Banking and Aggregate Risk

Max Gillman* & Ruthira Naraidoo**
*University of Missouri at St Louis **University of Pretoria

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Abstract

This paper presents a general equilibrium approach to including banking as the means of transfering goods across time. The bank intermediates savings by the consumer into investment by the firm. Now markets are incomplete to the degree that banking uses up real resources in the production of the across time transfer. A shock to bank productivity in this setting causes what can be considered aggregate risk in that the degree of optimal consumption smoothing that takes place in competitive markets becomes compromised by unexpected banking productivity changes, with the result that the equity return rises during a drop in banking productivity, as during a bank crisis and as in anecdotal evidence. We examine the macroeconomic fluctuations by preliminary impulse response functions from a calibrated DSGE model within a unified framework that incorporates regime switching in shock variances.

Keywords: Financial Intermediation, Aggregate Risk

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[a]Economics department, University of Missouri at St Louis, US. E-mail: gillmanm@cf.ac.uk

[b]University of Pretoria, Department of Economics, Pretoria, 0002, South Africa. Phone: +27 12 420 3729, Fax: +27 12 362 5207. E-mail: ruthira.naraidoo@up.ac.za.

1 The Financial Intermediation Approach

The main idea of the financial intermediation approach is that the labor and the capital in the banking industry, along with the deposited funds, all needs to be accounted for. In general equilibrium this means there is a production function for turning funds from one form into another. Some amount of funds are deposited in the bank. And minus the labor and capital costs, the funds are distributed in a new form, either as a loan, or as a deposit in a bank account, or as a payment of insurance when the bad state occurs. Also with the representative agent approach, the agent acts in part as a consumer, as a goods producing firm, and as a bank.

The idea of the representative agent acting in part as a bank is quite old, for example, Nobel Laureate John R. Hicks in his 1935 *Economica* article on "A Suggestion for Simplifying the Theory of Money ", Hicks (1935)suggests in one paragraph on page 12 that

> "So as far as banking theory is concerned, this is real the method which is currently adopted;...then my suggestion is that we ought to regared every individual in the community as being, on a small scale, a bank. Monetary theory becomes a sort of generalisation of banking theory."

In previous work Benk, Gillman, and Kejak (2008, 2010), the financial intermediation approach of banking Clark (1984) and Hancock (1985) has been applied to the production of intratemporal credit that the consumer uses as an alternative means of exchange to money, allowing for avoidance of the inflation tax at the cost of the resources used up in banking production of the credit.

Here the banking theory will be used for all such costly means of transfering funds from one point to another, and from one time to another. This will include a general type of insurance that can be posited for intertemporal transfers.

Consider that the representative agent who acts as a bank in part therefore becomes the owner of the bank in the decentralized problems of the consumer, and the firm as goods producer and as bank service producer. The idea is that the bank takes in funds, or deposits of money that will be denoted by d, and uses the deposits for a variety of financial services. The consumer puts funds in the bank, and gets back the funds, either at another time (for example with interest earned minus the cost of investing the funds) or at another place (minus the cost of transfering the funds) or in another state of nature (minus the cost of transfering funds across time).

2 Savings-Investment Intermediation

2.1 Consumer Problem

Financial intermediation is needed when the consumer cannot directly take savings and turn them into investment of capital. Assume this is the case, that the consumer now cannot invest directly in capital for renting to the firm or in financial markets and instead must invest through the bank. To so this the consumer deposits d_t into the bank and receives a return of $\left(1+R_t^d\right) d_t$, where R_t^d is the dividend return. The consumer owns the bank so the total dividends received are $R_t^d d_t$, which are the profit of the bank. This dividend is equivalent to interest earned on the dividends. The only difference is the ownership structure. Here the consumer is assumed to own the bank and receives the profit. Alternately it could be assumed that the consumer rents capital to the bank in the form of deposits d_t and receives the deposits back next period plus the rental cost in the form of interest income; this interest would be equal to $R_t^d d_t$. With the ownership assumption, the way it works is that the consumer gets one share of ownership with each dollar deposited. The price of the share is fixed at one, but variable profits still can result. These are given back to the consumer as dividends per unit of deposited funds, with the dividend rate per unit of deposits R_t^d. By paying out all profits as these dividends the bank earns no extra profit; profit is zero after paying out dividends.

