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Aftermath of banking crises: Effects on real and monetary variables

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Abstract

This paper models the effects of a banking crisis, and in particular distinguishes between a short-term crisis, such as a banking panic, and a longer-term crisis, such as a banking insolvency. Using an optimizing framework, it shows that depositors shift from deposits into cash in both types of crises, which results in an increase in the interest rates on deposits and loans, and a contraction in output and consumption. However, when the crisis is resolved in a finite time period, there is an intertemporal substitution of consumption, and consumption is postponed until the crisis is resolved. This in turn results in a further decline in the demand for money, availability of credit and output.

JEL classification: F41; G21

Keywords: Banking crisis; Bank panic; Bank insolvency

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1. Introduction

Banking crises have become a global phenomena in recent years. As shown by Lindgren et al. (1996), since 1980 almost three-fourth of the member countries of the IMF have experienced significant problems in their banking sectors. The effects of banking crises on economic growth, demand for money, and interest rates have been observed to be quite significant.[1] Banking crises can take the form of either a liquidity crisis or a solvency crisis.[2] While liquidity crises are usually short-term panics, the solvency crises are reflections of fundamental deterioration in banks' health, and usually take longer to resolve.

This paper models the effects of a banking crisis using a variant of Edwards and Vegh's (1997) perfect foresight, optimizing, representative agent model.[3] In the framework used here, the households 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; and the banks' intermediate funds between households and firms. Banking is assumed to be a costly activity, where the cost of intermediation depends on the total amount of loans and deposits.

The paper in particular compares the dynamics of a banking crisis, which lasts for a finite time period, with the dynamics of a banking crisis which lingers permanently. We call these crises a "temporary crisis" and a "permanent crisis", respectively. While the first may be thought of as an example of a short-term panic, the second case may be thought of as an extreme example of an insolvency crisis. This exercise relates to the literature in international economics, in which the implications of a temporary and a permanent (or an incredible and credible) policy change are compared (see Calvo and Vegh, 1990, 1993).

We find that in both the cases, when the quality of deposits deteriorates, the opportunity cost of holding deposits increases and consumers shift from deposits into cash. 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. Since cash is a more efficient means of liquidity at the margin, its demand increases by less than the decline in the demand for deposits and the demand for broad money and money multiplier decline. Consumption declines because of a contraction in output.

However, if the deterioration in the quality of deposits is 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—consumption is postponed until the crisis is resolved. Thus there is an additional decline in the demand for cash and deposits, available credit, and output. The net effect on the

[1] Banking crises typically result in an increase in the ratio of cash to deposit, a decline in the demand for money, money multiplier, credit and output.

[2] Calomiris et al. (2000) make this distinction clear when they analyze whether the banking distress during the Great Depression was due to a liquidity crisis or a solvency crisis.

[3] Edwards and Vegh (1997) use this framework to study the effects of external disturbances, such as an increase in world interest rates, on bank specific and macro-variables.

demand for cash, and on the current account is not clear and would depend on the intertemporal elasticity of substitution, and the degree of substitution between cash and deposits. When the deterioration is perceived to be permanent, there is no intertemporal substitution of consumption. Thus the effects of a short-run banking panic are likely to be sharper than the effects of a longer-run banking insolvency.

The paper proceeds as follows. The model is discussed and the equilibrium conditions are derived in Section 2. The implications of a banking crisis are analyzed in Section 3, and Section 4 concludes.

2. Basic model and equilibrium condition

We consider a small open economy with four representative agents: households, banks, firms and the government. The economy operates under a predetermined exchange rate. One internationally traded final good is produced and consumed in this economy, which is used as the numeraire. 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 households consume the final good and use cash and demand deposits for liquidity. The firms produce the final good using an imported input and finance the import bill through loans from the banks. The banks, operating in a perfectly competitive industry, accept deposits from the households. The government returns the proceeds from the inflation tax and interest income to households in each period.

