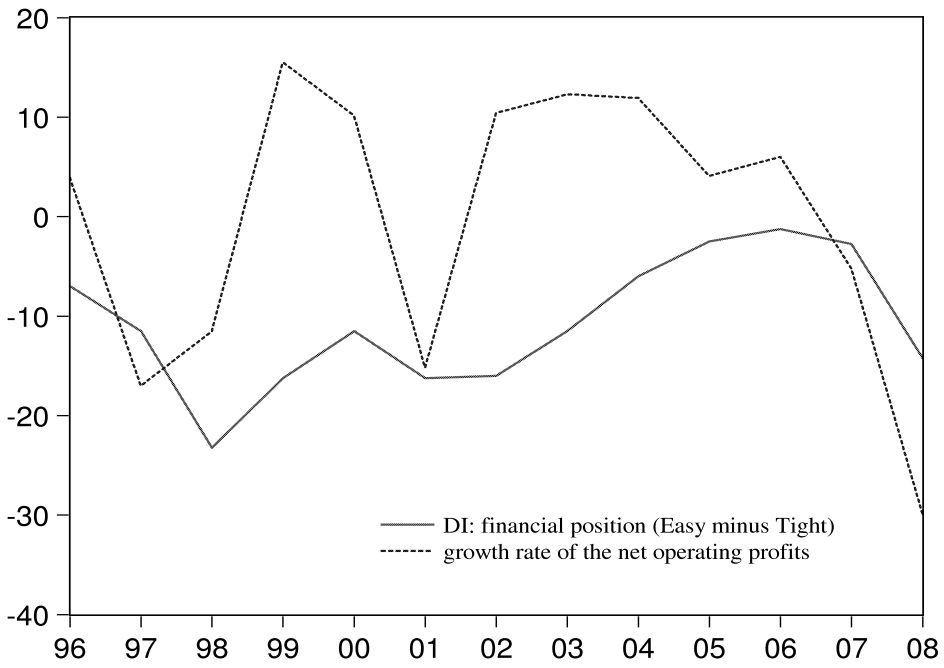

Figure 2: Easiness in external finance and net operating profits (Source: *TANKAN*, Bank of Japan)

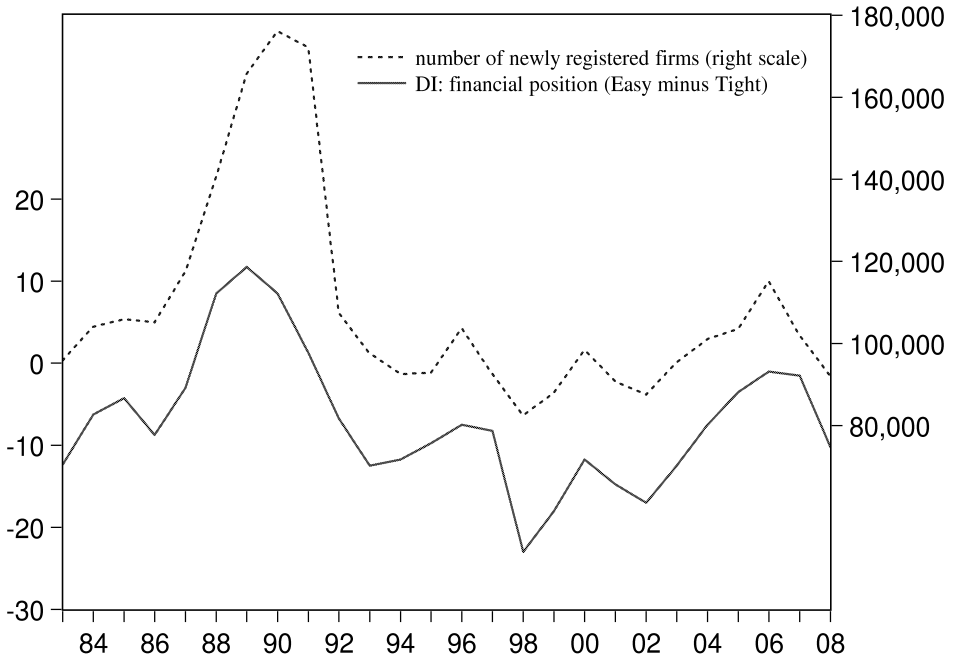

Figure 3: Easiness in external finance and firm entry (Source: *TANKAN*, Bank of Japan, and *White paper on Small and Medium Enterprises 2009*, The Ministry of Small and Medium Enterprise Agency)

