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Aftermath of Banking Crises: Effects on Real and Monetary Variables

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Aftermath of Banking Crises: Effects on Real and Monetary Variables[1]

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Abstract

In this paper a simple optimizing model is developed to analyze the implications of a banking crisis. Banks are incorporated by assuming that they intermediate funds between firms and households. It is shown that when depositors perceive the quality of deposits to have deteriorated, they switch from deposits to cash. Because of the higher cost of liquidity, consumption, M2 and the M2 multiplier decline; interest rates on deposits and loans increase and output contracts. The findings of the paper match the key stylized facts of banking crises.

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I. Introduction

Banking crises have become prevalent both in developing and developed countries in recent years. Lindgren, Garcia, and Saal (1996), report that since 1980 almost three fourths of the member countries of the IMF have experienced significant problems in their banking sectors.

The causes of banking crises may range from an external shock to the banks or their private debtors– such as a deterioration in the terms of trade, a devaluation of the currency, or a crash in equity or property prices, etc.– or to self-fulfilling runs.[2] But once they occur, their effects on the economy have been observed to be quite severe. Besides entailing a significant impact on economic activity, banking problems have often necessitated a large scale bailout of the banking sector and have been accompanied by weaker currency. Calvo and Reinhart (1999) show that the GDP growth rate averaged -3.2 percent during the banking crises episodes in their sample of 20 countries; the cost of bailing out the banking sector exceeded the historic mean by 15 percent of GDP during 1995-97 in East Asia, and by 8.3 in Latin American countries. In a similar vein, Kaminsky and Reinhart (1999) had earlier found that since the 1970s half the currency crises in their sample of 20 Asian, European and Latin American countries were preceded by banking crises.[3]

The theoretical literature on banking crisis until recently had mainly focused on closed economy models to explain bank runs. Important early contributions to this literature include Diamond and Dybvig (1983) and Gorton (1988). Due to the increased importance of capital flows and the effect of external disturbances on banking sectors throughout the world, the literature has recently been extended to include open economy models of bank runs. Contributions include Chang and Velasco (1998) and Goldfajn and Valdes (1997). However, while explaining the mechanics and the dynamics leading up to the bank run, none of these papers study the period after the banking crisis.

A number of papers, e.g., Gorton (1988), Lindgren, Garcia and Saal (1996), Calvo and Reinhart (1999) and Kaminsky and Reinhart (1999), have studied the period around the banking crises empirically and established several stylized facts pertaining to the aftermath period.[4] In these papers the aftermath period has been shown to be accompanied by the following characterization of monetary and real variables: a withdrawal of deposits, a decline in the demand for money, an increase in the ratio of cash to deposits, a decline in the bank credit, an increase in the interest rates on credit and deposits, an increase in the M2 multiplier, and a decline in economic activity (these stylized facts have been summarized in Table 1).

The purpose of this paper is to present an analytical model that may be useful in understanding these implications of banking crises. In an important contribution Edwards and Vegh (1997) have embedded banks in an open economy perfect foresight framework and use the framework to explain how the banking sector affects the propagation of domestic and external

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[2] See Caprio and Klingebiel (1996) for the evidence on the sources of the banking crises for a sample of 69 countries.

[3] Also see Reinhart, Gupta, and Kaminsky (1999).

[4] In a forthcoming paper Demirgüc-Kunt, Detragiache and Gupta (1999) systematically study the aftermath of a large number of banking crises cases.

Table 1. Stylized Facts on Banking Crisis

	Sample	**Episodes**	**Stylized Facts**
Gorton (1988)	United States, 1873-1914	7 panics in U.S. National Banking Era Panics	Cash to deposit ratio declined, deposits suffered losses, output declined.
Kaminsky and Reinhart (1999)	20 countries, 1970-1997	26 episodes of banking crisis	M2 multiplier declines, deposits decline, domestic credit-to-GDP ratio increases, output smaller, lending-to-deposit interest rate increases.
Lindgren, Garcia and Saal (1996)	34 countries, 1980-Spring 1996 1/	36 episodes	High interest rates and high interest rate spreads, financial disintermediation (credit crunch, lower growth, decline in deposit to GDP ratio), increase in the cash to deposit ratio, decrease in money multiplier, increased credit to the banks, substantial cost of restructuring, loss in international reserves and depreciated exchange rate.

1/ The study covers 131 members countries of the IMF. However, a smaller sample of 34 countries has been used for the analysis of the effects of banking crisis.

shocks. This paper differs from that of Edwards and Vegh in the following respects: first, it specifically analyzes the issue of a banking crisis, and for this purpose it explicitly incorporates the possibility of a banking crisis in the households' maximization problem and derives the effects of banking crisis on the monetary aggregates and real variables and thereby assist understanding the above stylized facts. Among the modelling aspects, it allows the households to hold both deposits and cash to finance consumption, thus explaining the switch from deposits to cash and the effects on the monetary aggregates after a banking crisis.

The model uses a representative agent, perfect foresight model where households can use cash and deposits for liquidity; firms use bank credit to finance the import of an input which is used in the production of a final good. The banks are modeled as in Edwards and Vegh (1997), and are assumed to operate in a perfectly competitive environment and to intermediate funds between households and firms by accepting deposits from households and making loans to firms. Banking is assumed to be a costly activity, where the cost of intermediation depends on the total amount of loans and deposits. The cost function is assumed to be convex with complementarity in the production of deposits and loans. The results are also compared with costless banking in the paper.

The dynamics of the model are analyzed when banks are perceived to be unhealthy by depositors such that they believe that either the banks will restrict the withdrawal of deposits or will default on their deposits, since these are the common responses of the banks during crises, specially if deposit insurance is incomplete or nonexistent. In either case, by losing their liquidity or their value, the deposits deteriorate in quality.

First we analyze the case when depositors perceive the banks to be fragile only for a temporary period. Thus they believe that at a certain date in the future the deposits will regain their quality. Second, we discuss the case when health of the banking sector is perceived to have deteriorated permanently, a belief which may be revised later, e.g. after a restructuring of the banking sector. We find that when the quality of deposits deteriorates then the opportunity cost of holding deposits increases and consumers switch from deposits to cash; the demand for broad money and money multiplier decline.[5] The decline in deposits causes a liquidity squeeze for the bank and there is financial disintermediation: the interest rate on credit increases, the demand for credit declines and output contracts. If the deterioration in the quality of deposits is perceived to be temporary then, due to the liquidity-in-advance constraint, the current effective price of consumption is higher and there is an intertemporal substitution of consumption. The net effect on the demand for cash and current account depends on the intertemporal elasticity of substitution, the degree of substitution between cash and deposits and the output effect of crisis. When the deterioration is perceived to be permanent, there is no intertemporal substitution of consumption and the current account always balances.

The paper proceeds as follows. The model is developed and the equilibrium conditions are derived in Section II. The implications of a banking crisis are analyzed in Section III and Section IV concludes.

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[5] We assume that international funds dry up at the same time that deposits are withdrawn. If the banks could raise sufficient liquidity from other sources then they will not have to restrict the liquidity of their deposits or engage in a fire sale of the assets.