2.1. Household

The households maximize the present discounted value of utility derived from the consumption of the final good. The objective function of the representative household is:

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

$$\text{s.t.}\quad c_t \le l(z_t, d_t),\ l_z > 0,\ l_d > 0,\ l_{zz} < 0,\ l_{dd} < 0,\ l_{zd} > 0. \tag{2}$$

The instantaneous utility function, $u(\cdot)$, is assumed to be increasing in c, twice-continuously differentiable and strictly concave. The constant subjective discount rate, ρ, is assumed to be equal to the world interest rate. The consumer is subject to a "liquidity in advance" constraint, given by Eq. (2), which requires that consumption does not exceed the liquidity services provided by cash, z_t, and deposits, d_t.[4] The liquidity function $l(\cdot)$ is concave, homogeneous of degree one, and twice-continuously differentiable. A subscript with l is used to denote the partial

[4] See Calvo and Vegh (1990, 1993) and Edwards and Vegh (1997).

derivative of the function with the respective argument. Besides cash and deposits, consumers also hold an internationally traded bond, b_t^h, which yields a constant real interest rate, r.[5] 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 of the exchange rate, i.e., $i_t = r + \varepsilon_t$. Total real financial wealth of the representative household, a_t^h, equals:

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

Denoting the nominal interest rate on deposits by i_t^d, the real yield on demand deposits equals $(i_t^d - \varepsilon_t)$, and the real yield on cash equals $-\varepsilon_t$. 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:

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

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

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

Eq. (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 Eq. (5) forward and imposing the no-Ponzi condition, the household's lifetime budget constraint reduces to:

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

The household chooses the optimal time paths of c_t, d_t and z_t to maximize Eq. (1) subject to Eqs. (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:

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

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

where λ is the time invariant Lagrange multiplier associated with the constraint given by Eq. (6).[6] Eq. (7) equates the marginal utility of consumption to the marginal

[5] It is assumed that the households cannot borrow from the international financial market. See Krugman (1979) and Chang and Velasco (2000) for a similar assumption.

[6] It is assumed that i_t and $i_t - i_t^d$ are positive, hence the liquidity in advance constraint holds with equality at all times.

utility of wealth, times the effective price of consumption. Eq. (8) says that the marginal rate of substitution between cash and effective demand deposits equals the ratio of their opportunity costs at an optimum. Since $l(z_t, d_t)$ is linearly homogenous in z_t and d_t, Eq. (8) can be written as:

$$\frac{z}{d}=\varphi\left[\frac{i_t}{i_t-i_t^{\mathrm{d}}}\right] \tag{9}$$

where $\varphi'[\cdot] < 0$. We define the effective price of consumption, P, as the market price of the good, which is equal to unity, plus the marginal cost of acquiring the liquidity services required to purchase a unit of the consumption, i_t/l_z, i.e. $P = 1 + (i_t/l_z)$. Using Eq. (9) and homogeneity of the liquidity function, P can be written as:

$$P\left(i_t,i_t^{\mathrm{d}}\right)=1+\frac{i_t}{l_z\left(1,\varphi\left[\frac{i_t}{i_t-i_t^{\mathrm{d}}}\right]\right)},\quad P_{i_t}(\cdot)>0;\ P_{i_t^{\mathrm{d}}}(\cdot)<0. \tag{10}$$

The higher the cost of liquidity, the higher the effective price of consumption. Thus, P increases in i_t, and decreases in i_t^{d}. By combining Eqs. (2) and (9), 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 than deposits 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, the demand for money (sum of cash and deposits) can be written as 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[7]:

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

$$d_t=\psi^{\mathrm{d}}\left(\underset{+}{c_t},\underset{+}{\frac{i_t}{i_t-i_t^{\mathrm{d}}}}\right), \tag{12}$$

$$m_t=\psi^{\mathrm{m}}\left(\underset{+}{c_t},\underset{+}{\frac{i_t}{i_t-i_t^{\mathrm{d}}}}\right). \tag{13}$$

[7] See Calvo and Vegh (1990).

2.2. Firm

The firm produces the final good by using an imported input, n_t. The production function, $f(n)_t$, satisfies the usual concavity properties.[8]

$$y_t = f(n_t). \tag{14}$$

It is assumed that the firm is subject to a loan in advance constraint, and needs bank credit to finance its import bill, given by Eq. (15)[9]

$$l_t \geq \alpha(p_t n_t) \tag{15}$$

where p_t denotes the constant terms of trade.

