Liquidity*

Ernst-Ludwig von Thadden†

January 2002

Abstract

This is a survey of the literature on liquidity provision through banks. I first formulate the basic model underlying the modern literature on liquidity provision for households and then introduce the more recent literature on liquidity provision through banks and markets. Then I turn to liquidity provision on the asset side of banks' balance sheets and conclude with a brief discussion of how the two sides of the balance sheet interact.

JEL classification: G21

*I am grateful to Sudipto Bhattacharya for his comments.

†DEEP, Université de Lausanne, email: elu.vonthadden@hec.unil.ch.

Liquidity provision is usually considered to be one of the main macroeconomic functions of the banking system. Yet, while this notion is old and can be traced back at least to Adam Smith, precise definitions and analyses of the role of banks for liquidity provision date only from the early 1980s. In this survey, I will briefly review this earlier literature, thus paving the way for some of the work of the nineties that is collected in the main part of this section.

To begin with, it is useful to define what is meant by liquidity, because this term is used in different contexts and with varying meanings. The core of the different notions of liquidity used in finance is similar: liquidity allows agents to transact when they most want it. Yet, the definitions begin to differ when it comes to the institutional setting, with two broad directions standing out. In one view, concerned mainly with market structure and marketability, "an asset is liquid if it can be bought or sold quickly at low transaction costs and a reasonable price" (Biais, Foucault, Hillion, 1997). In the other perspective, grounded more in security design and financial engeneering, "liquidity refers to the availability of instruments (market and nonmarket) that can be used to transfer wealth across periods" (Holmström-Tirole (1998) and in this volume), where wealth transfers are gauged by the intertemporal substitution preferences of the agents in question.

The first and the second type of definition are largely complementary, as they refer to different institutional settings. However, the two definitions can be in conflict, if the institutional settings are mixed up. For example, the existence of a market that is highly liquid according to the first definition may adversely affect the liquidity of an asset according to the second definition. Among the papers in the present volume, this issue arises in the work of Diamond (1997) and Bhattacharya, Fulghieri and Rovelli (1998), and is still a subject of ongoing research.

In general, banks can provide liquidity through operations on their asset side and on their liability side. The work on banking and liquidity of the early 1980s is concerned with the liability side and mainly associated with the names of Bryant, Diamond, Dybvig, Haubrich, King, Bhattacharya, Gale, and Jacklin. For brevity, this is what I will focus on, and briefly turn to the liability side at the end of these notes.[1]

As a basis for this discussion, I will present a simple model along the lines

[1] For a more comprehensive and more thorough survey of the earlier literature, see Jacklin (1989).

of Bryant (1980) and Diamond and Dybvig (1983). This model assumes an economy with three dates, $t = 0, 1, 2$, one (physical) good, and a continuum of agents $a \in [0, 1]$ who each have identical endowments of 1 at date 0, nothing thereafter, and identical preferences over future consumption at date 0, given by

$$U(c_1, c_2) = \begin{cases} u(c_1) & \text{with probability } q \\ u(c_2) & \text{with probability } 1 - q. \end{cases}$$

The individual consumption shocks of different agents are realised at date 1, are identically distributed and satisfy the Law of Large Numbers. Hence, there is no uncertainty about aggregate consumption needs. This utility is extreme in the sense that agents only consume once in their lives (they are either extremely "impatient" or "patient"), but the analysis can be extended to more general preferences.[2] Individual consumption needs are private information. Therefore, if agents interact, type-dependent consumption allocations must be incentive-compatible.

In this model, preferences for liquidity arise from uncertainty over future utility, given fixed endowments. The alternative modelling approach is to assume that utility is fixed and certain, but future endowments are uncertain. This approach has been proposed by Haubrich and King (1990), but not been followed in most of the literature.

The final ingredient of our model is one (real) investment opportunity, which has constant returns to scale, is arbitrarily divisible, is available to everybody, and yields a gross return per unit invested at date t of either R_1 in $t + 1$ or R_2 in $t + 2$, where $R_1^2 \leq R_2$ and $R_2 > 1$. Hence, if investment takes place at time 0 it can either be "left in place to mature", or it can be "liquidated early".