II. Basic Model and Equilibrium Condition

A small open economy is considered which operates under a predetermined exchange rate and is inhabited by four types of representative agent: households, banks, firms and the government. One internationally traded final good is produced and consumed in the economy. This good is used as the numeraire and all the real variables are measured in terms of this good.

There is free movement of the good across countries and purchasing power parity holds. Thus, assuming that the foreign price of the good is constant, the rate of inflation of the domestic good, π_t, equals the rate of depreciation of the nominal exchange rate, ε_t. The world real interest rate, r, is assumed to be constant. Perfect capital mobility implies that the interest rate parity condition holds, therefore the nominal interest rate equals the real international interest rate plus the expected rate of depreciation, i.e., $i_t = r + \varepsilon_t$. The households consume the final good and use cash and demand deposits denominated in domestic currency for liquidity. The production of the good requires an imported input. The firms produce the final good and finance the import bill through loans from the banks. The banks, operating in a perfectly competitive industry, accept deposits from the households and also borrow internationally. The government returns the proceeds from the inflation tax and interest income to households in each period.

A. The Household

The households maximize the present discounted value of lifetime utility which they derive from the consumption of the final good. The objective function of the representative household is given by:

$$\max_{c_t} \int_0^\infty u(c_t)\, e^{-\rho t} dt \tag{1}$$

The instantaneous utility function, $u(.)$, is assumed to be increasing in c, twice continuously differentiable and strictly concave. ρ denotes the constant subjective discount rate, which is assumed to be equal to the world interest rate. The consumer is subject to a "liquidity in advance" constraint whereby he needs to hold liquid assets to make purchases.[6] In the current formulation of this constraint he can hold cash and demand deposits denominated in domestic currency for liquidity services. The liquidity-in-advance constraint requires that consumption should not exceed the liquidity services provided by cash and deposits, i.e.,

$$c_t \leq l(z_t, d_t), \qquad l_z > 0,\ l_d > 0,\ l_{zz} < 0,\ l_{dd} < 0,\ l_{zd} > 0 \tag{2}$$

where z_t and d_t denote the real balances of cash and demand deposits respectively; $l(.)$ is a concave, homogeneous of degree 1, twice-continuously differentiable function; a subscript

[6] The assumption of a cash-in-advance or liquidity-in-advance constraint is quite standard in the literature, see, e.g., Calvo and Vegh (1990), Calvo and Vegh (1995), Edwards and Vegh (1997) etc. For an interpretation of the cash-in-advance constraint in continuous-time models see Feenstra (1985).

with l is used to denote the partial derivative of the function with respect to that argument. The consumer also holds an internationally traded bond, b_t^h, whose rate of return is equal to r. The households have limited access to the international financial market in the sense that they can hold only positive amounts of international bonds, (for a similar assumption see Krugman (1979) and Chang and Velasco (1997)). Total financial wealth of the household, in real terms, equals:

$$a_t^h = b_t^h + z_t + d_t \tag{3}$$

The nominal yields on z_t and d_t equal zero and i_t^d respectively. The real yield on cash is -ε_t. Since demand deposits are denominated in domestic currency, the real yield on demand deposits equals $\left(i_t^d - \varepsilon_t\right)$. The households earn profits from their ownership of the banks and firms and also get lump-sum transfers from the government, denoted by π_t^b, π_t^f and τ_t respectively. The flow budget constraint of the representative household is given by:

$$\dot{a}_t^h = rb_t^h + \left(i_t^d - \varepsilon_t\right) d_t + \tau_t + \pi_t^b + \pi_t^f - c_t - \varepsilon_t z_t \tag{4}$$

adding and subtracting $rz_t + rd_t$ in the R.H.S. of equation (4) we get

$$\dot{a}_t^h = ra_t^h + \tau_t + \pi_t^b + \pi_t^f - c_t - \left[i_t - i_t^d\right] d_t - i_t z_t \tag{5}$$

Equation (5) says that the rate of change in the wealth of the household consists of the return on wealth, a lump-sum transfer from the government, profits from the firms and banks, less consumption expenditure and the opportunity cost of holding deposits and cash. Integrating forward and imposing the no-Ponzi condition, the household's lifetime budget constraint reduces to:

$$a_0^h + \int_0^\infty \left[\tau_t + \pi_t^b + \pi_t^f - c_t - \left(i_t - i_t^d\right) d_t - i_t z_t\right] e^{-rt} dt = 0 \tag{6}$$

The household chooses the optimal time paths of c_t, z_t and d_t to maximize equation (1) subject to equations (2) and (6), given the initial real wealth, a_0^h, and time paths of r, τ_t, π_t^b, π_t^f, i_t^d and ε_t. The first order conditions are:

$$u'\left(c_t\right) = \lambda \left[1 + \frac{i_t}{l_z}\right] \tag{7}$$

$$\frac{l_z}{l_d} = \frac{i_t}{i_t - i_t^d} \tag{8}$$

where λ is the time invariant Lagrange multiplier associated with constraint given by equation (6).[7] Equation (7) has the interpretation that the marginal utility of consumption equals the marginal utility of wealth times the effective price of consumption. The effective price of consumption equals the market price of the good which is equal to unity, plus the marginal cost of

[7] It is assumed that i and $i - i_d$ are positive, hence the liquidity in advance constraint holds with equality at all times.

producing the liquidity services required to purchase a unit of the consumption, $\frac{i_t}{l_z}$. The effective price of consumption, P, thus equals:

$$P\left(i_t, i_t^d\right) = 1 + \frac{i_t}{l_z\left(1, \phi\left[\frac{i_t}{i_t - i_t^d}\right]\right)}, \quad P_{i_t}(.) > 0; \quad P_{i_t^d}(.) < 0 \tag{9}$$

The effective price of consumption is higher, the higher the cost of liquidity. Thus P increases in i_t and decreases in i_t^d. Equation (8) says that the marginal rate of substitution between cash and effective demand deposits is equated to the ratio of their opportunity costs at an optimum. Since $l(z_t, d_t)$ is linearly homogenous in z_t and d_t, equation (8) can be written as:

$$\frac{z}{d} = \phi\left[\frac{i_t}{i_t - i_t^d}\right] \tag{10}$$

where $\phi^{'}[.] < 0$. By combining equations (2) and (10), the demand for cash can be written as a positive function of consumption and a negative function of the relative opportunity cost of cash and deposits; the demand for deposits can be written as a positive function of consumption and a positive function of the relative opportunity cost of holding cash and deposits.

An increase in the relative opportunity cost of holding cash induces the household to increase the ratio of deposits to cash. Since cash is more productive at the margin, the demand for deposits increases by more than the decline in the demand for cash, therefore the demand for money increases. Thus, we may write the demand for money, defined as the sum of cash and deposits, to be a positive function of the relative opportunity cost of cash and deposits and a positive function of consumption. More specifically the demand for cash, deposits and money may be expressed as below[8]:

$$z_t = \Psi^z(\underset{+}{c_t}, \underset{-}{\frac{i_t}{i_t - i_t^d}}) \tag{11}$$

$$d_t = \Psi^d(\underset{+}{c_t}, \underset{+}{\frac{i_t}{i_t - i_t^d}}) \tag{12}$$

$$m_t = \Psi^m(\underset{+}{c_t}, \underset{+}{\frac{i_t}{i_t - i_t^d}}) \tag{13}$$

where $m_t = z_t + d_t$.

