Banks versus Markets in Processing the Payments Shock

D. Vinogradov[1]

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[1]Alfred-Weber-Institute, University of Heidelberg (mailing address: Chair of Economic Theory I, AWI, Grabengasse 14, 69117, Germany). E-mail: Dmitri.Vinogradov@awi.uni-heidelberg.de.

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Abstract

The paper focuses on a comparison of bank-based and market-based financial systems with respect to their ability to smooth the negative consequences of a macroeconomic shock. The model describes a two-market OLG economy with two types of agents (workers and entrepreneurs) and a financial system represented through either banks or a direct market. The dynamic setting allows for a comparison regarding the speed of economic recovery after the shock. The principal finding is that the market-based system provides better arrangements to speed up the recovery, but concentrates the burden of the shock in one period. In contrast, the bank-based system allows for both quick recovery and postponing and smoothing the negative consequences of the shock over several periods, if proper regulation and interventions are used, otherwise the banking system can collapse. As an example of regulatory interventions, liquidity provisions and a deposit rate ceiling are considered. This allows to give some light on the difference between the roles the Deposit Insurer and the Regulator (LOLR) can play in the evolution of events. In particular, deposit insurance alone can not provide an intertemporal shock smoothing and requires additional regulatory interventions.

Keywords: Financial intermediation, Bank-based system, Market-based system, Regulation, Deposit insurance

JEL Classification: D50, G21, G28, E44, E53, O16

1 Introduction

A discussion of market- and bank-based financial systems, largely initiated by Allen and Gale (1997, 2000), who give an example of different effects of an oil shock in American (market-based) and German (bank-based) economies, is particularly important for developing countries and countries in transition. As Bolton (2002) notes, these countries must decide, how to set up their financial system, which type of financial system should be adopted, and what kind of financial system would most efficiently promote economic development and growth.

This paper uses the main features of the OLG model with financial intermediation (Vinogradov, 2003) to study the consequences of an external shock. The shock considered here is primarily payments shock, which allows one to focus on other types of shocks in addition to a production shock. The OLG setting provides a framework to consider the dynamics of events, and the simple general equilibrium environment enables one to study the macroeconomic effects of the shock over several periods.

The paper contributes to the macroeconomics of banking, i.e. to the study of general equilibrium in the presence of financial intermediation (see e.g. works by Bernanke and Gertler, 1987, and Bencivenga and Smith, 1991). Particular attention is paid to the crisis situation, which is modelled through an external macroeconomic shock. Exogenous and policy shocks belong to the sources of financial crises (see e.g. Sachs, 1998, who distinguishes between four triggering mechanisms of financial and banking crises: an exogenous shock, a policy shock, an exhaustion of borrowing limits and a self-fulfilling panic; and Mishkin, 2001, for analysis of sources of financial crises). Rochet (2004) studies the effect of a macroeconomic (liquidity) shock in a microeconomic model with moral hazard. The model presented here, in contrast, focuses on macroeconomic consequences of the shock.

The main feature of the model is an unpredictable shock, which influences the asset side of the banks' balance sheets, or directly the earnings of the population in the case of a market based system. This shock deteriorates balance sheets of banks and leads to a decrease in the real wages of population. As a regulation measure, we assume state guarantees on deposits, which prevent bank runs, and consider two additional interventions under this assumption: liquidity injections to let banking system to remain solvent[1] as

[1] As usual, we understand solvency as an ability to meet the (current) obligations, in

well as a deposit rate ceiling, which creates a positive profit margin for the banks to cover their negative capital. Under these circumstances the bank-based system can recover after the shock and reallocate the burden of the shock over several periods, whereas the market-based system leads to a huge burden borne by people in a single period but does not provide intertemporal risk smoothing.

The paper starts with the description of the model in part 2. In part 3 general equilibrium is defined and analyzed in a static as well as in a dynamic manner. Part 4 of the paper studies the pure market economy and its evolution after the shock. In part 5 and in part 6 regulatory measures are introduced and studied in the context of the development of events in the intermediated economy. The paper concludes with some policy relevant implications.

2 The Model

2.1 Agents and decisions

Consider the economy with a population, which lives for two periods and is divided into two groups: workers and entrepreneurs. The whole population is distributed at the interval $[0, 1]$, and the subinterval $[0, p)$ belongs to workers, leaving $[p, 1]$ for entrepreneurs, so that p is the share of workers in this generation.[2] The entrepreneurs can only run their firms as they acquire some experience in the first period of their lives, so that the whole generation consists only of workers when young. The young generation works, consumes and saves. The old generation consumes (if workers) or produces and consumes (if entrepreneurs). All workers are therefore endowed with one unit of labour in each period, and the entrepreneurs possess equal entrepreneurial skills, which they apply in the second period of their lives, so that there is no heterogeneity among workers and among entrepreneurs. This setting is similar to that of Gersbach and Wenzelburger (2002 a and b), who also consider

contrast to bankruptcy, which means negative capital of the banks. In a static setting these concepts could coincide. However in a dynamic setting a bankrupt institution (with negative capital) can still be solvent due to newly acquired funds from the next generations of depositors.

[2] We assume here for simplicity that the share of workers in each generation is fixed. This seems not to be crucial, and qualitatively similar results can be obtained with the market–side-switching as in Gersbach and Wenzelburger (2002 a and b).

a macroeconomy with financial intermediation and shocks, but fix the size of investment projects and assume the interest elasticity of savings to be zero.

All the agents of generation t have identical intertemporal utility function $u(c_t, c_{t+1})$, increasing in consumption in both periods, twice differentiable and quasi-concave. The time-index denotes the beginning of the period, so that generation t is born at the moment t when the period t begins, is young until the moment $t+1$, is old in the period $t+1$, and dies at the moment $t+2$, which ends the period $t+1$.