The assumption that $R_2 > 1$ means that the economy is not shrinking and is made for notational convenience. The assumption that $R_1^2 \leq R_2$ simply means that the option of leaving the asset in place is meaningful, i.e. not dominated by liquidating early and reinvesting. If $R_1^2 < R_2$, the investment has an "irreversibility, or goods-in-process, feature" (Wallace, 1988): leaving the investment in place for two periods yields strictly higher returns than a sequence of short-term investments.

The model describes a situation in which agents are facing a liquidity problem, in the sense that they may be forced to consume their investments when these have not yet matured. This will be the case under autarky, where

[2] See Haubrich and King (1990), Jacklin (1987) or Jacklin and Bhattacharya (1988).

the consumption path of each agent is given by $(c_1, c_2) = (R_1, R_2)$ (note that an agent consumes either c_1 or c_2). By definition, an allocation is said to provide liquidity if it insures the agent against such an outcome. Optimal liquidity is then defined as first-best intertemporal insurance, i.e. as the allocation agents would like best at date 0 if there were no informational constraints ex post. Formally, this amounts to maximising expected utility subject only to the constraint that consumption is feasible in the aggregate:

$$\begin{aligned} \max \qquad & qu(c_1) + (1-q)u(c_2) \\ \text{subject to} \quad (\qquad & R_1 - qc_1)\frac{R_2}{R_1} = (1-q)c_2 \\ \Leftrightarrow \qquad & q\frac{c_1}{R_1} + (1-q)\frac{c_2}{R_2} = 1 \end{aligned}$$

The second version of the resource constraint shows that $1/R_t$ can be interpreted as the state-price density in a standard dynamic consumption problem. The solution to this problem will then depend on the relative magnitude of the intertemporal income and substitution effects for the representative agent. Formally, it is given by the following first-order condition, which equates state-price weighted marginal utilities:

$$R_1 u'(c_1) = R_2 u'(c_2).$$

The first-best solution has the following qualitative features. If the income effect compensates exactly the substitution effect (logarithmic utility), then $c_t^* = R_t$ and autarky is optimal. If the substitution effect dominates, then $c_1^* < R_1 < R_2 < c_2^*$, and if the income effect dominates, then $R_1 < c_1^* < c_2^* < R_2$. For liquidity concerns to play a role, the literature typically assumes that the elasticity of instantaneous marginal utility with respect to consumption ("intertemporal relative risk aversion") is larger than 1. In this case, the income effect dominates and agents want to consume more in the short run than they have under autarky, hence need "liquidity".

Having discussed the first-best, let us return to the informationally constrained problem and suppose that there exist competitive markets for intertemporal trade in $t = 0$ and $t = 1$, in which agents can take market clearing prices as given. Obviously, in $t = 0$ there is no trade because everybody is identical, and everybody invests 1 unit into the (real) asset.

In $t = 1$, agents differ and can trade the asset (or equivalently, date 2 consumption). Let p denote the price (at date 1) of 1 unit of the asset (i.e.

of R_2 units of date 2 consumption). In principle, each agent now has five possibilities: (i) liquidate the asset and consume the proceeds, (ii) liquidate the asset and use the proceeds to buy the asset in the market, (iii) sell the asset in the market and consume the proceeds, (iv) sell the asset in the market and invest the proceeds in new units of the asset, and (v) hold on to the asset. Note that impatient agents will choose between (i) and (iii) and patient agents between (ii), (iv), and (v).