[8]For further details see Calvo and Vegh (1990).

B. The Bank

The representative bank accepts deposits from households, holds cash reserves, lends to firms and invests in an internationally traded bond. The financial assets of the bank consist of international bonds, b_t^b, loans, l_t, and cash reserves, $\gamma_t d_t$, where γ_t denotes the required reserve ratio. Liabilities of the bank consist of deposits denominated in domestic currency, d_t and domestic credit from the government.[9] It is assumed that the bank does not hold any excess cash reserves and therefore its cash reserves equal $\gamma_t\, d_t$. From the balance sheet identity the net assets of the bank can be written as:

$$a_t^b = b_t^b + l_t - (1-\gamma_t)d_t \tag{14}$$

Net assets evolve according to the following equation:

$$\dot{a}_t^b = r_t b_t^b + \left(i_t^l - \varepsilon_t\right) l_t - \left(i_t^d - (1-\gamma)\varepsilon_t\right) d_t - C\left(l_t,\, d_t\right) - \pi_t^b \tag{15}$$

where i_t^l is the interest rate on loans and $C\left(l_t,\, d_t\right)$ denotes the cost of operating the bank. By adding and subtracting $rl_t - r(1-\gamma)d_t$ the evolution of net assets may be rewritten as

$$\dot{a}_t^b = r_t a_t^b + \left(i_t^l - i_t\right) l_t - \left(i_t^d - (1-\gamma)i_t\right) d_t - C\left(l_t,\, d_t\right) - \pi_t^b \tag{16}$$

It is assumed, à la Edwards and Vegh (1997), that banking is a costly activity. The assumption of costly banking has previously also been made by Fischer (1983) and Calomiris (1999). Various types of costs that banks may have to incur include: evaluating creditors, managing deposits, renting buildings, maintaining ATMs, etc. Calomiris (1999) argues that banks invest in private information to allocate capital, which is reflected in the special quality of bank lending and in bank-firm relationships, e.g. they screen new customers and keep track of and control the behavior of existing customers. Since these activities are costly, banks are paid for their trouble in the form of higher fees and interest. In this paper the cost function is assumed to be linearly homogenous, strictly increasing and convex:[10]

$$C_l > 0,\ C_d > 0,\ C_{ll} > 0,\ C_{dd} > 0,\ C_{ld} < 0 \quad \text{and} \quad C(0,0) = 0,\ C_d(l,0) = 0,\ C_l(0,d) = 0 \tag{17}$$

Thus, the marginal cost of providing credit and accepting deposits is positive and increases with an increase in the stock of loans or deposits. The negative cross partial derivative between loans and deposits indicates that there is complementarity in the production of credit and deposits. Thus the marginal cost of granting credit increases for the bank if deposits decrease. This may reflect the fact that the fall in deposits lowers the available information on borrowers which makes it more costly to monitor loans (also see Fama (1985) for such an interpretation). It may

[9] We assume that the deposits are offered in terms of domestic currency only. The model can also be extended to the case where banks offer deposits denominated in foreign currency as well.

[10] A possible form of the cost function which satisfies these properties is $\sqrt{l^2 + d^2}$, as given in Edwards and Vegh (1998).

also reflect the fact that when banks are flush with deposits they scrutinize the creditors less, rather than when deposits are relatively scarce.[11] Similarly, the marginal cost of holding deposits increases for the bank if loans decrease or do not increase proportionately. To close the model it is assumed that the household and/or firm collects the operational cost from the bank as payments for the input services provided. [12]

By integrating forward and imposing the no-Ponzi condition, the present discounted value of the total distributed profits can be written as:

$$\underset{l_t,d_t}{Max}\int_0^\infty \pi_t^b e^{-rt}dt = a_0 + \int_0^\infty \left[\left(i_t^l - i_t\right)l_t - \left(i_t^d - (1-\gamma)i_t\right)d_t - C\left(l_t,\, d_t\right)\right]e^{-rt}dt \tag{18}$$

The bank chooses the time paths of l_t and d_t given the initial value of its assets, a_0, and paths of r, i_t, i_t^l, i_t^d, and γ to maximize equation (18).[13] Since the banking industry is assumed to be perfectly competitive each bank takes these interest rates as given and determines its supply of deposits and loans. The interest rates are determined by the total demand and supply of loans and deposits as will be shown below. The first order conditions with respect to l_t and d_t are given by equations (19) and (20) respectively.

$$i_t^l = i_t + C_l\left(\frac{l}{d}, 1\right) \tag{19}$$

$$i_t^d = (1-\gamma_t)i_t - C_d\left(1, \frac{d}{l}\right) \tag{20}$$

Equations (19) and (20) simultaneously determine the supply of loans and deposits by the bank for given i_t^l, i_t, i_t^d, γ_t. Households and firms take the interest rates on deposits and loans as given and determine the demand for deposits and loans respectively. The determination of interest rates on deposits and loans is illustrated in Figure 1. Panel A in the figure depicts the total demand of credit by firms and the total supply of credit by the banking sector (obtained by aggregating the demand and supply of credit by individual firms and banks respectively). Similarly, panel C depicts the total demand of deposits by households and the total supply of deposits by the banking sector. Since the cost function is assumed to be convex, the supply of loans is an increasing function and the supply of deposits is a decreasing function of the respective interest rates.

