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The Liquidity Effect in Bank-Based and Market-Based Financial Systems

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Abstract

This paper assesses how the financial system influences the strength of the liquidity effect in a calibrated limited participation model of the monetary transmission mechanism. The model suggests that bank-based systems should be characterized by smaller liquidity effects since monetary injections are spread out over a larger number of firms.

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1 Introduction

Empirically, it appears that a monetary contraction is associated with a liquidity effect, according to which the the nominal short-term interest rate increases(see e.g. Christiano and Eichenbaum, 1992; Christiano et al., 1997). However, in most theoretical models the response of nominal interest rates to a monetary contraction is determined by the Fisher effect, which implies that the lower expected rate of inflation associated with the reduction in monetary growth leads to a decline in nominal interest rates. Consequently these models have been unable to explain the liquidity effect. Lucas (1990), Fuerst (1992) and Christiano and Eichenbaum (1992) construct general equilibrium models with limited-participation frictions that can generate a liquidity effect. In these models, households only infrequently re-optimize their asset holdings and therefore monetary surprises have to be absorbed by the agents that participate in financial markets at the time of the surprise. Due to the rigidity of households' portfolios, a reduction in liquidity increases the nominal interest rate despite its impact on expected inflation. Thus, what ultimately results in a liquidity effect in these models is the assumption that only a subset of the agents in the economy has to absorb variations in liquidity. [1]

A typical assumption in limited participation models is that the business sector has to absorb liquidity injections (see e.g. Christiano and Eichenbaum, 1992; Christiano et al., 1997). Intuitively, monetary injections increase the amount of loanable funds in the financial sector and financial intermediaries provide additional loans to the firms in the economy. However, not all firms in the economy rely on bank loans. Hence, monetary injections should be

[1] Despite their success in generating a liquidity effect, limited-participation models suffer mainly from two shortcomings: Their inability to generate persistent liquidity effects and the relatively strong inflation response.

largely absorbed by firms that borrow from intermediaries as opposed to firms that participate directly on financial markets. Since the relative size of the sector that receives monetary injections has implications for the liquidity effect (see e.g. Cole and Ohanian, 2002), it follows that the interest rate response to policy shocks may vary across financial systems.[2] The purpose of this paper is to highlight this link between the financial system and the strength of the liquidity effect.

A similar point is emphasized in the literature on the bank lending channel. This branch of the literature argues that monetary policy influences real economic activity via the reserves of the banking sector (see e.g. Bernanke and Gertler, 1995). Consequently, the size of the sector which ultimately has to absorb variations in liquidity or reserves of the banking sector should be closely related to the number of firms that rely mostly on banks to obtain external finance. This similarity between the bank lending channel and the limited participation assumption has not received much attention in the literature (see Kashyap and Stein, 1994).

Despite a large literature that documents the liquidity effect in the data (see e.g. others Christiano et al., 1999; Fung and Kasumovich, 1998; Hamilton, 1997; Cushman and Zha, 1997; Grilli and Roubini, 1996), differences in the liquidity effect across countries and financial systems have received only limited attention. Lastrapes and McMillin (2004) study cross-country differences in the liquidity effect and find that variables associated with the size of the financial intermediary sector have explanatory power for the cross-country variation in the strength of the liquidity effect.

The model applied in this paper is a variant of the limited participation model in Christiano et al. (1997) which allows for an heterogenous business

[2] See Allen and Gale (2000) for a classification and comparison of financial systems.

sector. Due to a simple informational friction, some firms in the economy cannot issue bonds directly and rely on bank loans to obtain working capital. The remaining firms issue corporate bonds. This modification of an otherwise standard limited participation model makes the model consistent with the main characteristics of the bank lending channel as emphasized by Kashyap and Stein (1994): Some firms in the economy are dependent on bank loans as a source of external finance, banks cannot easily compensate policy induced variations in liquidity and money is non-neutral.

The main result of the paper is that monetary shocks lead to larger liquidity effects in market-based financial systems. Intuitively, monetary injections have to be absorbed by a smaller number of firms in market-based systems and therefore these shocks become relatively important at the level of the individual bank-dependent. It follows that the interest rate has to move substantially. However, output and inflation responses are similar across financial systems, as long as the size of the liquidity shock is constant. The model also suggests that the real effects of monetary policy shocks are larger in bank-based systems if the monetary authority targets interest rates and adjusts liquidity endogenously.

The remainder of the paper is organized as follows: Section 2 describes the model. Section 3 presents the simulations and discusses the results. Section 4 summarizes and concludes the paper.