Comparing the returns from (i) and (iii) yields the following asset excess demand by impatient agents:

$$D^I(p) = \begin{cases} -q & \text{if } p > R_1 \\ [-q, 0] & \text{if } p = R_1 \\ 0 & \text{if } p < R_1 \end{cases}$$

Similarly, patient agents' excess demand correspondence is:

$$D^P(p) = \begin{cases} -(1-q) & \text{if } p > \frac{R_2}{R_1} \\ [-(1-q), 0] & \text{if } p = \frac{R_2}{R_1} \\ 0 & \text{if } R_1 < p < \frac{R_2}{R_1} \\ [0, (1-q)\frac{R_1}{p}] & \text{if } p = R_1 \\ (1-q)\frac{R_1}{p} & \text{if } p < R_1 \end{cases}$$

Not surprisingly, patient agents sell when the price is high, hold when it is intermediate, and buy when it is low. Setting aggregate excess demand equal to zero shows that in equilibrium patient agents must be indifferent between holding and buying. More precisely, we have:

Proposition 1 (Diamond-Dybvig, 1983): *In a competitive market for intertemporal trade, the unique equilibrium price is $p = R_1$, and the resulting consumption path is the autarkic one, $(c_1, c_2) = (R_1, R_2)$.*

Note that there may be trivial trades in equilibrium, of patient agents who liquidate their asset holdings with impatient ones who do not. But the resulting allocation is no improvement over autarky. This proposition also shows that the definition of liquidity used here is very different from the first notion of liquidity introduced earlier: Because of the price-taking assumption, the competitive market is perfectly "liquid" (according to the market-microstructure definition), but it does not provide "liquidity" as defined here.

Let us now consider, as an alternative to the Walrasian market of Proposition 1, a simple model of demand deposit contracts (offered by "the banking system"), which collect the agents' funds at date 0, invest them, and pay back a prespecified amount at either time 1 or 2.[3] Formally, a demand deposit outcome is a list $(d_1, d_2, \alpha, A_1, A_2)$, where A_1 and A_2 are a partition of the set of all agents, such that

1. each agent invests the fraction α of her funds in the real asset and deposits $1-\alpha$ with the bank in $t=0$,
2. depositors $a \in A_1$ withdraw $(1-\alpha)d_1$ at date 1 and nothing at date 2,
3. depositors $a \in A_2$ withdraw $(1-\alpha)d_2$ at date 2 and nothing at date 1,
4. each depositor prefers her withdrawal date over the alternative one,
5. the repayments satisfy $\lambda \frac{d_1}{R_1} + (1-\lambda)\frac{d_2}{R_2} \leq 1$, where λ is the measure of A_1.

In this definition, d_1 and d_2 are the gross interest rates paid on deposits over one, resp. two periods, and $1-\alpha$ can be interpreted as the size of the banking system. Note that we have imposed symmetry ex ante (which is reasonable because all agents are identical ex ante).

Proposition 2 (Diamond-Dybvig, 1983): *Suppose that* $R_1 = 1$ *and that no markets for intertemporal trade exist. Then the first-best consumption path can be implemented as a demand deposit outcome* $(d_1, d_2, \alpha, A_1, A_2) = (c_1^*, c_2^*, 0, \{impatients\}, \{patients\})$. *The implementation is unique if the deposit contract suspends convertibility in case of excess withdrawal.*

Suspension of convertibility is a mechanism which has historically been used as a "circuit breaker" in banking panics. In the present model it states that the bank pays out significantly less than d_1 to at least some depositors at date 1 if more than λ depositors demand their money back.[4] The proposition

[3] In the basic model of this section, the case of competing banks is not different from the single-bank case. In some of the later work, this assumption is not without loss of generality.

[4] A demand deposit outcome as defined above includes the notion of a Nash equilibrium in an appropriately defined withdrawal game between depositors. Without suspension of convertibility, a "panic outcome" is possible, too, in which all depositors withdraw at date 1.

then simply states that, in the absence of markets, banks can provide optimal liquidity, and that optimal liquidity provision cannot be upset by bank runs if suspension of convertibility is imposed.