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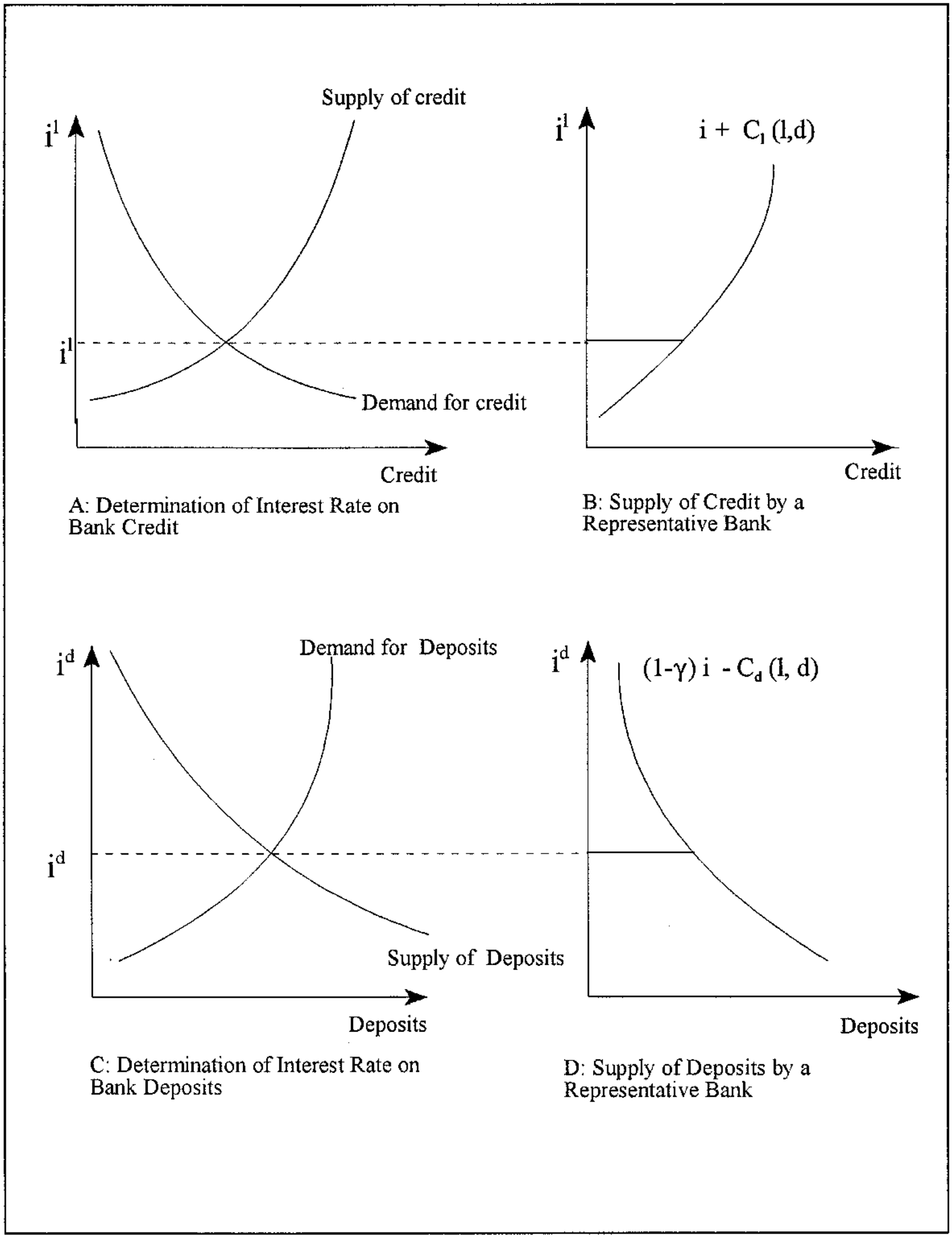
[11] It would then also imply that if the banks can attract a large amount of deposits, there would be a credit boom and the quality of bank credit would deteriorate. However, since it is beyond the scope of the paper we do not analyze this phenomenon here.

[12] We could have also assumed that government obtains the operational cost from the bank, as has been done by Edwards and Vegh (1997). If, instead, this expenditure is assumed to be a social waste then it would show up in the economy wide equilibrium condition and would imply that the cost for the economy increases when the total absolute amount of loans or deposits increases.

[13] Due to the assumptions of perfect competition and constant returns to scale, the bank earns zero profit in equilibrium.

Figure 1. Interest Rates and Supply and Demand of Credit and Deposits



The intersection of respective demand and supply schedules determines the equilibrium interest rates on credit and deposits. Each bank takes these interest rates as given and determines its supply of credit and deposits, as shown in panels B and D in the figure. A decline in deposits would make the supply of credit more costly and by shifting the supply curve to the left results in an increase in the interest rate on credit. Also notice that for the costless banking, $i_t^l = i_t$ and $i_t^d = (1 - \gamma_t)i_t$.

C. Firm

The firm produces the final good by using an imported input denoted by n_t. The production function, $f(n_t)$, satisfies the usual concavity properties.[14]

$$y_t = f(n_t) \tag{21}$$

It is assumed that the firm is subject to a loan in advance constraint, which says that it needs to hold bank credit to finance its import bill, given by equation (22), [15]

$$l_t \geq \alpha(p_t n_t) \tag{22}$$

where p_t denotes the terms of trade.

In principle, firms can borrow domestically or in the international capital market. Domestically, the firm borrows from a domestic bank. The international capital market offers two types of financial instruments: an international bond and a foreign bank credit line. The firm accumulates its wealth in international bond, b_t^f, which yields a constant real interest rate r. Foreign bank credit is assumed to be a perfect substitute for the credit from the domestic bank. The bank credit line is used for the short term and variable credit needs of the firm and presumably offers special services to the firms; e.g., if the credit requirements of firms are random then these credit lines provide the convenience of taking out variable amounts from the account. The interest rate on the bank credit is higher than r.

We assume that even if the firms have access to a foreign bank credit line, in practice (because of the lower cost) they rely exclusively on domestic banks for such credit needs. The assumption is consistent with the evidence which shows that the firms in developing countries predominantly depend on domestic banks for most of their credit needs.[16] The assumption can further be justified by arguing that in equilibrium the firms and domestic banks may find it optimal to build relationships with each other, since the cost of building such relationships may be lower than with foreign creditors (e.g., because of the physical proximity). Moreover, since domestic agents hold deposits with the domestic banks, the latter may find it less costly to evaluate the credit worthiness of the firms and therefore may be able to offer cheaper credit.

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[14] We could include labor as a factor of production as well. It would, however, not add much to the analysis.

[15] To interpret the loan in advance constraint in continuous timing α can be interpreted as the length of time for which the firm must hold credit to finance its import bill; see Feenstra (1985).

[16] For evidence see, Rojas-Suarez and Weisbord (1995), and Calomiris (1999).

Thus, the representative firm accumulates its wealth in the form of international bonds and uses the credit line from the domestic bank for liquidity purposes. The net financial wealth of the firm, a_t^f which equals $b_t^f - l_t$, evolves according to the following equation:

$$\dot{a}_t^f = ra_t^f + y_t - \left(i_t^l - i_t\right) l_t - p_t n_t - \pi_t^f \tag{23}$$

where π_t^f denotes the profit distributed to the household. By integrating equation (23) forward, substituting for the loan in advance constraint and imposing the no-Ponzi condition, the present discounted value of distributed profit equals:

$$\underset{n_t}{Max}\int_0^\infty \pi_t^f e^{-rt}dt = a_0^f + \int_0^\infty \left[f\left(n_t\right) - \left(1 + \alpha(i_t^l - i_t)\right) p_t n_t\right] e^{-rt}dt \tag{24}$$

The firm chooses the optimal path of n_t to maximize equation (24) given the initial stock of assets, a_0^f, and the paths of r, i_t, i_t^l and p_t. The first order condition is given by:

$$f'\left(n_t\right) = \left(1 + \alpha(i_t^l - i_t)\right) p_t \tag{25}$$

which says that at an optimum the firm equates the marginal product of imported input to the opportunity cost of buying the input which equals the market price at which the input is purchased plus the opportunity cost of using credit to finance it.