In principle the firms can either borrow domestically or borrow from an international credit institution, but we assume that even if the firms have access to credit from a foreign bank, in practice they rely only on domestic banks. 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 (Rojas-Suarez and Weisbord, 1995; Calomiris, 1999).[10]

The firm accumulates its wealth in the international bond, b_t^{f}. The net financial wealth of the firm, a_t^{f}, which equals $b_t^{\mathrm{f}} - l_t$, evolves according to the following equation:

$$\dot{a}_t^{\mathrm{f}} = r a_t^{\mathrm{f}} + y_t - \left(i_t^{\mathrm{l}} - i_t\right) l_t - p_t n_t - \pi_t^{\mathrm{f}} \tag{16}$$

where π_t^{f} denotes the profit distributed to the households. By integrating Eq. (16) forward, substituting for the loan in advance constraint and imposing the no-Ponzi condition, the present discounted value of distributed profit equals:

$$\max_{n_t} \int_0^{\infty} \pi_t^{\mathrm{f}} \mathrm{e}^{-rt}\, \mathrm{d}t = a_0^{\mathrm{f}} + \int_0^{\infty} \left(f(n_t) - \left(1 + \alpha\left(i_t^{\mathrm{l}} - i_t\right)\right) p_t n_t\right) \mathrm{e}^{-rt}\, \mathrm{d}t. \tag{17}$$

The firm chooses the optimal path of n_t to maximize Eq. (17) 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 Eq. (18):

$$f'(n_t) = \left(1 + \alpha\left(i_t^{\mathrm{l}} - i_t\right)\right) p_t, \tag{18}$$

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.

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[8] We could have included labor as a factor of production. However, it would not have added much to the analysis and made the household's optimization problem more complex.

[9] 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).

[10] Because of the physical proximity the firms and domestic banks may find it optimal to build relationships with each other.

2.3. Bank

Banks accept deposits from households, hold cash reserves, lend to firms and invest 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. It is assumed that the bank does not hold any excess cash reserves, and its cash reserves equal $\gamma_t d_t$. From the balance sheet identity, the net assets of the bank can be written as:

$$a_t^{\mathrm{b}} = b_t^{\mathrm{b}} + l_t - (1-\gamma_t)d_t. \tag{19}$$

Net assets evolve according to the following equation:

$$\dot{a}_t^{\mathrm{b}} = r_t b_t^{\mathrm{b}} + \left(i_t^{\mathrm{l}} - \varepsilon_t\right)l_t - \left(i_t^{\mathrm{d}} - (1-\gamma)\varepsilon_t\right)d_t - C(l_t, d_t) - \pi_t^{\mathrm{b}} \tag{20}$$

where i_t^{l} is the interest rate on loans and $C(l_t, d_t)$ denotes the cost of operating the bank. Banking is assumed to be a costly activity. Calomiris (1999) argues that banks invest in private information to allocate capital, e.g., they screen new customers and keep track of, and control the behavior of existing customers. The cost function is assumed to be linearly homogenous, strictly increasing and convex[11]:

$$C_l > 0,\ C_d > 0,\ C_{ll} > 0,\ C_{dd} > 0,\ C_{ld} < 0, \text{ and } C(0,0) = 0,\ C_d(l,0) = 0,\ C_l(0,d) = 0. \tag{21}$$

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 (Fama, 1985).[12] Similarly, the marginal cost of holding deposits increases if loans do not increase proportionately. To close the model it is assumed that the government obtains the operational cost from the bank.[13] By adding and subtracting $rl_t - r(1-\gamma)d_t$, the evolution of net assets can be rewritten as:

$$\dot{a}_t^{\mathrm{b}} = r_t a_t^{\mathrm{b}} + \left(i_t^{\mathrm{l}} - i_t\right)l_t - \left(i_t^{\mathrm{d}} - (1-\gamma)i_t\right)d_t - C(l_t, d_t) - \pi_t^{\mathrm{b}}. \tag{22}$$

[11] A possible form of the cost function which satisfies these properties is $\sqrt{l^2 + d^2}$, see Edwards and Vegh (1997).