2 Model

The model presented in this section is a variant of the limited participation model in Christiano et al. (1997), hence the description will be brief. The economy consists of households, financial intermediaries, a monetary authority and a business sector. Firms have to borrow working capital in the form of cash at the beginning of the period to finance the wage bill which is paid in advance of production. Some firms are subject to idiosyncratic shocks which are not verifiable by the households. This assumption ensures that these firms have to borrow from the financial intermediaries. The remaining firms can issue directly placed debt instruments. Monetary policy is conducted in terms of cash injections which are placed in the households' accounts at the financial intermediaries. Households have to decide on deposits, bond and money holdings before the monetary shocks are realized.

2.1 Firms

The business sector of the economy consists of a continuum of firms normalized to have unit mass. The firms produce a homogenous consumption good and are of two types, depending on whether their output is subject to idiosyncratic shocks. Each firm i hires labor, H_{it}, and produces output according to:

$$Y_{it} = \theta_i H_{it}^{1-\alpha}, \tag{1}$$

were $\alpha \in (0,1)$. The parameter θ_i represents an idiosyncratic shock, in particular

$$\theta_i = \begin{cases} 1 & \text{with probability} \quad \pi \\ 0 & \text{with probability} \quad 1-\pi \end{cases}$$

for $i \in [0,\lambda]$ and $\theta_i = 1$ for $i \in [\lambda, 1]$. Hence, firms in the interval $[0,\lambda]$ can only repay their debt with probability π. In case of default, firms can walk away from their debt obligations. Moreover, the realizations of θ_i are not publicly observable for $i \in [0,\lambda]$, only the financial intermediaries have access to a monitoring technology that allows verification of the realizations of θ_i. Since labor is paid in advance of production, firms have to borrow working capital to finance the wage bill. In principle, each firm has two sources of credit. They can either issue nominal bonds which are sold directly to the households or they can enter into debt contracts with a financial intermediary. However, since the realizations of the idiosyncratic shocks are not public knowledge, firms in the interval $[0, \lambda]$ have an incentive to misreport their output and default on bonds owned by households. Consequently, these firms will not be able to issue bonds in the first place and will be forced to borrow from the financial intermediaries instead. Since all borrowing and hiring decisions are made after the monetary shock has occurred, optimality requires:

$$R_t^L \frac{W_t}{P_t} = (1-\alpha) H_{it}^{-\alpha}, \tag{2}$$

for $i \in [0, \lambda]$, where W_t is the nominal wage, P_t denotes the price level and R_t^L is the bank-lending rate.

For firms in the interval $i \in [\lambda, 1]$, the fact that $\theta_i = 1$ is common knowledge, therefore debt contracts do not involve any default risk. Hence, these firms are able to sell bonds directly to the households without the need for a financial intermediary. The optimal amount of bonds to be issued is determined by

$$R_t^B \frac{W_t}{P_t} = (1-\alpha) H_{it}^{-\alpha}, \tag{3}$$

for $i \in [\lambda, 1]$, where R_t^B denotes the yield on corporate bonds. $R_t^L > R_t^B$ will always be satisfied in equilibrium, hence firms always have an incentive to issue bonds. Note that although firms in the interval $i \in [0, \lambda]$ are subject to idiosyncratic shocks, the probability π does not appear in (2), since firms can walk away from debt obligations in case of default. Thus, although $Y_{it} > 0$ only with probability π, debt has to be repaid only with probability π. It follows that π drops out of (2). At the end of the period loans and bonds are repaid and profits are distributed to the households.

2.2 Households

Households maximize their expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \log \left[C_t - \frac{\psi_0}{1+\psi} L_t^{1+\psi} \right], \tag{4}$$

where $\psi, \psi_0 > 0$ are parameters, β is a discount factor, C_t is consumption in period t and L_t denotes labor supply in period t. At the beginning of each period households hold the entire stock of money, M_{t-1}, and must decide how much money to use for consumption in the current period, for deposits at the financial intermediaries, A_t, and for purchases of bonds, B_t, issued by firms. Deposits yield a gross interest rate of R_t^D. Interest rates are determined after the state of the world is revealed. Nominal labor income, $L_t W_t$, can be used for purchases in the goods market in the current period. Hence, the households face the following cash-in-advance constraint:

$$P_t C_t \leq M_{t-1} - A_t - B_t + W_t L_t. \tag{5}$$

The amount of money the households carry over into the next period is

$$M_t = M_{t-1} - A_t - B_t + W_t L_t - P_t C_t + R_t^D (A_t + X_t) + R_t^B B_t + D_t, \tag{6}$$

where D_t is the sum of all profits of the firms distributed at the end of period t and X_t represents a cash injection by the central bank.