D. Government (Monetary Authority)

The government issues high powered money, H_t, which is held by households in the form of cash and by banks in the form of cash reserves, i.e.

$$H_t = z_t + R_t = z_t + \gamma_t d_t \tag{26}$$

and sets the path of the rate of devaluation and the minimum reserve requirement ratio. It makes credit available to the banks, holds international bonds, b_t^g, and gives lump sum transfers to households which is denoted by τ_t. Ignoring domestic credit for the time being, the flow constraint of the government can be written as:

$$\dot{b}_t^g = rb_t^g + \dot{H}_t + \varepsilon_t H_t + C(l, d) - \tau_t \tag{27}$$

Integrating forward and imposing the no-Ponzi condition, the lifetime budget constraint of the government can be written as:

$$\int_0^\infty \tau_t e^{-rt}dt = b_0^g - H_0 + \int_0^\infty \left[i_t H_t + C(l, d)\right] e^{-rt}dt \tag{28}$$

where b_0^g denotes the government's initial holdings of bonds. The government rebates the interest income, inflation tax and the money collected from the banks to the households in each period so that in equilibrium, τ_t equals:[17]

$$\tau_t = rb_t^g + \varepsilon_t H_t + C(l,d) \tag{29}$$

Therefore change in b equals the change in H (minus government consumption if any) at time t, i.e.,

$$\dot{b}_t^g = \dot{H}_t \tag{30}$$

E. Equilibrium Conditions

The economy's life-time resource constraint, obtained by combining equations (6), (18), (24) and (28), is given as:

$$b_0 + \int_0^\infty \left[f\left(n_t\right) - p_t n_t\right] e^{-rt} dt = \int_0^\infty c_t e^{-rt} dt \tag{31}$$

where b_0 denotes the economy's initial bond holdings, which equals the sum of bonds held by all the agents in the economy. The above equation says that the present discounted value of consumption equals the present discounted value of the resources in the economy, the latter being equal to the stock of international bonds and the present discounted value of net output. We derive the equilibrium path of consumption assuming a log utility function, i.e. $u\left(c\right) = \log\left(c\right)$. The first order condition for consumption is:

$$\left(1/c_t\right) = \lambda \left[1 + \frac{i_t}{l_z}\right] \tag{32}$$

Using equations (31) and (32), the equilibrium value of the Lagrange multiplier can be written as:

$$\lambda = \frac{1}{b_o + \int_0^\infty \left(f\left(n_t\right) - p_t n_t\right) e^{-rt} dt} \int_0^\infty \frac{e^{-rt}}{\left(1 + \frac{i_t}{l_z}\right)} dt \tag{33}$$

By substituting for λ into equation (32) we get the equilibrium consumption path as:

$$c_t = \frac{1}{\int_0^\infty \frac{e^{-rt}}{\left(1+\frac{i_t}{l_z}\right)} dt} \frac{b_o + \int_0^\infty \left(f\left(n_t\right) - p_t n_t\right) e^{-rt} dt}{1 + \frac{i_t}{l_z}} \tag{34}$$

The first term on the right hand side of equation (34) can be interpreted as the average effective price of consumption over the interval $[0, \infty)$; and the denominator in the second term

[17] We are assuming that the government balances the budget in each period. We could have also assumed that the government runs a fiscal deficit, but this would result in a depletion of reserves and culminate in a currency crisis. See Calvo (1995) for details on the mechanics of a balance of payments crisis in a cash-in-advance setup.

as the current effective price of consumption. Thus, consumption is greater than the present discounted value of resources, if the current effective price is lower than the average effective price of consumption and vice versa. The equilibrium current account path can be derived by combining equations (5), (16), (23) and (27) and may be written as:

$$\dot{b}_t = rb_t + f(n_t) - p_t n_t - c_t \tag{35}$$

Current account thus equals the interest on foreign assets and output net of imported inputs and consumption.

III. Banking Crises

Banking crises have been defined in several alternative ways in the literature. A distinction is often made between a bank run and bank insolvency, but the latter also often results in a run on the bank. A widely accepted definition of bank panics is provided by Calomiris and Gorton (1991) whereby: a banking panic occurs when bank debt holders at all or many banks in the banking system suddenly demand that banks convert their debt claims into cash to such an extent that the banks suspend convertibility of their debt into cash. A bank, on the other hand, is said to be insolvent if its net worth is negative. Caprio and Klingebiel (1996) find that the financial insolvency in the banks is usually preceded by shocks such as a deterioration in the terms of trade, a crash in equity or property prices, etc.

The major explanations of banking crisis have been provided in Random Withdrawal Hypothesis (put forth by Diamond and Dybvig (1983)) and Asymmetric Information Hypothesis (by Gorton (1988)). According to the Random Withdrawal Hypothesis, panics can occur as a result of self-fulfilling beliefs. In the Asymmetric Information Hypothesis panics are most likely to occur when bad news follows a period of high loan demand and a prolonged expansion in economic activity, as bank leverage is high. The shock causes depositors to revise their perceived risk of deposits if they are uninformed about bank asset portfolio values.

The banks' response to a run may be either to suspend or limit the withdrawal of their liabilities, which are predominantly deposits, or to liquidate its assets at a loss and return a proportionate amount to its creditors, who are mostly depositors. In either case the relative opportunity cost of holding the deposits increases for the consumer. In our model we introduce two parameters, μ and θ, to measure the impact of banking crisis on the liquidity and value of the deposits, respectively. μ denotes the liquidity parameter associated with deposits and θ denotes the rate of default on deposits.[18]

Since we are primarily interested in the aftermath of the banking crises, the source of the crisis is not important to the analysis. The depositors perceive, possibly after a shock, that either the liquidity or the asset quality of the bank is poor and therefore the bank would restrict the withdrawal of deposits or not redeem them at their par value. Some possible factors which may generate these kinds of beliefs include: a revelation about the poor asset or liquidity position of

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[18] See Lindgren et al. (1996) for the instances of banking crises where the withdrawal of deposits has been constrained in practice.

the bank which makes the depositors update their beliefs about the true health of the bank and the safety of their deposits; a sudden cessation of capital flows etc.[19]

Ignoring domestic credit, a withdrawal of deposits needs to be met through a reduction in bank credit and/or the cash reserves or an inflow of international credit, otherwise the bank will have to restrict the withdrawal of deposits. Thus, each depositor would be allowed to withdraw only a certain proportion of deposits, which would be determined by the available funds. Thus, assuming that the banks do not hold any excess reserves and that the international flows dry up at the same time (or precede) when there is a run on the banks, the following equation needs to hold at each point in time:[20] $(1-\gamma)\Delta d = \Delta l$ or $\Delta d = \Delta l/(1-\gamma)$.

If, however, credit contracts by less than the amount required to reimburse the depositors (net of cash reserves), then the amount of deposits that can be withdrawn will be constrained to the available liquid funds. Thus, $\mu = \Delta l/(1-\gamma)\Delta d$, is the proportion of deposits that can be withdrawn by households. It is assumed that each depositor takes μ as given, i.e. he cannot affect μ unilaterally. In equilibrium μ will of course be determined by the total deposit withdrawal from the banks as compared to the liquidity that the banks can arrange from loans and other sources such as the international capital market, the monetary authorities etc. If the banks could arrange sufficient funds from the government or from the international financial market then they would not have to restrict liquidity. After incorporating μ, the liquidity in advance constraint can be written as:

$$c_t \leq l(z_t, \tilde{d}_t),\ 0 \leq \mu \leq 1, \quad \text{where} \quad l_z > 0,\ l_{\tilde{d}} > 0,\ l_{zz} < 0,\ l_{\tilde{d}\tilde{d}} < 0,\ l_{z\tilde{d}} > 0,\ l_d = \mu l_{\tilde{d}} \quad (36)$$

where $\tilde{d}_t = \mu_t d_t$ measures the effective holding of deposits.