The framework modifies the baseline dynamic neoclassical model, in which the consumer invests directly in physical capital. The only difference is that now the investment takes the form of choosing d_{t+1}, the new deposits to make for next period, while receiving $\left(1+R_t^d\right) d_t$ in the current period as the return of the deposited funds along with the dividends earned.

The consumer allocates time between working in the goods production sector, l_t, in the bank sector, l_{Ft}, and taking leisure x_t. The allocation of time constraint with a time endowment of one is :

$$l_{Gt}^s + l_{Ft}^s + x_t = 1. \tag{1}$$

Recursive utility is of CRRA and CES type at the same time, whereby utility is additively separable in consumption (c_t^d; where 'd' stands for demand) and labor (l_t^s; where 's' stands for supply). $\sigma > 0$ is the coefficient of relative risk aversion and its inverse is the intertemporal elasticity of substitution and $\phi > 0$ is the elasticity of marginal disutility with respect to labor supply , and the "state" variable d_t.

$$V(d_t) = \underset{c_t^d, l_{Gt}^s, l_{Ft}^s, d_{t+1}}{Max:} \frac{\left(c_t^d\right)^{1-\sigma}}{1-\sigma} - \frac{\left(l_t^s\right)^{1+\phi}}{1+\phi} + \beta E_t V(d_{t+1}) \tag{2}$$

$$= \underset{c_t^d, l_{Gt}^s, l_{Ft}^s, d_{t+1}}{Max:} \frac{\left(c_t^d\right)^{1-\sigma}}{1-\sigma} - \frac{\left(l_{Gt}^s + l_{Ft}^s\right)^{1+\phi}}{1+\phi} + \beta E_t V(d_{t+1}) \tag{3}$$

Consumption is equal to wage income, which with w_t the real wage is equal to $w_t\left(l_{Gt}^s + l_{Ft}\right)$, plus the dividend income $R_t^d d_t$ is added to the labor income, and the net increase invested in deposits at the bank, of $d_{t+1} - d_t$. This makes consumption being equal to income minus investment, in the form of the budget constraint :

$$c_t^d = w_t\left(l_{Gt}^s + l_{Ft}^s\right) + R_t^d d_t - d_{t+1} + d_t, \tag{4}$$

$$c_t^d = w_t\left(l_{Gt}^s + l_{Ft}^s\right) - d_{t+1} + d_t\left(1 + R_t^d\right). \tag{5}$$

The consumer maximizes recursive utility with respect to the above budget constraint.

$$V(d_t) = \underset{c_t^d, l_{Gt}^s, l_{Ft}^s, d_{t+1}}{Max:} \frac{\left(c_t^d\right)^{1-\sigma}}{1-\sigma} - \frac{\left(l_{Gt}^s + l_{Ft}^s\right)^{1+\phi}}{1+\phi} + \beta E_t V(d_{t+1}) + \tag{6}$$

$$\mu_t\left(w_t\left(l_{Gt}^s + l_{Ft}^s\right) - d_{t+1} + d_t\left(1 + R_t^d\right) - c_t^d\right) \tag{7}$$

The first order equilibrium conditions for labor supply in goods production (l_{Gt}^s) and banking production (l_{Ft}^s) and deposits d_{t+1} are respectively

$$\left(c_t^d\right)^\sigma \left(l_{Gt}^s + l_{Ft}^s\right)^\phi = w_t, \tag{8}$$

$$\left(c_t^d\right)^\sigma \left(l_{Gt}^s + l_{Ft}^s\right)^\phi = w_t \tag{9}$$

$$\left(\frac{1}{c_t^d}\right)^\sigma = \beta \frac{\partial E_t V(d_{t+1})}{\partial d_{t+1}}, \tag{10}$$

and the envelope condition is

$$\frac{\partial V(d_t)}{\partial d_t} = \left(\frac{1}{c_t^d}\right)^{\sigma}\left(1+R_t^d\right). \tag{11}$$