Propositions 1 and 2 study markets and banks separately. In important papers, Jacklin (1987) and Haubrich and King (1990) have asked the following question, which in hindsight is obvious: what is the role of deposit contracts if a market for intertemporal trade exists in the model introduced above? In fact, in his paper, Jacklin made three important contributions, which should be kept apart. First, he showed that other institutional arrangements than deposit contracts (market based ones) can provide liquidity in the Diamond-Dybvig model. Second, he generalised the model to less extreme, smooth preferences. His third contribution, the "Jacklin critique" discussed here, however, was less convincing as it stood, because it considered individual deviations from the banking contract at date 0, without modelling trading at date 1 (if every agent but one invests in the bank, there is no market!).[5]

The following argument corrects this lacuna, by integrating the concept of (Walrasian) market equilibrium used earlier with that of demand deposits. Again, we assume that all agents behave identically at date 0, which is plausible and standard, given that they are identical. Hence, market activity only takes place at date 1. We can then define a market equilibrium with banking as a demand deposit outcome $(d_1, d_2, \alpha, A_1, A_2)$ with $\alpha < 1$ and an asset price p, together with net trades for each agent at date 1, such that all agents maximise their utility from trading and the asset market clears.

In market equilibria with banking, the trading possibilities at date 1 are richer than in the situation of Proposition 1. Without going into the details, however, one can derive the following proposition.[6]

Proposition 3: *Suppose the bank offers a deposit contract* (d_1, d_2) *at date* 0 *and a perfect asset market exists at date* 1*. At a market equilibrium with banking one has* $d_1 = R_1$*, and*

- *either all agents withdraw their deposit at date* 1*, and the patient agents buy the impatients' asset holdings with the proceeds from the withdrawal,*

- *or all impatients withdraw their deposits at date* 1*, patients are indifferent between withdrawing and not, and withdraw just enough to buy*

[5] All these three points can also be found in Haubrich and King (1990).

[6] For details, see von Thadden (1999).

the impatients' asset holdings.

Both of these two types of equilibria yield the autarkic consumption path (R_1, R_2) to each agent, and in both banking is degenerate. In each type of equilibrium, the return path from banking is identical to the one from investing directly into the asset (taking into account trading in the first type of equilibrium), and hence, agents are indifferent ex ante between investing in the asset or the bank. The proposition, therefore, is nothing but a new version of the famous insight that "banks are useless in the Arrow-Debreu world" (Freixas, Rochet, 1997).

Although this finding comes as no surprise to anybody brought up on general equilibrium theory, it still constitutes a basic conceptual problem for banking theory: a market that is perfectly liquid according to the first definition given at the beginning of this article, makes liquidity provision in the sense of the second definition impossible. Since the mid-80s, the literature has developed in several directions in response to this dilemma, some of which I will briefly review in the sequel.

In a pragmatic approach, Wallace (1988) simply proposed to interpret the Diamond-Dybvig model differently. In his interpretation, the three dates of the model are periods during which the agents live without interacting with each other. Banking then is a substitute for market activity in a world where agents are isolated. In practice, this means that demand deposits either concern only those financial activities for which markets do not form, such as minor transactions services, or are used only by agents who do not have access to existing markets, such as unsophisticated savers.

Yet, as von Thadden (1998, 1992) has pointed out in a model that generalizes the preceding model to many periods, even in Wallace's (1988) isolated world, a basic incentive constraint must be taken into account: agents can withdraw and re-invest deposits privately. This point does not concern the original model of Diamond and Dybvig (1983), where $R_1 = 1$. It only becomes relevant in the more general model above when $R_1 > 1$, where it can be shown that the scope for liquidity provision through demand deposits depends on the degree of irreversibility of the market investment opportunity. If the latter is fully reversible, no liquidity provision is possible at all.

On the other hand, the less the investment opportunity is reversible, the more liquidity can be provided through demand deposits. In complementary work, building on Haubrich and King (1990) and Bhattacharya and Gale (1987), von Thadden (1997) identified another element facilitating liquidity provision, by extending the above base model to include a second investment opportunity with a different intertemporal return structure. In such a model, any autarkic portfolio has the additional downside that whenever an agent consumes, she consumes one asset whose yield is not optimal at the time of consumption. Hence, in addition to the "liquidity risk" discussed until now, there is "maturity risk". Von Thadden (1997) showed that in the model with two assets, demand deposit contracts can fully eliminate maturity risk and provide partial insurance against liquidity risk. Even more, in a multi-period setting, demand deposit contracts can provide first-best insurance if intertemporal risk aversion is sufficiently large. Insurance against maturity risk therefore stabilises insurance against liquidity risk in the sense that the latter becomes incentive compatible if the former is provided in conjunction with it.