If instead of restricting the withdrawal of deposits the bank decides to liquidate its assets at a loss, i.e. it engages in a fire sale of its assets in order to meet the demand for liquidity, and decides to pass on the losses to the depositors, then the net yield on deposits is reduced by the rate of default. Thus the net return on deposits becomes $i_t^d - \theta_t$. Default may also occur if the bank is running a high level of non-performing loans, possibly because of a negative shock to asset values, and it transfers the loss to the households in proportion to their deposits, then the rate of default would equal $\theta = npl/d$.[21]

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[19] Other shocks such as deterioration of the terms of trade or a productivity shock to the firm, may also trigger banking problems by increasing problem loans. These will, however, have some additional effects of their own; e.g., they will lowering the demand for credit by the firm, thus lower the interest rate offered on deposits, resulting in lower consumption and output. As we will see below, most of the real and monetary effects of banking crises will remain the same in such cases, but their magnitudes will differ.

[20] Velasco (1987) assumes that because of uncertainty and the possibility of default, there may be a ceiling on the international borrowings.

[21] In Gruben and Welch (1993) a similar parameter θ is defined as one minus the proportion of deposits returned to each depositor by an insolvent bank; the latter equals the ratio of the market value of assets to total deposits, which is less than one for an insolvent bank.

Though default on deposits is admittedly a less frequently observed phenomenon in the real world, since deposits are usually federally insured, it remains relevant because often these guarantees are implicit and the rules of the game are ill defined. Moreover, default also becomes a possibility when the total amount of deposit guarantees falls short of the extent of insolvency; this situation is likely to arise when there is a system wide bank insolvency. Here we are assuming that the explicit deposit guarantee is not sufficient to rule out a default, for simplification we may assume the guarantee to be zero. After incorporating μ and θ in the maximization problem of the household, the first order conditions may be written as

$$u'(c_t) = \lambda \left[1 + \frac{i_t}{l_z}\right] \tag{37}$$

$$\frac{l_z}{l_{\tilde{d}}} = \frac{\mu_t i_t}{i_t - (i_t^d - \theta_t)} \tag{38}$$

From equation (38) an increase in θ or a decrease in μ, at given i_t^d, will make deposits less attractive as compared to cash and will result in a switch from deposits. However, since a change in θ or μ affects the demand for deposits, it also affects i_t^d. Below we will show that in equilibrium when there is a decrease in μ (or an increase in θ), i_t^d increases but does not fully compensate the household for the decline in μ (or an increase in θ) and therefore the cash to deposits ratio increases.

Below we discuss the effects of a decrease in μ. Since an increase in θ is an analytically similar case, we do not discuss it separately. We first analyze the case when depositors perceive the decline in μ to be a temporary phenomenon, and they expect that at a certain date in the future μ will revert back to the higher level. For analytical interest we also discuss the case where banks are perceived by consumers to have become permanently weaker, though they may revise their beliefs later. We also discuss the implications of deterioration in the quality of deposits when banking is costless.

A. Temporary Decrease in the Liquidity Parameter of Deposits

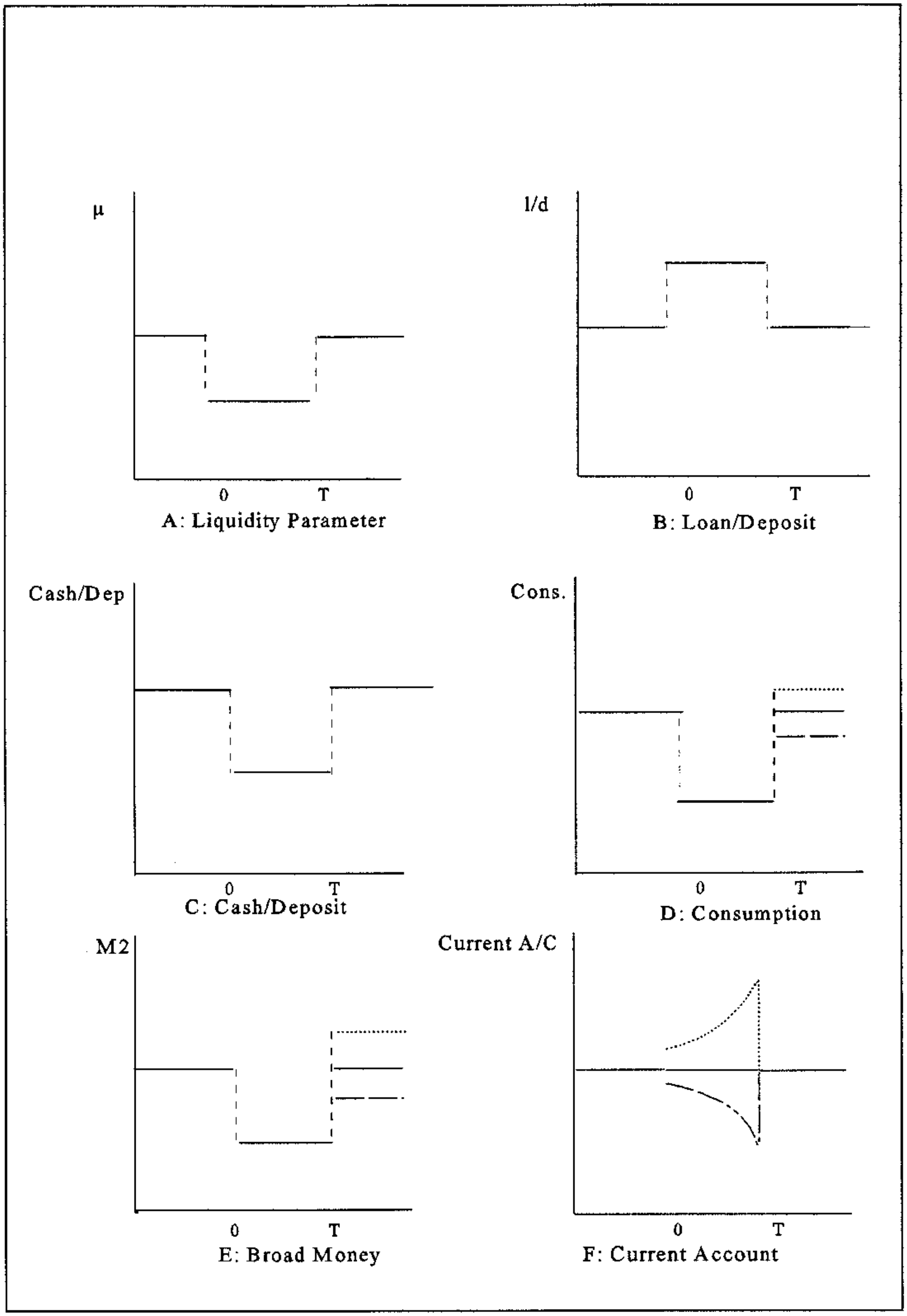
Suppose that at time 0 the liquidity of deposits worsens such that μ decreases from μ_H to μ_L, and that depositors perceive that at time T in the future it will be brought back to μ_H,[22] which may be assumed to be equal to one, and that $\varepsilon_t = \varepsilon$, $\theta = 0$, $p_t = p$ and $\gamma_t = \gamma$ for $t \geq 0$. More formally,

$$\begin{aligned} \mu_t &= \mu_L,\ 0 \leq t < T \\ \mu_t &= \mu_H,\ t \geq T \end{aligned} \tag{39}$$

where $\mu_L < \mu_H$. Initially, at time 0, there is steady state and consumption is equal to $rb_0 + f(n) - pn$, therefore the current account is in balance. The following proposition summarizes the behavior of relevant variables following a temporary decrease in μ. Main results of this exercise are also summarized in Figure 2.