[12] It may also reflect the fact that when banks are flushed with deposits they scrutinize the creditors less, rather than when deposits are relatively scarce.

[13] See Edwards and Vegh (1997). If 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.

By integrating Eq. (22) forward and imposing the no-Ponzi condition, the present discounted value of the total distributed profits can be written as:

$$\max_{l_t,d_t}\int_0^\infty \pi_t^{\mathrm{b}}\,\mathrm{e}^{-rt}\,\mathrm{d}t = a_0+\int_0^\infty \left[\left(i_t^{\mathrm{l}}-i_t\right)l_t-\left(i_t^{\mathrm{d}}-(1-\gamma)i_t\right)d_t-C(l_t,d_t)\right]\mathrm{e}^{-rt}\,\mathrm{d}t. \tag{23}$$

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 Eq. (23). The banking industry is assumed to be perfectly competitive, where the interest rates are determined by the total demand and supply of loans and deposits. The first order conditions with respect to l_t and d_t are given by Eqs. (24) and (25), respectively.

$$i_t^{\mathrm{l}} = i_t + C_l\left(\frac{l}{d},1\right). \tag{24}$$

$$i_t^{\mathrm{d}} = (1-\gamma)i_t - C_d\left(1,\frac{d}{l}\right). \tag{25}$$

Eqs. (24) and (25) simultaneously determine the supply of loans and deposits by the bank for given i_t, i_t^{l}, i_t^{d} and 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 Fig. 1. Fig. 1A 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). Similarly, Fig. 1C 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. A decline in deposits makes the supply of credit more costly and by shifting the supply curve to the left result in an increase in the interest rate on credit. Also notice that for costless banking, $i_t^{\mathrm{l}} = i_t$ and $i_t^{\mathrm{d}} = (1-\gamma_t)i_t$.

2.4. 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 reserve requirement. It holds international bonds, b_t^{g}, and gives lump-sum transfers to households, τ_t. The flow constraint of the government can be written as:

$$\dot{b}_t^{\mathrm{g}} = rb_t^{\mathrm{g}} + \dot{H}_t + \varepsilon_t H_t + C(l_t,d_t) - \tau_t. \tag{27}$$

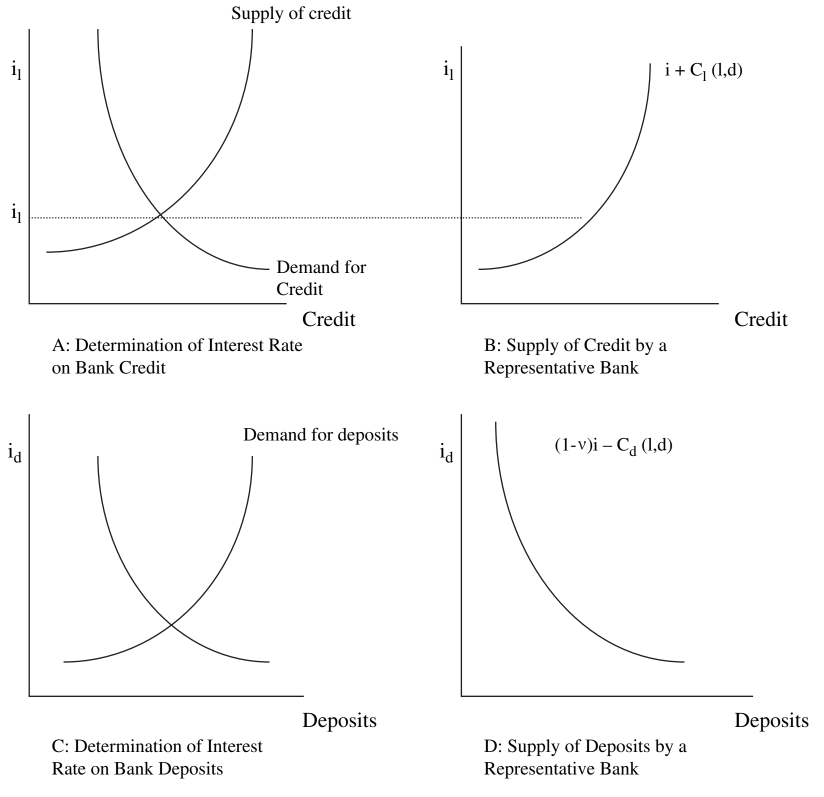

Fig. 1. Interest rates and supply and demand for credit and deposits.