The last two conditions imply that the intertemporal marginal rate of substitution is given by

$$\beta E_t\left\{\left(\frac{c_{t+1}^d}{c_t^d}\right)^{-\sigma}\right\} = \frac{1}{1+R_t^d} \tag{12}$$

$$\text{or } \frac{\left(\frac{1}{c_t^d}\right)^{\sigma}}{\beta E_t\left(\frac{1}{c_{t+1}^d}\right)^{\sigma}} = 1+R_t^d. \tag{13}$$

2.2 Goods Producer Problem

With R_t^q the price of loans from the bank to the firm, the goods producer time t profit, denoted by Π_t, is given by

$$\Pi_t = A_{Gt}(l_{Gt}^d)^{\gamma}(k_t^d)^{1-\gamma} - w_t l_{Gt}^d - k_{t+1}^d + k_t^d(1-\delta_k) + q_{t+1} - q_t\left(1+R_t^q\right), \tag{14}$$

subject to the constaint that new investment in capital is paid for by new loans from the bank:

$$i_t = k_{t+1}^d - k_t^d = q_{t+1} - q_t. \tag{15}$$

This being in place from the beginning of time, say at time $t=0$, it implies that the capital stock k_t equals the outstanding loans q_t, so that

$$k_t = q_t. \tag{16}$$

With this substituted into the goods producer maximization problem, it reduces to a static problem, rather than a dynamic one, given by

$$\underset{l_{Gt}^d,k_t^d}{Max}: \Pi =_{Gt} (l_{Gt}^d)^{\gamma}(k_t^d)^{1-\gamma} - w_t l_{Gt}^d - k_t^d\left(R_t^q+\delta_k\right). \tag{17}$$

The marginal product of capital then just equals the loan interest rate R_t^d plus the depreciation rate δ_k :

$$(1-\gamma)A_{Gt}\left(\frac{l_{Gt}^d}{k_t^d}\right)^{\gamma} = R_t^q+\delta_k, \tag{18}$$

while the marginal product of labor equals the real wage as before.

2.3 Bank Maximization Problem

The bank can have labor and capital costs. For simplicity assume only labor costs from employing labor in the bank. Denoting this labor by l_{Ft}, for labor in the financial intermediary, the representative agent supplies l_{Ft} when working for the bank. The total cost of the labor is the wage bill of $w_t l_{Ft}$.

The production function for the financial intermediary, or bank, service is that the loans q_t are produced using the deposited funds d_t and the labor l_{Ft}, via a Cobb-Douglas production function, just as was used for the production of the consumption good. Here the productivity parameter is $A_F \geq 0$ and the production function is

$$q_t = A_{Ft}(l_{Ft}^d)^{\kappa}(d_t)^{1-\kappa}, \tag{19}$$

where κ is a parameter between 0 and 1; $\kappa \in [0,1]$.

Now, it is very easy to see what this production function means by taking the case when κ goes towards 0. At $\kappa = 0$, the function becomes simply

$$q_t = A_{Ft} d_t. \tag{20}$$

In this case only deposits are used and no labor is necessary. Further if $A_{Ft} = 1$ (assumed a constant for simplicity), then

$$q_t = d_t, \tag{21}$$

and the amount of deposits put in the bank are what get paid out as the output of the bank. However if there are costs, then the transfering of funds across time, distance, or states of nature is requires that some lessor amount of funds than what was deposited will be available after the transfer.

Then the bank's time t profit, denoted by Π_{Qt}, is revenue of $q_t\left(1 + R_t^q\right) + d_{t+1}$ minus costs of $q_{t+1} + d_t\left(1 + R_t^d\right) + wl_F$:

$$\Pi_{Qt} = -q_{t+1} + q_t\left(1 + R_t^q\right) + d_{t+1} - d_t\left(1 + R_t^d\right) - wl_F. \tag{22}$$