[22] Either because the shock is temporary or because the bank will be restructured by the government at time T.

Figure 2. A Temporary Decrease in μ



Proposition 1: Consider a perfect foresight equilibrium path along which $\theta_t = \theta = 0$, $\varepsilon_t = \varepsilon, p_t = p$ and $\gamma_t = \gamma$ for all $t \epsilon [0, \infty)$, if μ_t decreases temporarily at $t = 0$ then l/d increases, i^l and i^d increase, d and l decline, $\frac{z}{d}$ increases, c and m decline.

Proof: We first show that when μ decreases temporarily at time 0, $\frac{l}{d}$ increases, proving it by contradiction:

(i) Suppose that when μ decreases at time 0, $\frac{l}{d}$ remains unchanged, i.e. $\left(\frac{l}{d}\right)_0 = \left(\frac{l}{d}\right)_{0-}$. From equations (19) and (20) this implies that $i_t^l - i_t$ and $i_t - i_t^d$ are unchanged and combined with equation (25) it has the implication that l and thus d remain unchanged. From equation (38) the ratio of cash to deposits increases at given i_t^d. If deposits remain unchanged then it implies that cash holdings and M2 increase; there is an intertemporal substitution of consumption, and consumption declines. This gives a contradiction with an increase in M2 and an increase in the share of cash in M2.

(ii) Suppose that when μ decreases at time 0, $\frac{l}{d}$ decreases, i.e. $\left(\frac{l}{d}\right)_0 < \left(\frac{l}{d}\right)_{0-}$. From equations (19) and (20) this implies that $i_t^l - i_t$ and $i_t - i_t^d$ increase and combined with equation (25) it has the implication that l increases, thus d increases proportionately more. From equation (38) the cash to deposit ratio increases, which implies that cash increases proportionately more than deposits, therefore M2 increases. However the current effective price of consumption is higher both because of a decline in μ and an increase in $i_t - i_t^d$ thus there is an intertemporal substitution of consumption and consumption declines. This gives a contradiction with an increase in M2 and an increase in the share of cash in M2.

Therefore when μ decreases at time 0, $\frac{l}{d}$ increases. Since $C(l, d)$ is convex, an increase in l/d implies that the cost of bank credit increases, which results in a decrease in the demand for credit from equation (25). An increase in l/d combined with a decrease in l implies that there is a more than proportionate decrease in deposits and from equation (20) i^d increases. Next we show that the increase in i^d is not sufficient to offset the decline in μ.

If the increase in i^d more than offsets the decline in μ, then from equation (38) we get a decline in the ratio of cash to deposits. Also the effective price of consumption is now lower and therefore consumption increases. A decline in deposits combined with a decline in the ratio of cash to deposits implies that cash decreases proportionately more than the decline in deposits. Therefore demand for money declines which gives a contradiction with an increase in consumption.

Thus when μ decreases i^d increases, but the increase in i^d is does not completely offset the decline in μ in equilibrium. Thus from equation (38) we get an increase in the z/d ratio. Since there is a switch to a more expensive source of liquidity, the cost of liquidity is higher and therefore the effective price of consumption is higher between period 0 and T as compared to the period from T onwards. For $t \geq 0$, the consumption path is given by:

$$c_t = \frac{1}{\frac{1-e^{-rT}}{rP^H} + \frac{e^{-rT}}{rP^L}} \frac{1}{P^H} \left[b_o + \int_0^{\infty} \left(f\left(n_t\right) - p_t n_t \right) e^{-rt} dt \right] \quad 0 \leq t < T \tag{40}$$

$$c_t = \frac{1}{\frac{1-e^{-rT}}{rP^H} + \frac{e^{-rT}}{rP^L}} \frac{1}{P^L} \left[b_o + \int_0^\infty \left(f\left(n_t\right) - p_t n_t \right) e^{-rt} dt \right] \quad t \geq T \tag{41}$$

where P^L and P^H, respectively, are the effective prices of consumption between period 0 and T and from T onwards. Because of the higher liquidity cost, $P^H > P^L$, therefore consumption and the demand for money are smaller between time 0 and T.

Notice that because of a decline in l, output is smaller as well between period 0 and T. Since both output and consumption are smaller between 0 and T, the effect on the current account is ambiguous. The current account at time T will depend on the intertemporal elasticity of substitution, IES, and the output effect. If output does not contract much between period 0 and T and the IES is large, then the current account will become positive. The level of consumption at T, as compared to the period prior to the crisis, is also not clear and depends on the current account. If the intertemporal substitution effect and output effects are strong enough to yield a positive current account between period 0 and T, then the economy will accumulate foreign assets and consumption at time T will be higher than the pre-crisis level and vice versa. Panels D and F in Figure 2 exhibit these various possibilities.

The demand for cash is subject to two offsetting forces: a positive substitution effect, because of the higher cost of holding deposits, and a negative level effect, because of lower consumption. The net effect is ambiguous. The level effect would be stronger than the substitution effect if the IES is high and/or the intratemporal elasticity of substitution between cash and deposits is small.[23] Notice that the demand for M2 is lower both because there is a switch to a more costly and therefore more productive source of liquidity, the substitution effect, and because of lower consumption. Because of the substitution effect, the decline in M2 is proportionately more than the decline in consumption, therefore M2 multiplier (defined as M2/consumption) is smaller.

Thus to summarize: a worsening of the liquidity of deposits increases the opportunity cost of holding deposits; and the effective price of consumption increases. Therefore households switch from deposits to cash and consumption and total money demand declines. A decline in deposits implies that the banks find it more costly to offer credit, therefore the interest rate on credit increases and output declines.

When banking is costless, equation (8) reduces to $\frac{l_z}{l_{\tilde{d}}} = \frac{\mu_L}{\gamma_t}$. A decrease in μ makes it more costly to hold deposits and the effective price of consumption to rise between period 0 and T. Thus there is a switch from deposits to cash and consumption falls at time 0. M2 falls both because of the level effect and the substitution effect. The cost of bank credit is not, however, affected by the deposits withdrawal in this case; therefore the amount of credit and output do not change. The same level of output and smaller consumption levels imply that the current account turns positive at time 0 and improves during the period 0 and T.