2.3 Financial Intermediaries

At the beginning of the period, financial intermediaries receive deposits from the households and cash injections from the monetary authority. The total amount of loanable funds, $A_t + X_t$, is used to provide loans to firms which cannot borrow from households directly. In contrast to households, financial intermediaries can observe the realization of idiosyncratic shocks and are therefore able to enforce debt contracts. For simplicity, financial intermediation and monitoring are assumed to be costless and competitive. At the end of the period, the financial intermediaries receive payments from their solvent borrowers and return deposits with interest to the household. The remaining profits are paid to the households as dividends.

The objective of the financial intermediary is to choose the optimal amount of loans to maximize dividends given by $F_t = \pi(A_t + X_t)R_t^L - (A_t + X_t)R_t^D$. Free entry into the banking sector ensures that $R_t^D = \pi R_t^L$ and that $F_t = R_t^D X_t$ will be paid to the households in form of dividends.

There is a clear role for financial intermediaries in this environment since without the intermediaries, bank-dependent firms would have no opportunity to borrow working capital and would be cut off from production. Furthermore, the financial intermediaries can eliminate idiosyncratic default risk by lending to an infinite number of borrowers (see Diamond, 1984).

2.4 Monetary Authority

The monetary authority provides liquidity to the financial sector of the economy. As in Christiano et al. (1997) the monetary growth rate, x_t, follows a three-state Markov process: $x_t \in \{\mu + \sigma, \mu, \mu - \sigma\}$ and $q_{ij} = Prob(x_{t+1} = x_j | x_t = x_i)$ for $i, j = 1, 2, 3$.

2.5 Equilibrium

A stationary competitive equilibrium for the model is characterized by stochastic sequences of allocations, prices and monetary growth rates such that: (i) The household's lifetime utility is maximized subject to the constraints (5) and (6). (ii) The necessary conditions (2) and (3) which determine optimal borrowing for bank-dependent firms and for bond-issuing firms hold. (iii)

The markets for labor, goods, loans and bonds clear:

$$L_t = \int_0^1 H_{it} di, \quad C_t = \int_0^1 H_{it}^{1-\alpha} di,$$

$$A_t + X_t = W_t \int_0^\lambda H_{it} di, \quad B_t = W_t \int_\lambda^1 H_{it} di.$$

3 Calibration and Results

To explore the quantitative properties of the model, parameter values have to be assigned. As it is standard in the literature, the discount factor is set to $\beta = 0.99$. For the labor supply elasticity, $1/\psi$, a value of unity is chosen and ψ_0 is adjusted such that labor supply is equal to unity in each simulation. The parameter α in the production function is set to 0.36. The money growth process is calibrated as in Christiano et al. (1997): The unconditional monetary growth rate is set to $\mu = 0.02$, for σ the value 0.017 is chosen and $q_{ij} = 1/3$ for $i, j = 1, 2, 3$. The repayment probability π is set to 0.99.[3] The resulting default probability is close to the values chosen by Cooley and Nam (1998) and by Carlstrom and Fuerst (1997).

3.1 Simulation Results

All results are reported as elasticities with respect to a one percent reduction in the end-of-period money stock. Interest rates are reported as semi-elasticities and can be interpreted as percentage point changes.

Table 1 displays the impact responses generated by the model to an unanticipated fall in the monetary growth rate for different values of λ. The response of the deposit rate, $\mathrm{d}R_t^D$, declines with an increase in the relative size of the bank-dependent sector. Similarly, the reaction of the bank-lending

[3] As a sensitivity analysis, the simulations have been repeated with different values for π. Results are rather robust.

rate, dR_t^L, varies inversely with λ. Although a similar pattern can be observed for the bond yield, the response is substantially smaller in this case.

Table 1: Responses to a Monetary Contraction for different degrees of bank-dependence

λ	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
dR^D	7.19	3.35	2.18	1.62	1.29	1.07	0.91	0.80	0.71
dR^L	7.26	3.39	2.20	1.63	1.30	1.08	0.92	0.81	0.72
dR^B	0.07	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04
dY	-0.35	-0.32	-0.31	-0.30	-0.30	-0.30	-0.29	-0.29	-0.29
dP	-0.65	-0.68	-0.69	-0.70	-0.70	-0.70	-0.71	-0.71	-0.71
dH	-0.48	-0.47	-0.46	-0.46	-0.46	-0.46	-0.46	-0.45	-0.45

Notes: dY,dH are percentage changes in output and labor in response to a one percent decrease in the end-of-period-money stock. dR^D, dR^L, dR^B are percentage point changes in the deposit rate, the bank-lending rate and the bond rate in response to a one percent decrease in the end-of-period-money stock.

Intuitively, for low values of λ, only a small number of firms competes for bank loans and since the size of the monetary shock is constant across the experiments considered, each bank-dependent firm has to absorb a relatively large amount of the monetary injection. Consequently the bank-lending rate has to adjust markedly to restore equilibrium on the market for loans. The deposit rate responds strongly, since it is tightly linked to the bank-lending rate via the financial intermediary's zero-profit conditions. The bond yield response is small since the monetary tightening hits primarily the bank-dependent firms.