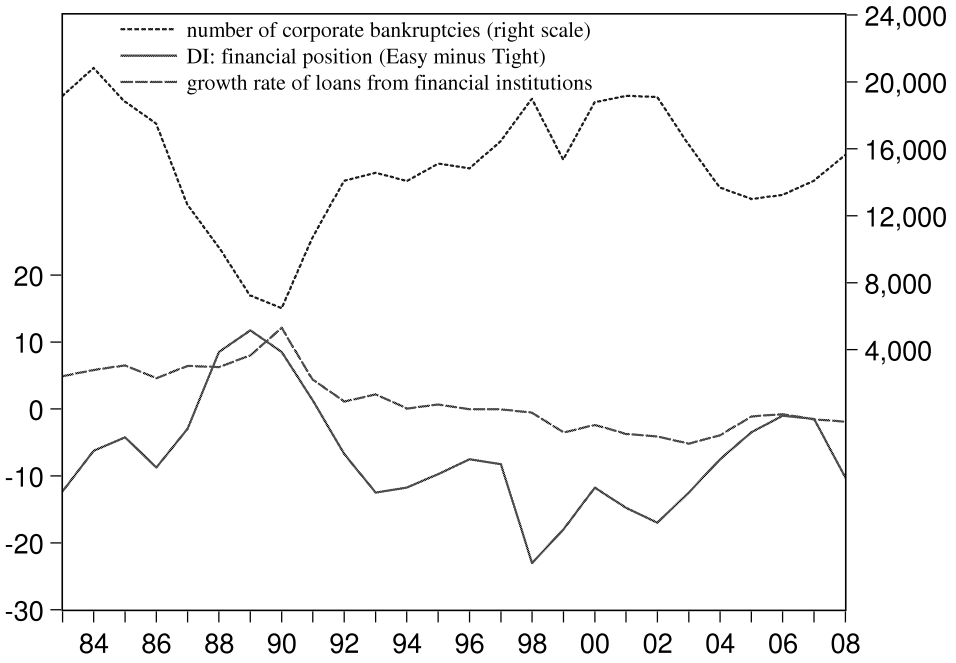

Figure 4: Easiness in external finance and the number of corporate bankruptcies (Source: *TANKAN*, Bank of Japan, and Tokyo Shoko Research Ltd.)