[23] Empirically, in many papers the IES has been found to be less than 1. The estimates of IES found by Ostry and Reinhart (1992) fall in the range of 0.4 to 0.8.

Identical dynamics are obtained if instead of restricting the liquidity of deposits the bank defaults on them. Thus, suppose that at time 0, θ becomes positive and equals θ_H, and at time T it is brought back to 0 and that $\varepsilon_t = \varepsilon$, $\mu = 1$, $p_t = p$ and $\gamma_t = \gamma$ for $t \geq 0$; the results are analytically similar to the previous case in which the liquidity of deposits worsens.

B. Permanent Decrease in the Liquidity Parameter of Deposits

Suppose that at time 0 the liquidity of deposits worsens such that μ decreases from μ_H to μ_L, and that $\varepsilon_t = \varepsilon$, $\theta = 0$, $p_t = p$ and $\gamma_t = \gamma$ for $t \geq 0$. More formally,

$$\mu_t = \mu_L, \quad t \geq 0 \tag{42}$$

When the depositors perceive the deposits to have deteriorated in quality permanently, the intertemporal substitution in consumption does not take place. Since deposits become more costly the switch from deposits to cash still takes place. Thus the deposits are withdrawn, which in turn causes i^d and i^l to rise and l and output to contract. Consumption falls at time 0 from the pre-crisis level because of the negative output effect, but stays constant there after. The current account balances in each period. Because of the substitution and level effects, the demand for cash, as compared to the pre-crisis level, is not clear and M2 and the money multiplier are smaller compared to their pre-crisis levels.

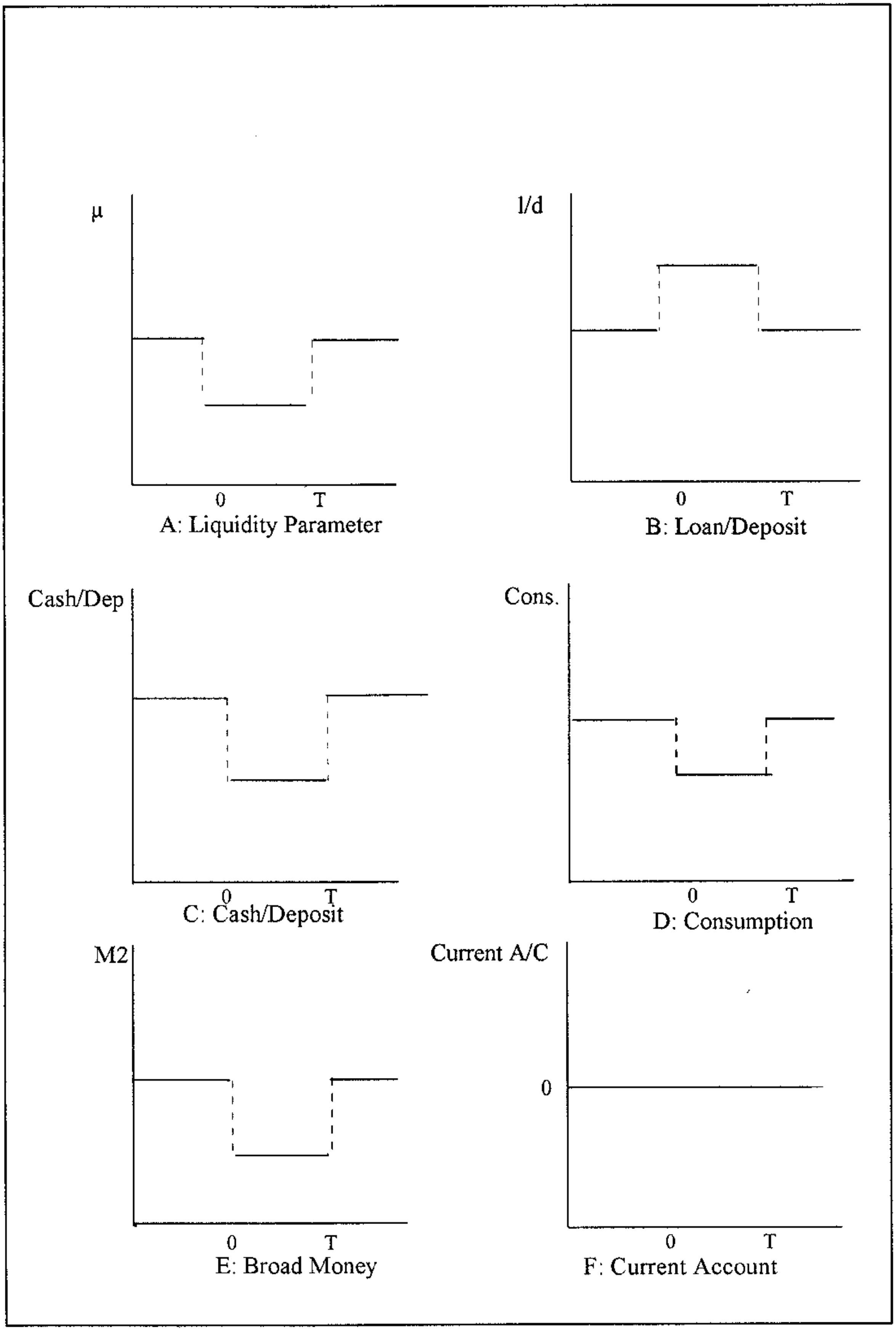
Now suppose that depositors' confidence in the banking system is revived at some time, let's say T, possibly due to positive news, such that they revise their beliefs, and bring μ_t back to μ_H. Until time T, the dynamics remain the same as when the decline in μ was perceived to be a permanent change, but at time T the reverse dynamics are obtained: the depositors switch back into deposits, which brings interest rates down, increases credit and output; consumption, M2 and the M2 multiplier increase (the current account, however, balances from period T onwards as well). See Figure 3.

IV. Conclusion

This paper explains the stylized facts which show that banking crises are associated with: a withdrawal of deposits, a decline in the demand for money, an increase in the ratio of cash to deposits, a decline in bank credit, an increase in the interest rates on credit and deposits, a decrease in the M2 multiplier and lower economic activity. The paper shows that a banking crisis makes deposits less attractive relative to cash for a consumer who uses cash and deposits for liquidity purposes; thus, there is a switch from deposits into cash. The demand for consumption declines because of the higher opportunity cost of holding liquidity. Deposit withdrawal, in turn, results in a credit crunch and higher interest rates, and thereby a decline in economic activity.

Several extensions are possible within the framework developed in the paper. First, the model can be used to analyze the effects of financial liberalization. In the model, financial liberalization will result in a decline in the intermediation cost and more favorable interest rates on loans and deposits, and will encourage economic activity and generate a lending boom.

Figure 3. A Permanent Decrease in μ: Beliefs Revised at Time T



If, however, in a zeal to lend the surplus funds the banks' scrutiny of potential debtors slackens, then it can eventually result in defaults and losses and culminate in banking distress and panic. Second, it is also possible to show in the existing framework another channel whereby banking and currency crises may be linked. This channel is different from the bailing out story, and works through a decline in the demand for money which accompanies the banking crisis. The weaker demand for money would increase the possibility of a currency crisis.

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