This profit is subject to the production technology in equation (19) and also to a balance sheet constraint that the change in loans is equal to the change in deposits :

$$q_{t+1} - q_t = d_{t+1} - d_t. \tag{23}$$

This added constraint is a simplification that reduces the problem to the static bank maximization problem :

$$\underset{l_{Ft}, d_t, q_t}{Max}\, \Pi_{Qt} = R_t^q q_t - w_t l_{Ft} - R_t^d d_t, \tag{24}$$

subject to the production function in equation (19). Writing this by substituting in the production function, then the problem is

$$\underset{l_F,d}{Max} R_t^q A_F l_{Ft}^{\kappa} d_t^{1-\kappa} - w l_F - R_t^d d_t. \tag{25}$$

The first-order equilibrium conditions of the bank are that

$$\kappa A_F \left(\frac{l_{Ft}}{d_t}\right)^{1-\kappa} = \frac{w_t}{R_t^q}; \tag{26}$$

from differentiating with respect to l_{Ft}, and also that

$$(1-\kappa) A_F \left(\frac{l_{Ft}}{d_t}\right)^{\kappa} = \frac{R_t^d}{R_t^q}, \tag{27}$$

from differentiating with respect to d_t.

2.4 Markov processes

We also have the following loglinearized equations for goods sector productivity and banking sector productivity, following Liu, Waggoner and Zha (2011):

The economy is buffeted by two sources of shocks, namely goods sector productivity shock and banking sector productivity shock. The variance of goods sector shock switches between a finite number of regimes denoted by $s_t^* \in S^*$ with the Markov transition probabilities summarized by the transition matrix $Q^* = [q_{ij}^*]$. The variable A_{Gt} denotes a neutral technology shock, which follows a log-linearized stochastic process:

$$\ln a_{gt} = (1-\rho_g) \ln a_g + \rho_g \ln a_{gt-1} + \sigma_{gt}\varepsilon_{gt}, \tag{28}$$

where $\rho_g \in$(-1, 1) measures the persistence, $\sigma_{gt} \equiv \sigma_g(s_t^*)$ denotes the regime-switching standard deviation, and ε_{gt} is an i.i.d. white noise process with a zero mean and a unit variance.

We assume that the banking sector productivity shock A_{Ft} follows the log-linearized stationary stochastic process

$$\ln a_{ft} = (1-\rho_f) \ln a_f + \rho_f \ln a_{ft-1} + \sigma_{ft}\varepsilon_{ft} + \rho_{fg}\sigma_{gt}\varepsilon_{gt}, \tag{29}$$

where we follow Liu, Waggoner and Zha (2011) and Smets and Wouters (2007) that assume that the government spending shock responds to productivity shocks. Instead here we let the banking productivity shock react to goods sector productivity shock that follows a Markov process with a correlation coefficient ρ_{fg}. The idea here is that the banks have idiosyncratic risk that they can insure against, but they are not so able to insure when there is correlation of the bank productivity shock with the goods sector productivity shock. As the definitions of systemic risk seem to be about the aggregate productivity shock,this correlation will hopefully allow us to capture this aggregate risk impact on the economy.

3 Results and implications for bank crisis

The DSGE model is calibrated with standard parameter values. To gain intuition about the model's transmission mechanisms, we analyze impulse responses of selected variables following an aggregate productivity shock. We show the impulse responses for both shock regimes, viz., low and high volatility shock regimes. Fig. 1 to Fig. 3 show the impulse responses to an aggregate productivity shock in the low and high volatility regimes on the key macro variables.