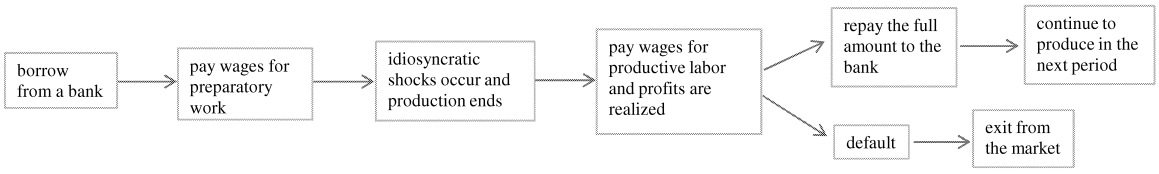

Figure 5: Sequence of events

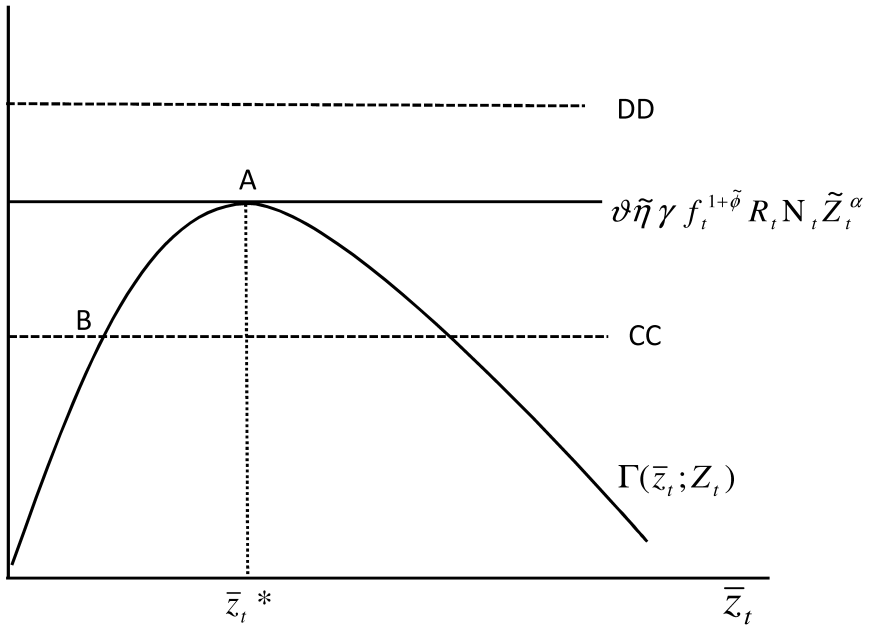

Figure 6: Graphical illustration of equilibrium credit rationing