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

$$\int_0^{\infty} \tau_t \, \mathrm{e}^{-rt} \, \mathrm{d}t = b_0^{\mathrm{g}} - H_0 + \int_0^{\infty} [i_t H_{\mathrm{t}} + C(l_t, d_t)] \mathrm{e}^{-rt} \, \mathrm{d}t \tag{28}$$

where b_0^{g} denotes the government's initial holdings of bonds. The government rebates the interest income, inflation tax, and other revenue from the banks to the households in each period so that in equilibrium, τ_t equals[14]:

$$\tau_t = r b_t^{\mathrm{g}} + \varepsilon_t H_t + C(l_t, d_t). \tag{29}$$

[14] We assume that the government balances its budget in each period. If the government runs a fiscal deficit, it would result in the depletion of foreign exchange reserves and culminate into a currency crisis.

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

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

2.5. Equilibrium conditions

The economy wide lifetime resource constraint, obtained by combining Eqs. (6), (17), (23) and (28) is given as:

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

where b_0 denotes the economy's initial bond holdings, which equals the sum of bonds held by all the agents in the economy. Eq. (31) says that the present discounted value of consumption equals the present discounted value of the stock of international bonds and net output. We derive the equilibrium path of consumption by assuming a log utility function, i.e. $u(c) = \log(c)$. The first order condition for consumption is:

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

Using Eqs. (31) and (32), the equilibrium value of the Lagrange Multiplier can be written as:

$$\lambda = \frac{1}{b_0 + \int_0^{\infty} (f(n_t) - p_t n_t) e^{-rt} \, dt} \int_0^{\infty} \frac{e^{-rt}}{\left(1 + \frac{i_t}{l_z}\right)} dt. \tag{33}$$

By substituting for λ in Eq. (32), we get the equilibrium consumption path as:

$$c_t = \frac{1}{\int_0^{\infty} \frac{e^{-rt}}{\left(1 + \frac{i_t}{l_z}\right)} dt} \; \frac{b_0 + \int_0^{\infty} (f(n_t) - p_t n_t) e^{-rt} \, dt}{\left(1 + \frac{i_t}{l_z}\right)}. \tag{34}$$

The first term on the right hand side of Eq. (34) can be interpreted as the average effective price of consumption over the interval $[0, \infty)$; and the denominator in the second term as the current effective price of consumption. Thus, if the current effective price is lower than the average effective price, consumption exceeds the present discounted value of resources, and vice versa. The equilibrium current account path can be derived by combining Eqs. (5), (16), (22) and (27):

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

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

3. Banking crisis

In the analysis below, a banking crisis occurs due to a random withdrawal of deposits. Though we can also analyze the case when the crisis occurs due to an adverse shock and asymmetric information, however, in the latter case the shock itself will likely affect some of the variables considered below.

If there is a random withdrawal of deposits, which exceeds the contraction in bank credit and cash reserves, then the bank may restrict the withdrawal of deposits and allow each depositor to withdraw only a certain proportion of their deposits, μ, which equals: $\Delta l/(1-\gamma)\Delta d$. In equilibrium, μ is determined by the total deposit withdrawn as compared to the liquidity that the banks can arrange. Each individual depositor takes μ as given. After incorporating μ the liquidity in advance constraint can be written as:

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

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

If the problem that the banks face is one of loan losses, and they pass on the losses to the depositors, then the net yield on deposits will be smaller by this "rate of default", θ, and will equal $i_t^{\mathrm{d}} - \theta_t$.[15] Though a default on deposits is a less frequently observed phenomenon, 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. After incorporating μ and θ in the maximization problem of the household, the first order conditions may be written as

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

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

From Eq. (38) a decrease in μ, or an increase in θ, at given i_t^{d}, will make deposits less attractive as compared to cash and will result in a switch from deposits. A change in μ or θ will also affect i_t^{d}. Below we show that in equilibrium, a decrease in μ (or an increase in θ) increases i_t^{d}, but this increase does not fully compensate the households for the decline in μ (or an increase in θ)[16]. Thus the ratio of cash to deposits 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

[15] 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.