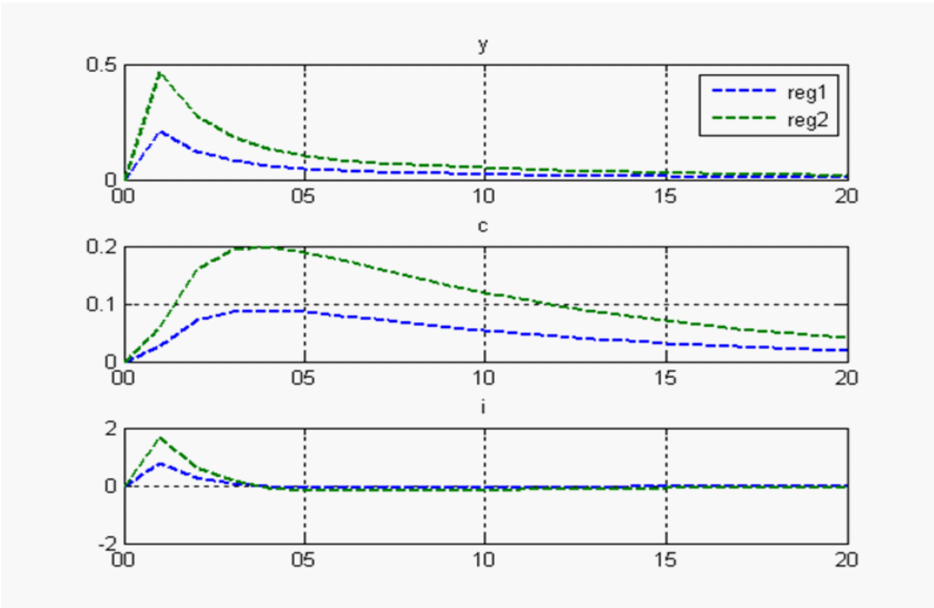

Fig. 1. Impulse responses of output (y), consumption (c) and investment (i).

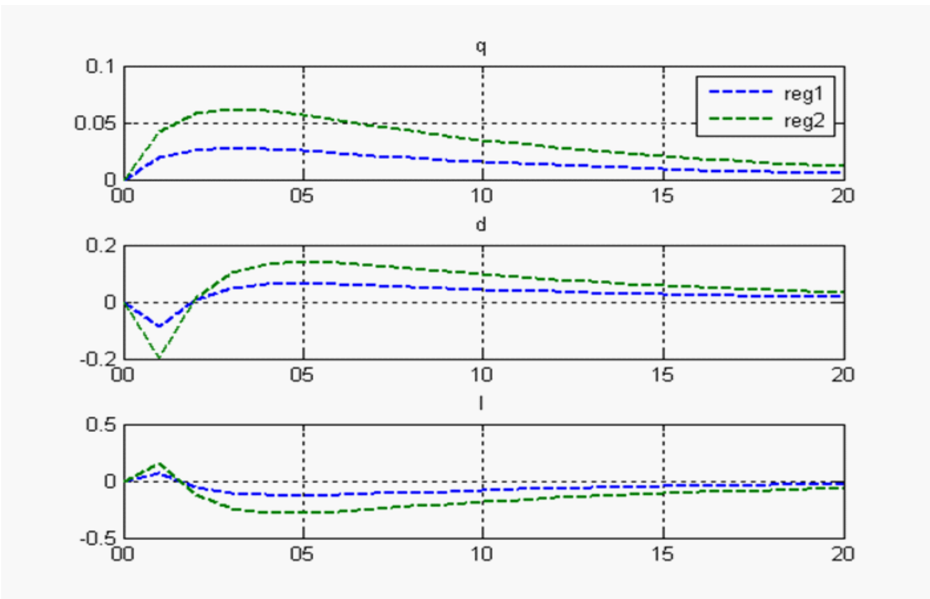

Fig. 2. Impulse responses of loan (q), deposits (d) and labour (l).