Diamond (1997, and in this volume), in work building on Wallace (1988), also considered a model with two assets and addressed the Jacklin critique head on.[7]. Weakening Wallace's isolation assumption, he assumes that at date 1 there exists a Walrasian market as introduced above, but that a certain fraction of all agents learns at time 1 that they will not have access to the market. The size of this group is known at date 0, but not its composition, so agents are exposed to the risk of individual exclusion, but can provide for it collectively. Banks now do exactly that: Diamond (1997) shows that all short-term asset holding is optimally done through banks (agents at date 0 only hold deposits and the long-term asset), and that banks typically trade at date 1 in order to reallocate deposits among patient and impatient agents. The first feature is that of maturity insurance discussed above, the second feature shows how markets can actually be complements rather than substitutes for banks in the creation of liquidity.

Diamond's (1997) work takes up the general insight that interim trading among bank clients must be restricted in order for banks to have a role. In the one-asset case, this is the theme of Proposition 3, in the case of assets with different maturities, the problem lies in the fact that investment in the more liquid assets may be sub-optimal because of the free-rider problem in the use of ex-post liquidity. Limited market participation is, therefore, an important feature of bank liquidity models.[8]

[7] Diamond (1997) assumes two investment opportunities R and S, with $R_1 \leq 1, R_2 = R_1^2$ (short-term), and $S_1 = 0$ (complete irreversibility, long-term). Hence, the incentive problem discussed by von Thadden (1997,1998) does not arise.

[8] Among the first to explore this observation were Bhattacharya and Gale (1987) and

Another line of research, proposed mainly by Bhattacharya and Jacklin (1988), Jacklin (1993), Gorton and Pennacchi (1990), and De Nicoló (1993), introduces information asymmetries into the problem, in order to make collective contracting more attractive than market interaction. This line of work starts from the insight that trading can impose costs on market participants stemming from informational asymmetries, and argues that demand deposits are an institutional reaction to this deficiency of markets. For such a theory to work, the base model is generalized in two directions. First, the long-term return, R_2, is assumed to be uncertain and agents have different information about the realization of R_2 when they contemplate trading at date 1. Second, agents differ with respect to their expected liquidity preference q, (which, therefore, also becomes a random variable, whose values are realized at date 1). Under this type of two-dimensional uncertainty, market prices at date 1 typically fail to be fully revealing and, hence, cannot achieve social optimality. Now there is room for institutions to offer deposit or debt-like contracts, precisely to help avoid the costs of market trading. Some individuals will prefer to hold deposits, which are less information sensitive and, therefore, have low individual risk, others will hold tradeable assets and incur the informational risk related to the lemons problem in this market. Again, banks and markets naturally coexist, but for reasons very different from those in Diamond (1997).[9]

The final line of research concerning banks and markets to be reviewed here has been mainly pioneered by Bernanke and Gertler (1987), Bencivenga and Smith (1991), Qi (1994), and Fulghieri and Rovelli (1993). This literature takes a fully dynamic view on the interaction between banks and investors, by embedding the base model above in an overlapping-generations framework. Much of this literature has been concerned with steady-state allocations $(\overline{c}_1, \overline{c}_2)$ obtainable through demand deposit contracts, where $\overline{c}_1$ and $\overline{c}_2$, respectively, denote gross returns (i.e. consumption) of middle-aged, respectively old-aged, agents who have deposited their one unit of endowments with the bank when young.

A basic insight of this type of work has been that due to the open-

Bencivenga and Smith (1991). Allen and Gale (1994) have explored asset pricing theory when investors face liquidity needs and limited market participation. Bolton and von Thadden (1998) have developped a theory of corporate control in the presence of liquidity needs and limited market participation.