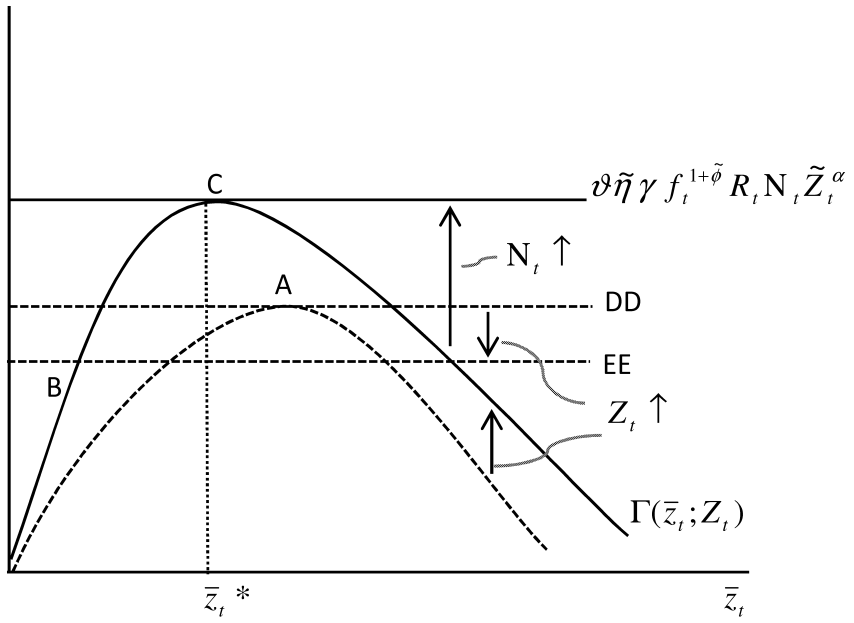

Figure 7: The impacts of a positive common productivity shock

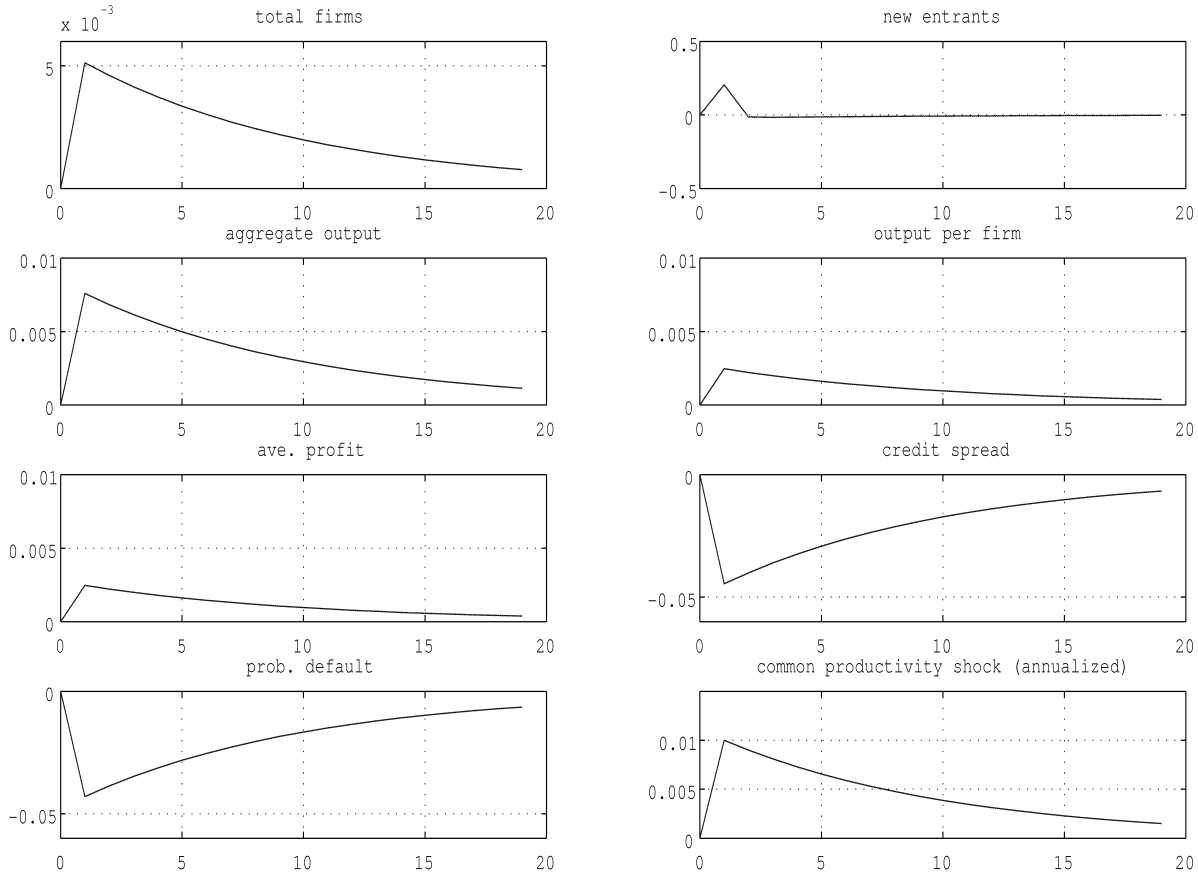

Figure 8: Impulse responses to a