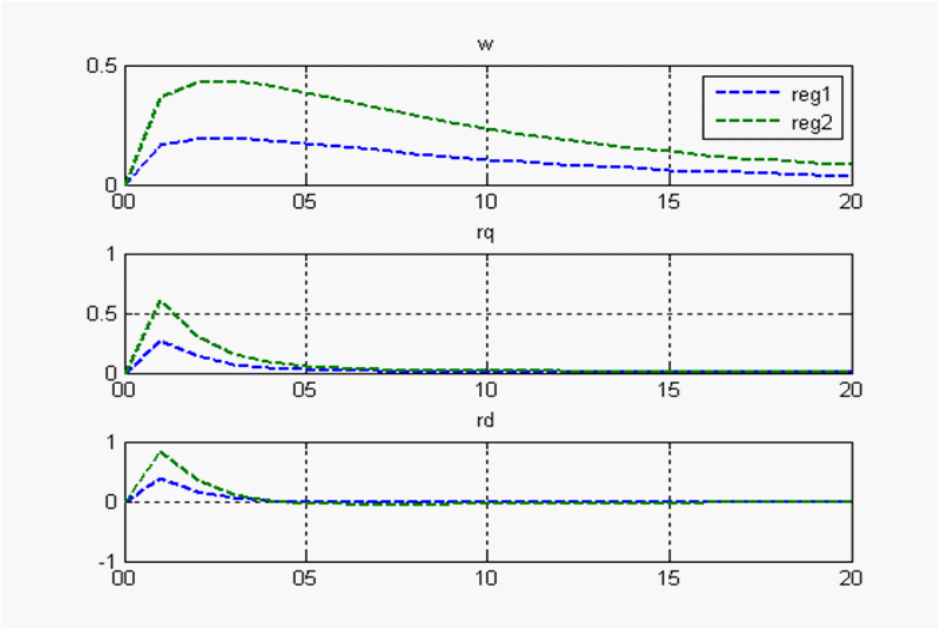

Fig. 3. Impulse responses of wages (w), loan rate (rq) and depo rate (rd).

The impulse responses following a positive one-standard-deviation shock to the aggregate productivity process increases banking productivity together with capital/loans so that the increase is even more significant in the high volatility regime, trigerring investment, output and consumption increases. But in contrast, when there is a bank crisis in which the productivity of banking falls as aggregate productivity declines, then the wage rate and capital declines drastically, more so in the high volatility regime, as do consumption, investment and output.

The results clearly have a number of important insights that we discuss below.

4 Crashes of 1929 and 2007-2009

Bank crises can arise for a variety of reasons, including industry specific risk but more likely from aggregate risk components. For example the bank crisis of 2007-2009 came about after huge debt was undertaken in the US during wartime activity on two fronts in Iraq and Afganistan. Astronomical debt increases pose the threat of future taxes which generally cause lower growth and so lower asset prices. This causes asset prices to fall. An unexpected asset price fall can lead to a bank crisis, if it includes the prices of assets that serve as collatoral for loans. In 2007-2009, housing prices fell after rising continuously for a long period of time. When interest rates rose as well, and so loan fees increased, consumers who found the new loan repayments too high could not sell the house and pay back the debt since the house prices fell. This caused bankruptcy and bank failure since many such loans were spread across banks all across the US and Europe.

5 Policy: Bank Insurance

The main policy option to governments to offset the aggregate risk is to insure the insurers in a systematic efficient fashion. The cleaning up of bank failures and the minimization of the after-effects of aggregate risk occuring has been a key government policy within countries and at international levels.

5.1 Deposit Insurance with Risk-Based Premiums.

The United States enacted deposit insurance only in 1933, at the height of the depression. Previously, banks had industry-formed "clearinghouses" which acted as a means of insuring depositors at a failing bank. This was designed to minimize the risk that a failure would spread to other banks. Therefore it was a market-based method of providing insurance against aggregate risk.

However with the establishment of the US Federal Reserve Bank in 1913, the government took over the clearinghouse functions and these private insurance mechanisms for the banks were dissolved. Yet when the banks failed during the depression the US failed to insure depositors of failing banks, and the panic then spread to other banks.

Establishment of the Federal Deposit Insurance Corporation (FDIC) in 1933 then created an insurance fund from which to insure depositors, and so avoid the spread of a bank panic. In 2005 the FDIC system was reformed to make the banks pay insurance fees, equal to our d in the analysis, which reflected the risk of the portfolio structure of the bank. These are called "risk-based premiums". And they are designed to insure the system fully by taking into account the different risk factors associated with each bank.

To this day, this system has largely worked, except that financial institutions not covered by the FDIC failed during the 2008 banking crisis. This led to a type of realization of aggregate risk that spread so as to cause a failure of FDIC insured banks. And the US government, using its specially authorized TARP funds, added funding to the FDIC fund so that it could cover the losses of the FDIC-insured bank failures that occured. So in a sense the FDIC coverage was only partial and did not cover the entire financial intermediation industry. And this resulted in the manifestation of aggregate risk of bank failure, or a fall in A_F, during the bad state of the concurrent recession of 2007-2009.