[9]An interesting application of this theory to the use, regulation, and macroeconomic impact of bank capital is given by Gorton and Winton (1999).

endedness of the horizon and the possibility of intergenerational transfers through the banking system, higher steady-state payoffs can be realized in the OLG-model than in the three-period base model. In particular, a steady-state (R_2, R_2) would be technically feasible. However, an incentive constraint similar to the one discussed by von Thadden (1998) makes these payoffs impossible: under such an interest rate path, a patient middle-aged depositor has an incentive to withdraw and redeposit elsewhere in the banking system, to obtain a payoff of $(R_2)^2$ when old. Taking this constraint into account, the optimal steady-state banking path has the feature that $\bar{c}_2 > R_2 > \bar{c}_1 > R_1$ and can be shown to yield higher ex-ante utility than the infinitely repeated solution (c_1^*, c_2^*) of the base model.

Even the basic OLG-model allows several other interesting insights. First, as in the case of Proposition 1 above, the optimal steady state cannot be realized as a decentralized Walrasian equilibrium outcome. Interestingly, this holds even if fiat money is introduced as an additional store of value into the model.[10] Second, and differently from the static base model, at the steady state, no side-payments among depositors can upset the banking contract. This is because $\bar{c}_2 > R_2$: the rewards of staying with the bank until old age are sufficiently high to make it attractive to forego even the individual long-term return. And third, suspension of convertibility is no longer sufficient (as in Proposition 2) to rule out bank runs. The reason for this important result is that an intergenerational bank will typically rely on new deposits to (partly) pay off existing depositors. In case of a run, then, suspension of convertibility can prevent existing deposits from flowing out of the bank, but it cannot force new deposits into the bank.

Building on these insights, the literature has then addressed several farther reaching questions, most notably the explicit comparison of stock market and banking environments and the transition to steady states (see, in particular, Bhattacharya, Fulghieri, and Rovelli (1998, and this volume)).

After this extensive discussion of bank liquidity provision on the liability side of the balance sheet, I now turn briefly to the asset side. Although it had long been claimed that banks serve to provide liquidity to firms, a precise description of the relationship between corporate liquidity needs and

[10] The reason is that the steady state requires transferring wealth from the old patient agents to the middle-aged impatient agents. Different from the classical transfer problem of Samuelson (1958), where the old must receive wealth from the middle-aged, money cannot accomplish this transfer, because the old do not value money. See Qi (1994) for an excellent discussion.

banking, analogous to that of the Diamond-Dybvig model for the household sector described earlier, was lacking. The problem quickly becomes clear if one tries to set up such a model.

Suppose a firm has an investment project that needs initial finance I at date 0 and continuation finance I_1 at date 1 to generate a return of R at date 2. If the lending relationship is subject to uncertainty and borrower moral hazard, I_1 is stochastic, and the firm earns insufficient short-term returns, then full ex-ante financing is typically impossible, I_1 can be interpreted as a liquidity shock, and the lending of the necessary additional funds as liquidity provision. Such sequential lending models are useful in their own right,[11] but they fail to address the basic question - the analogue of Proposition 1 above for the corporate sector - of why banks are needed to provide the liquidity.

One possible route to an answer is the theory of relationship banking, based on informational asymmetries, reviewed in Section 6 of this volume. Another, ingenious solution has been proposed by Holmström and Tirole (1998, and in this volume) who shed light not only on the liquidity problem, but also on the working of financial intermediation in general equilibrium and on possible policy concerns.[12]

Their work embeds a version of the above lending problem into a simple general equilibrium model with a continuum of ex ante identical firms and (in its first part) no aggregate uncertainty (note the similarity in structure to the household model described earlier). In principle, therefore, it seems that firms could insure themselves against liquidity problems by holding diversified portfolios of each others' shares (the market solution), because aggregate refinancing needs are certain. However, such redistribution of aggregate liquidity ex post is not sufficient to satisfy all liquidity demand for one simple reason: under this mechanism firms with low refinancing needs obtain liquidity that they don't need and that they cannot pass on because of borrower moral hazard. Hence, the market "wastes" liquidity. In this situation, banks can play a useful role in redistributing liquidity very much as in the model of household liquidity demand discussed earlier. In fact, banks can commit to liquidity redistribution through credit lines or liquidity covenants in short-term loans, because with these instruments, the unused liquidity of firms with

[11] See Fudenberg, Holmström and Milgrom (1990) for a general analysis of sequential contracting and, for example, Webb (1992) for an application to corporate finance.