[16] See Calomiris and Wilson (1998).

when depositors perceive the decline in μ to be a temporary phenomenon, and then the case when the decline in μ is considered to be permanent.

3.1. 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 (which may be assumed to be equal to one), to μ_L, but at time T in the future it will be brought back to μ_H; and that $\varepsilon_t = \varepsilon$, $\theta = 0$, $p_t = p$ and $\gamma_t = \gamma$ for $t \geq 0$.

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

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

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

Proof: We first show that when μ decreases temporarily at time 0, then l/d increases. We prove it by contradiction:

(i) Suppose that when μ decreases at time 0, l/d remains unchanged, i.e. $(l/d)_0 = (l/d)_{0-}$. From Eqs. (24) and (25) this implies that $i_t^l - i_t$ and $i_t - i_t^d$ are unchanged and combined with Eq. (18) it implies that l, and thus d remains unchanged. From Eq. (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. At the same time 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, l/d decreases, i.e. $(l/d)_0 < (l/d)_{0-}$. From Eqs. (24) and (25), this implies that $i_t^l - i_t$ and $i_t - i_t^d$ increase and combined with Eq. (18) it implies that l increases, and d increases proportionately more. From Eq. (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, 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 Eq. (18). An increase in l/d combined with

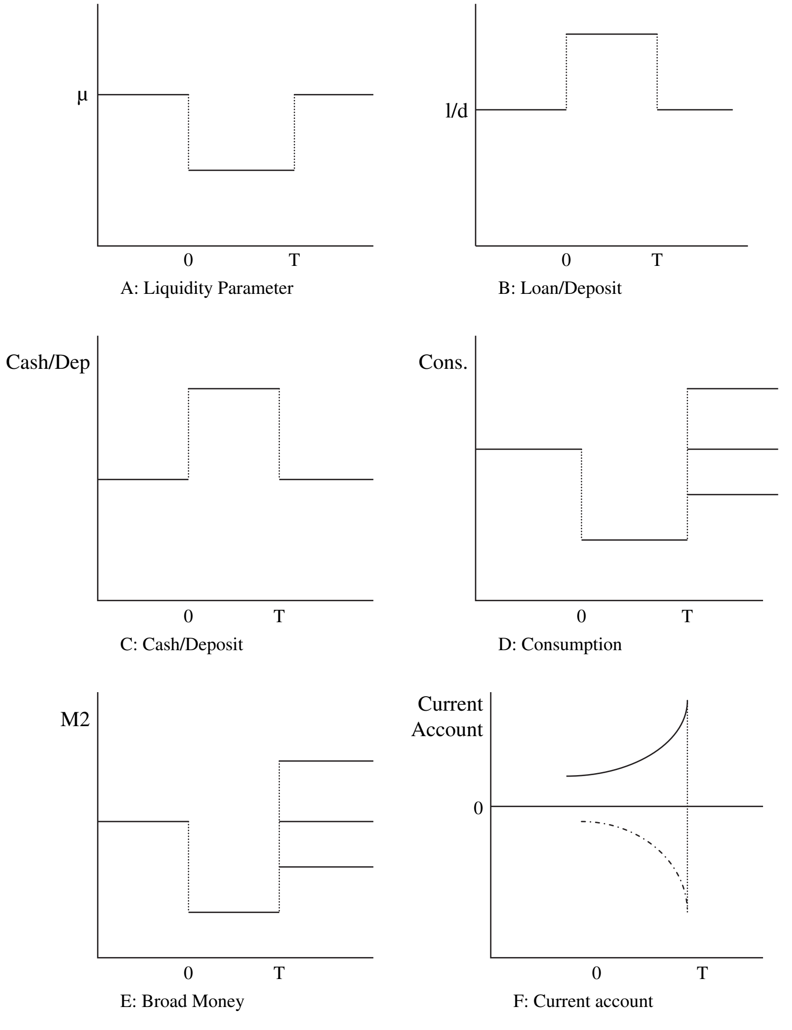

Fig. 2. A temporary decrease in μ.

a decrease in l implies that there is a more than proportionate decrease in deposits and from Eq. (25), i^{d} increases.