For example George Soros lectured recently (**?**) that

> "the Basel Accords made a mistake when they gave securities held by banks substantially lower risk ratings than regular loans: they ignored the systemic risks attached to concentrated positions in securities. This was an important factor aggravating the crisis. It has to be corrected by raising the risk ratings of securities held by banks. That will probably discourage the securitization of loans."

5.2 Policy for Global Bank Failure, Aggregate Risk and Moral Hazard

At the international level the widespread failure of banks within interconnected global capital markets has long been a basis for cooperative international government action. One of the main tools has been the International Monetary Fund, or IMF. This agency has been funded by governments internationally, and has acted to intervene to try to contain financial panics within countries or regions when they occur. Latin American intervention during the 1980s, and Asian intervention during the 1997 international bank crisis are key examples.

What the IMF actually does is never pre-determined or clear even after the fact. This has led to criticism of it being a very inefficient way to insure against aggregate risk. And if it allows private banks to be bailed out of their insolvencies, or even just their losses from a regional failure, then criticism has been that the IMF actually increases the probability of such a recurring bank failure. And this is called "moral hazard" when a policy action causes an increase in the probability of the bad state. This increase in the probability of the bad state, as the result of some action or system of actions, is the definition of moral hazard.

5.3 International Bank Policy Appraisal: Using Analysis

The success of the FDIC in the US suggests that if such a risk-based premium system were applied to all financial institutions and across all countries, then the aggregate risk of bank failure would be largely eliminated. The first requirement is to consider how to bring all US financial institutions into the FDIC insurance system (**?**).

Our analysis is well-suited for this. It suggests that whatever is the form of service that the bank is supplying, its expected outlays can be computed. In our analysis, the expected payout is $\left(1+R^d\right)d$, where R^d includes the cost of the transformation as well as the probabilities of the states occuring. For deposit insurance on commercial, or "retail" banking, such a computation has been fairly straightforward. And so the amount that commercial banks are required to pay into the FDIC is also clear. The problem is the so-called "wholesale" banks, or really the banks that provide services for firms rather than consumers. These investment banks provides loans to firms and help firms sell equity shares to the public markets, in what is called "underwriting". They also help in international risk-pooling through derivative packages and other forms of hedging and risk management.

Investment banks can be brought into a government insurance system in the same way as commercial banks. The only requirement is the assessment of what is R^d on the funds deposited with such investment banks. This assessment is more complicated than for commercial banks because of the variety of risk managment vehicles that investment banks offer. And the complication is also that the investment banks themselves invest in a variety of such risk transference vehicles. However, it is clear that such vehicles are subject to evaluation and a risk-premium can be assessed for all deposited funds at investment banks. Allowing these banks to be a part of the FDIC in the US would allow the entire financial sector to take part in the insurance system.

At the international level, a risk-based deposit insurance system that covered both commercial and investment banks could be implemented as a replacement for the ad hoc operation of the IMF in supply such financial insurance. Insurance firms could also be brought into such domestic and global deposit insurance schemes, again on the principle of evaluating the overall average R^d that attaches to each financial intermediary.

5.4 Concluding Remarks

In this paper we have developed a general equilibirum model, stretching the standard neoclassical model to include a financial market, viz., a banking sector. Markets are incomplete in the sense that resources are used up in the bank's transformation of deposits into loans. The model further introduces a banking sector correlation with aggregate productivity via a two-state markov process with low and high volatility.

The results show that when the bank productivity falls by a significant percent during an economic downturn, as in the 2007-2011 bank crisis, the savings and investment both fall significantly. Here we show evidence of the comovement of savings and investment and the fall in savings and investment in the bank crisis period, together with the impact on the macroeconomy. More precisely, the model shows the possibility of large fall in loans/capital and output following a shock in the high volatility regime, similar to what has been witnessed during the recent banking crisis 2007-11.

The paper has a number of policy implications. One is that as such risk is outside the control of an insurance system for banking, the actuarially-fair bank insurance system must account for this aggregate risk by raising premiums accordingly. What institutions have actually done is never predetermined or clear even after the fact. This has led to criticism of institutions being a very inefficient way to insure against aggregate risk. It is towards this very goal that we are working in future research.

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