[12] Holmström-Tirole (1999) provides a simple asset pricing model in this spirit, which allows to determine the market price of liquidity as an asset that insures against liquidity shortfalls due to managerial moral hazard.

low refinancing needs does not belong to these firms, but to the banks.[13]

Having discussed liquidity provision on the liability and on the asset side of banks' balance sheets, the last question I should briefly raise in the perspective of this survey is that of the relationship between the two sides. Put differently: is there an economic rational for liquidity provision to households and to firms to be undertaken by the same institution? The literature here is still relatively young, but the existing theory in this area - most prominently Calomiris and Kahn (1991), Diamond and Rajan (2001), Kashyap, Rajan, and Stein (2000) and Webb (2000) - all suggest that there exist synergies between the banks' special short-term lending function and the fragile structure of banks' liabilities created by their liquidity role for households.

Kashyap, Rajan, and Stein (2000) make this point in a simple model, which again relies on the basic assumption of limited market access discussed earlier. They consider two hypothetically separated institutions, one providing liquidity to households through demand deposits and one providing liquidity to firms through loan commitments. If these institutions cannot trade funds immediately and costlessly on the market when needed and if the liquidity shocks affecting households and firms are not perfectly correlated, the two institutions can improve efficiency by pooling their ressources. The empirical part of their work provides evidence supporting this theory: commercial banks provide more short-term liquidity to firms - especially through unsecured credit lines - than all other types of lending intermediaries.

[13] Bolton and Freixas (2000) discuss a similar liquidity problem in the context of a fully spelled out market equilibrium with adverse selection in equity markets. In their work, perfect renegotiation of the liquidity problem at the interim stage is impeded by a coordination failure among lenders.

References

Allen, Franklin and Douglas Gale (1994), "Limited Market Participation and Volatility of Asset Prices", *American Economic Revue* 84, 933-955.

Bencivenga, Valerie and Bruce Smith (1991), "Financial intermediation and endogenous growth", *Review of Economic Studies* 58, 195-209.

Bernanke, Ben and Mark Gertler (1987), "Banking and macroeconomic equilibrium", in: W.A. Barnett and K.J. Singleton (Eds.), New Approaches to Monetary Economics, *Cambridge University Press.*

Bhattacharya, Sudipto and Douglas Gale (1987), "Preference shocks, liquidity, and central bank policy", in: W.A. Barnett and K.J. Singleton (Eds.), New Approaches to Monetary Economics, *Cambridge University Press.*

Bhattacharya, Sudipto, Paolo Fulghieri and Ricardo Rovelli (1998), "Financial intermediation versus stock markets in a dynamic intertemporal model", *Journal of Institutional and Theoretical Economics* 154, 291-319.

Biais, Bruno, Thierry Foucault, and Pierre Hillion (1997), Microstructure des Marchés Financiers: Institutions, Modèles et Tests, *Presses Universitaires de France.*

Bolton, Patrick and Xavier Freixas (2000), "Equity, bonds, and bank debt: Capital structure and financial market equilibrium under asymmetric information", *Journal of Political Economy* 108, 324-351.

Bolton, Patrick and Ernst-Ludwig von Thadden (1998), "Blocks, liquidity and corporate control", *Journal of Finance* 53, 1-25.

Bryant, John (1980), "A model of reserves, bank runs, and deposit insurance", *Journal of Banking and Finance* 4, 335-344.

Calomiris, Charles and Charles Kahn (1991), "The role of demandable debt in structuring optimal banking arrangements", *American Economic Review* 81, 497- 513.

De Nicoló, Gianni (1993), "ε-Efficient banking without suspension or deposit insurance", manuscript, University of Minnesota.

Diamond, Douglas (1997), "Liquidity, banks, and markets", *Journal of Political Economy* 105, 928-956.