Overall, we can conclude that the size of the liquidity effect depends on the fraction of bank-dependent firms since this fraction also determines the size of the sector which has to absorb policy induced variations in liquidity. Moreover, the corporate bond yield is only marginally influenced by the liquidity effect. Thus, in line with the bank lending view, monetary policy has a substantially larger impact on interest rates related to financial intermediaries than on market rates. More generally, the reaction of the interest rates in the model is in line with results in Berger and Udell (1992), who find that the spread between the bank-lending rate and the Treasury Bill rate increases during a credit crunch. Similar results are presented in Kashyap et al. (1993) for the spread between the prime rate and the commercial paper rate.

The remaining lines of Table 1 show the responses of the price level, aggregate hours and output. For high values of λ the results broadly match those reported by Christiano et al. (1997). For extremely low values of λ, output and hours respond somewhat stronger. However, the response of aggregate output varies only from -0.33 percent for $\lambda = 0.2$ to -0.29 percent for $\lambda = 0.9$, which appears to be a small range. Thus, despite the variation in the liquidity effect, the model suggests that the response of output to a monetary contraction of a given size does not vary substantially with the fraction of bank-dependent firms.

This result can be understood by looking at how individual bank-dependent and bond-issuing firms respond to the monetary contraction. Table 2 displays $\mathrm{d}H_i$ and $\mathrm{d}Y_i$ which denote the elasticities of labor demand and output of bank-dependent firms ($i = 1$) and bond-issuing firms ($i = 2$) for different values for λ.

For any value of λ considered, output and labor demand of bank-dependent firms respond negatively to a monetary contraction and the magnitude of the response varies strongly with the fraction of bank-dependent firms in the economy. Bond-issuing firms respond positively to a monetary contraction and the output and labor demand responses are rather stable across different values for λ. Bond-issuing firms increase their level of activity since the real wage declines so strongly that hiring costs decline despite the higher interest

Table 2: Labor Demand and Output Responses of Bank-Dependent and Bond-Issuing Firms to a Monetary Contraction

λ	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
$\mathrm{d}H_1$	-17.24	-7.54	-4.51	-3.04	-2.16	-1.59	-1.18	-0.88	-0.64
$\mathrm{d}Y_1$	-11.03	-4.83	-2.89	-1.94	-1.39	-1.02	-0.76	-0.56	-0.41
$\mathrm{d}H_2$	1.13	1.15	1.15	1.16	1.16	1.16	1.16	1.16	1.16
$\mathrm{d}Y_2$	0.73	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74

Notes: $\mathrm{d}H_1$ and $\mathrm{d}Y_1$ denote the elasticities of labor demand and output of bank-dependent firms and $\mathrm{d}H_2$ and $\mathrm{d}Y_2$ denote the elasticities of labor demand and output of bond-issuing firms in response to a one percent decrease in the end-of-period-money stock.

rate. This result is consistent with empirical evidence presented in Gertler and Gilchrist (1994), who find that bank loans to small manufacturing firms decline when the Fed tightens monetary policy, whereas large firms actually increase their external financing by issuing commercial paper.

Overall, most of the variation in the output effect comes from bank-dependent firms with the largest impact on these firms for low values of λ. However, low values of λ also imply that the output responses of bank-dependent firms only have a small impact on aggregate output. A higher value for λ increases the degree to which aggregate output is influenced by the output responses of bank-dependent firms, but at the same time decreases the effect a monetary shock has on these firms. For plausible values of λ these two effects largely cancel out in the aggregate. Consequently, the impact of a monetary contraction on aggregate output is only slightly influenced by the fraction of bank-dependent firms in the economy.

The main implication of the simulations reported here is that the liquidity effect is negatively related to the size of the bank-dependent sector. How does this result compare to the empirical evidence? Lastrapes and McMillin (2004) present evidence based on a sample of industrialized countries and find that the liquidity effect tends to be smaller in countries characterized by a larger banking sector. Since it appears plausible that the size of the banking sector is correlated with the fraction of bank-dependent firms, this empirical result is consistent with the relationship between the financial system and the liquidity effect discussed here.

4 Summary

This paper analyzes the link between the financial system and the strength of the liquidity effect in a limited participation model. The model suggests that bank-based financial systems should be associated with smaller liquidity effects than market-based systems. Intuitively, in a bank-based system a large number of firms depends on bank loans. Thus, since liquidity is injected through the banking sector, policy induced variations in liquidity are ultimately absorbed by a large number of firms. Consequently, the interest rate responds only modestly since each individual firm has to absorb only a small fraction of the liquidity shock.

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