one-percent positive productivity shock

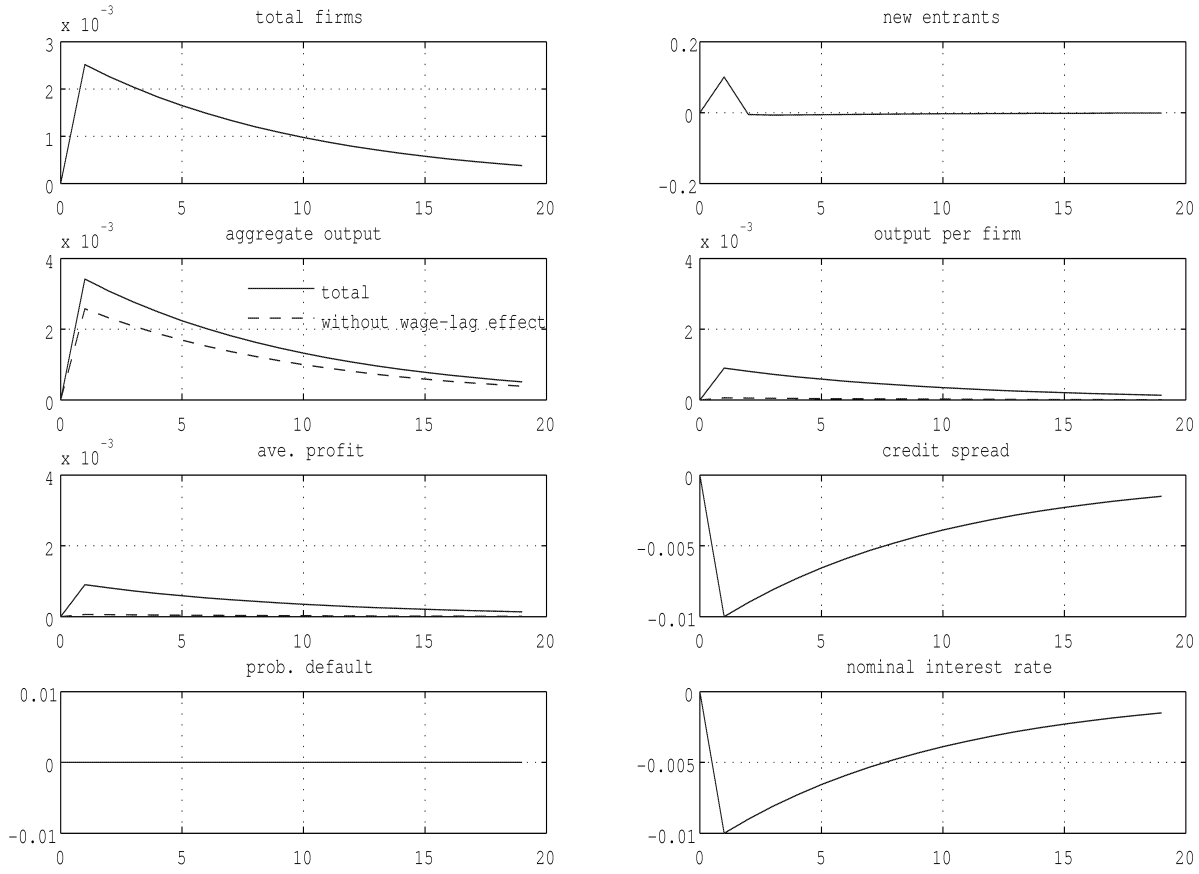

Figure 9: Impulse responses to a one-percent negative policy shock

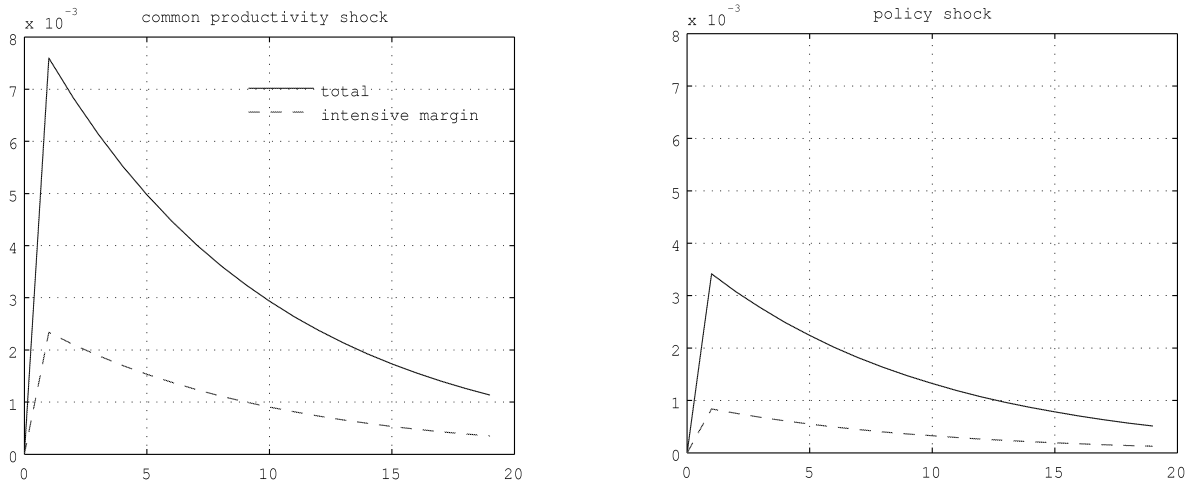