Diamond, Douglas and Philip Dybvig (1983), "Bank runs, deposit insurance, and liquidity", *Journal of Political Economy* 91, 401-419.

Diamond, Douglas and Raghuram Rajan (2001), "Liquidity risk, liquidity creation, and financial fragility: a theory of banking", *Journal of Political Economy* 109, 287-327.

Freixas, Xavier and Jean-Charles Rochet (1997), *The Microeconomic Theory*

of Banking, MIT Press.
Fudenberg, Drew, Bengt Holmström and Paul Milgrom (1990), "Short-term contracts and long-term agency relationships", *Journal of Economic Theory* 51, 1-31.
Fulghieri, Paolo and Ricardo Rovelli (1993), "Capital markets, financial intermediaries, and the supply of liquidity in a dynamic economy", manuscript, Columbia University.
Gorton, Gary and George Pennacchi (1990), "Financial intermediaries and liquidity creation", *Journal of Finance* 45, 49-71.
Gorton, Gary and Andrew Winton (1999), "Liquidity provision, the cost of bank capital, and the macroeconomy", manuscript, University of Minnesota.
Haubrich, Joseph and Robert King (1990), "Banking and insurance", *Journal of Monetary Economics* 26, 361-386.
Hellwig, Martin (1994), "Liquidity provision, banking, and the allocation of interest rate risk", *European Economic Review* 38, 1363-1390.
Holmström, Bengt and Jean Tirole (1998), "Private and public supply of liquidity", *Journal of Political Economy* 106, 1-40.
Holmström, Bengt and Jean Tirole (1999), "The LAPM", manuscript, Université de Toulouse.
Jacklin, Charles (1987), "Demand deposits, trading restrictions, and risk sharing", in: Contractual Arrangements for Intertemporal Trade (E.C. Prescott and N. Wallace, Eds.), *University of Minnesota Press* 26-47.
Jacklin, Charles (1989), "Banks and risk sharing: instabilities and coordination", in: S. Bhattacharya and G. Constantinides (eds.), *Frontiers of Modern Finance*, Totowa: Rowman and Littlefield.
Jacklin, Charles (1993), "Market rate versus fixed rate demand deposits", *Journal of Monetary Economics* 32, 237-258.
Jacklin, Charles and Sudipto Bhattacharya (1988), "Distinguishing panics and information-based bank runs: welfare and policy implications", *Journal of Political Economy* 96, 568-592.
Kashyap, Anil, Raghuram Rajan, and Jeremy Stein (2000), "Banks as liquidity providers: an explanation for the co-existence of lending and deposit-taking", manuscript, University of Chicago.
Qi, Jinpiang (1994), "Bank liquidity and stability in an overlapping generations model", *Review of Financial Studies* 7, 389-417.
Samuelson, Paul (1958), "An exact consumption-loan model with or without the social contrivance of money", *Journal of Political Economy* 66, 467-482.

von Thadden, Ernst-Ludwig (1997), "The term-structure of investment and the banks' insurance function", *European Economic Review* 41, 1355-1374.
von Thadden, Ernst-Ludwig (1998), "Intermediated versus direct investment: optimal liquidity provision and dynamic incentive compatibility", *Journal of Financial Intermediation* 7, 177-197.
von Thadden, Ernst-Ludwig (1999), "Liquidity creation through banks and markets: multiple insurance and limited market access", *European Economic Review* 43, 991-1006.
von Thadden, Ernst-Ludwig (2002), "An incentive problem in the dynamic theory of banking", *Journal of Mathematical Economics* forthcoming.
Wallace, Neil (1988), "Another attempt to explain an illiquid banking system: the Diamond and Dybvig model with sequential service taken seriously", *Quarterly Review, Federal Reserve Bank of Minneapolis,* Fall 1988, 3-16.
Webb, David (1992), "Two-period financial contracts with private information and costly state verification", *Quarterly Journal of Economics* 107, 113-23.
Webb, David (2000), "The impact of liquidity constraints on bank lending policy", *Economic Journal* 110, 69-91.