Both a decline in μ and an increase in i^{d} affects the demand for deposits in offsetting ways and the net effect is not clear. However, it can be shown that the increase in i^{d} does not fully offset the decline in μ. If the increase in i^{d} more than offsets the decline in μ, then from Eq. (38) we get a decline in the ratio of cash to deposits, and since the effective price of consumption is lower an increase in consumption. 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} does not completely offset the decline in μ. From Eq. (38), we get an increase in the z/d ratio. Since there is a switch to a more costly source of liquidity, 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:

$$c_t = \frac{1}{\dfrac{1-\mathrm{e}^{-rT}}{rP^{\mathrm{H}}} + \dfrac{\mathrm{e}^{-rT}}{rP^{\mathrm{L}}}} \frac{1}{P^{\mathrm{H}}} \left[b_0 + \int_0^{\infty} (f(n_t) - p_t n_t)\mathrm{e}^{-rt}\,\mathrm{d}t \right] \quad 0 \leq t < T, \tag{40}$$

$$c_t = \frac{1}{\dfrac{1-\mathrm{e}^{-rT}}{rP^{\mathrm{H}}} + \dfrac{\mathrm{e}^{-rT}}{rP^{\mathrm{L}}}} \frac{1}{P^{\mathrm{L}}} \left[b_0 + \int_0^{\infty} (f(n_t) - p_t n_t)\mathrm{e}^{-rt}\,\mathrm{d}t \right] \quad t \geq T \tag{41}$$

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, $P^{\mathrm{H}} > P^{\mathrm{L}}$, therefore consumption and the demand for money are smaller between time 0 and T.

Because of a decline in l, output contracts between period 0 and T. Since both output and consumption are smaller between 0 and T, the effect on current account is ambiguous and will depend on the intertemporal elasticity of substitution (IES), and the elasticity of output to credit demand. If output does not contract much between period 0 and T, and the IES is large, such that the negative consumption effect is larger, then the current account will be in surplus. The level of consumption at T in turn will depend on whether there is a current account surplus or a current account deficit between 0 and T. If the current account is in surplus, then the economy will accumulate foreign assets between 0 and T, and consumption at time T will be larger than the pre-crisis level, and vice versa (see Fig. 2A and B).

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 smaller consumption. The level effect would be stronger than the substitution effect, if the IES is large and the intratemporal elasticity of substitution between cash and deposits is small. Notice that the demand for M2 is smaller both because there is a switch to a more costly, and therefore more efficient, source of liquidity (the substitution effect), and because of lower consumption. The decline in M2 is proportionately more than the decline in consumption; therefore M2 multiplier (M2/consumption) is smaller.

Thus to summarize: a temporary worsening of the liquidity of deposits increases the opportunity cost of holding deposits, and the effective price of consumption. Because of the former, the 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. Because of the latter, consumption is postponed and there is a further decline in the demand for money, credit and output. Effects on cash and current account are ambiguous.[17]

3.2. Permanent decrease in the liquidity parameter of deposits

Now we look at the case when the banking crisis is permanent. Suppose that at time 0 the liquidity of deposits worsens such that μ decreases from μ_H to μ_L and that $\varepsilon_t = \varepsilon$, $\theta_t = \theta = 0$, $p_t = p$ and $\gamma_t = \gamma$ for $t \in [0, \infty)$, that is,

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

Proposition 1 remains valid in this case too, and a decrease in μ at time 0 implies an increase in l/d, a decrease in loans, a more than proportionate decrease in deposits, and an increase in i^d. The ratio of cash to deposits increases. Since there is a switch to a more costly source of liquidity, the effective price of consumption is higher. However, now this increase is permanent, thus there is no intertemporal substitution of consumption. The decline in available credit implies a contraction in output, therefore, consumption declines to the level which would keep the current account in balance. For $t \geq 0$, the consumption path is given by:

$$c_t = r\left(b_0 + \int_0^\infty (f(n_t) - p_t n_t)\mathrm{e}^{-rt}\,\mathrm{d}t\right) \quad t \geq 0.$$

The current account balances in each period. Because of the diverse substitution and level effects, the demand for cash, as compared to its pre-crisis level, is not clear. M2, and money multiplier, are smaller compared to their pre-crisis levels (Fig. 3).