Figure 10: Output responses: Intensive and extensive margins

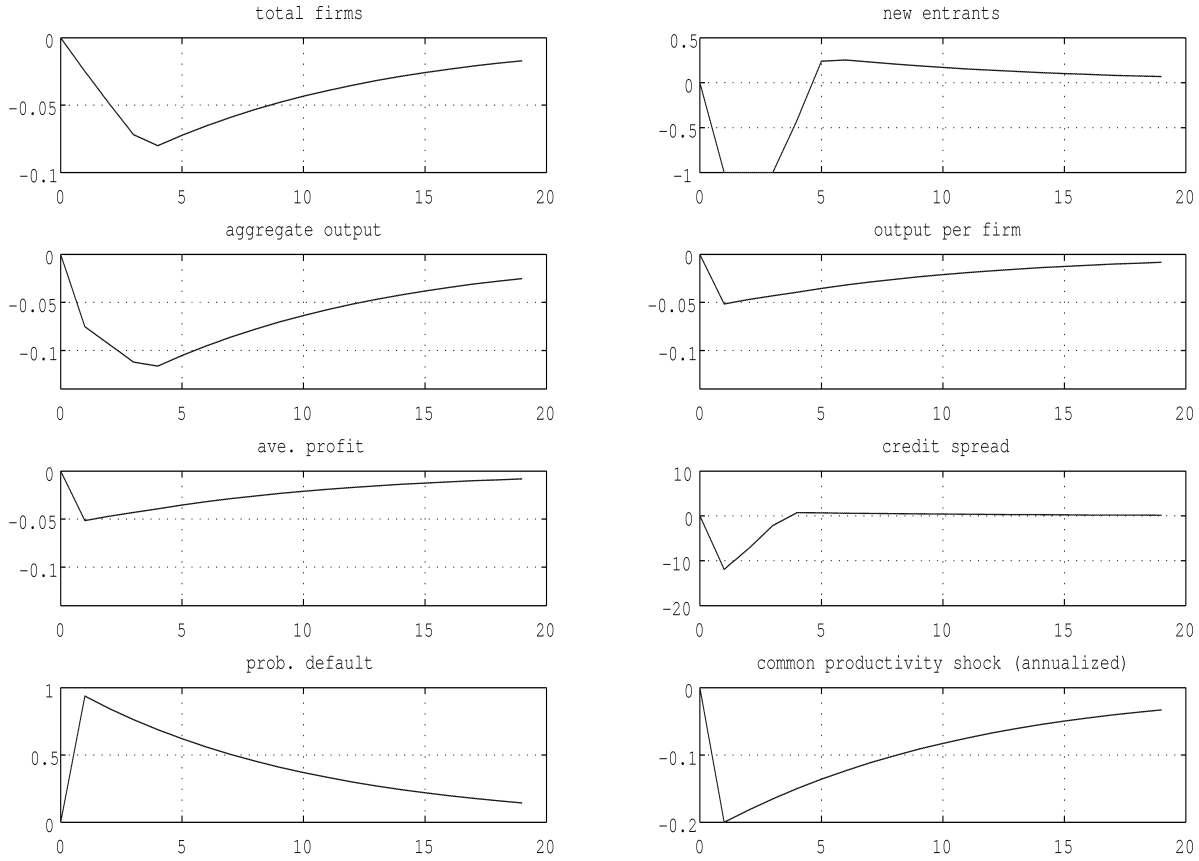

Figure 11: Impulse responses to a 20% negative productivity shock