4. Conclusion

This paper models the effects of a banking crisis and shows that a banking crisis makes deposits less attractive relative to cash, for a consumer who uses cash and deposits for liquidity purposes. Thus the consumer switches from deposits into cash. Deposit withdrawal in turn results in a credit crunch and higher interest rates, and thereby a decline in economic activity.

[17] When banking is costless, Eq. (8) reduces to $l_z/l_{\tilde{d}} = \mu_L/\gamma_t$. A decrease in μ makes it more costly to hold deposits and the effective price of consumption is higher between period 0 and T. Thus there is switch from deposits to cash and consumption falls at time 0. M2 falls both because of the level effect and the substitution effect. However, the cost of bank credit is not affected by the deposit withdrawal, therefore the amount of credit and output does not change. The same level of output and smaller consumption implies that the current account turns positive at time 0 and improves during the period 0 and T.

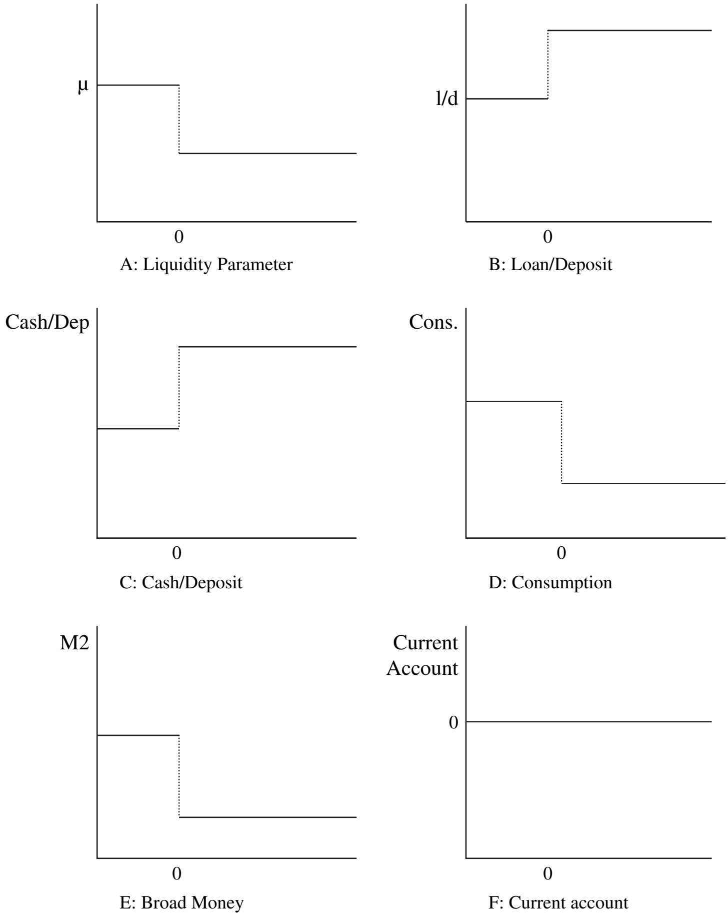

Fig. 3. A permanent decrease in μ.

The effects of a banking crisis also depend on whether the crisis is short lived, or lasts for a long enough period of time. If it is expected to be short lived, as the banking panics usually are, the consumers will intertemporally postpone their consumption. This will bring a further decline in the demand for money, availability of credit, and output. Thus the effect of a short-term crisis are likely to be sharper than the banking problems which are long drawn.

For future work, while the general implications of the model are corroborated by the stylized facts established by others, it will be useful to empirically test the implications of the model regarding the short-run and long run crises. The model presented here can also 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, will encourage economic activity, and generate a lending boom.

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