All agents, when young, solve intertemporal utility maximization problem, which determines their consumption c_t and savings e_t in period t. The agents have perfect knowledge about the wage rate w_{t+1} and interest rates r_t^d and r_t^c on deposits and credits correspondingly, which apply to deposits (credits) made (obtained) in the period t subject to repayment in the period $t+1$.

The optimization problem of the workers is given by

$$\max_{c_t, c_{t+1}} u(c_t, c_{t+1}) \tag{1}$$

$$\begin{aligned} c_t &= w_t - e_t^D \\ c_{t+1} &= \left(1 + r_t^d\right) e_t^D \end{aligned}$$

This problem determines the savings function of workers (depositors) $e_t^D\left(\underset{+}{r_t^d}, \underset{+}{w_t}\right)$.

Potential entrepreneurs solve their respective utility maximization problem

$$\max_{c_t, c_{t+1}} u(c_t, c_{t+1}) \tag{2}$$

$$\begin{aligned} c_t &= w_t - e_t^E \\ c_{t+1} &= \Pi_{t+1}^e\left(e_t^E, w_{t+1}, r_t^c\right) \end{aligned}$$

where Π_{t+1}^e denotes their expected profit in the period $t+1$ after starting production (running the firms). We assume that $\Pi_{t+1}^e \geq \left(1 + r_t^d\right) e_t^E$, otherwise the problem of switching from entrepreneurs to depositors arises (see e.g. Gersbach and Wenzelburger, 2002 a and b).

Entrepreneurs run firms when old, and the production technology of these firms is given by $f(k_{t+1}, l_{t+1})$, where k_{t+1} = physical capital for production in period $t+1$, and l_{t+1} = the amount of labour used for production in the period $t+1$. All entrepreneurs have access to the same production technology (so that there is no heterogeneity among entrepreneurs), and maximize their expected profits, thus determining both k_{t+1} and l_{t+1}. In period t, potential entrepreneurs apply for credit, I_t, to finance their investment, which is needed to acquire capital stock k_{t+1}, so that $k_{t+1} = e_t^E + I_t$. Note that $I_t \geq 0 \ \forall t$.[3]

The profit maximization problem is then

$$f(k_{t+1}, l_{t+1}) - (1 + r_t^c)\left(k_{t+1} - e_t^E\right) - w_{t+1} l_{t+1} \rightarrow \max_{k_{t+1}, l_{t+1}} \tag{3}$$

and the solution of this problem for any level of savings e_t appears as

$$k(r_t^c, w_{t+1}) : \frac{\partial k}{\partial r_t^c} < 0, \frac{\partial k}{\partial w_{t+1}} < 0 \tag{4}$$

$$l(r_t^c, w_{t+1}) : \frac{\partial l}{\partial r_t^c} < 0, \frac{\partial l}{\partial w_{t+1}} < 0 \tag{5}$$

Note that the solution of the profit maximization problem does not depend on the amount of savings accumulated by the entrepreneurs since it determines the amount of capital stock needed to run the firm, but not the amount of *borrowed* capital (this is a standard fact for a two-period optimization problem). Given this optimal choice of production factors, the utility maximization problem of the entrepreneurs determines their savings level:

$$\begin{aligned}
& \max_{c_t, c_{t+1}} u(c_t, c_{t+1}) \qquad (6) \\
c_t &= w_t - e_t^E \\
c_{t+1} &= \Pi_{t+1} = f(k_{t+1}, l_{t+1}) - (1 + r_t^c)\left(k_{t+1} - e_t^E\right) - w_{t+1} l_{t+1} \\
\text{with } (k_{t+1}, l_{t+1}) &= \arg\max \Pi_{t+1}
\end{aligned}$$

so that the savings of the entrepreneurs are given by the function

$$e_t^E = e\left(\underset{+}{w_t}, \underset{-}{w_{t+1}}, \underset{+}{r_t^c}\right) \tag{7}$$

[3]The term $(1 + r_t^c)\left(k_{t+1} - e_t^E\right)$ in the profit function can be rearranged as $(1 + \widehat{r}_t) k_{t+1}$ with $1 + \widehat{r}_t = (1 + r_t^c)\left(1 - \frac{e_t^E}{k_{t+1}}\right)$. Obviously, if e_t^E is initially smaller than k_{t+1}, and rises to approach k_{t+1} (so that I_t approaches zero), the price of capital $1 + \widehat{r}_t$ approaches zero, and the profit maximisation problem will imply infinitely high demand for capital, so that k_{t+1} still stay above e_t^E.

Properties of the solutions of the optimization problems are standard.[4]

2.2 Intermediation and interactions

Financial intermediation is represented in the economy by banks. The banks collect savings from workers in form of deposits, and offer credit to entrepreneurs to finance their demand for credits. The entrepreneurial demand for credit is given by the excess of the optimal capital level, as given by (4), over the accumulated entrepreneurial savings (7), which play the role of own funds of the entrepreneurs.

Collection of deposits D_t starts in the period t, when the workers of generation t create their savings e_t^D. At the end of the period t entrepreneurs apply for credits, I_t, to start their business (run firms). Payouts of the entrepreneurs to banks take place within the period $t+1$ and amount individually to $B_{t+1} = (1 + r_t^c)I_t$. There is no uncertainty with respect to the production technology, and the profit of the entrepreneurs is always positive, so that the entrepreneurs never default.

There is no other storage technology in the economy available to workers so that the value of deposits made with the banks is equal to the value of aggregate savings of the workers: $D_t = pe_t^D$. In period $t+1$ banks have to repay $p\left(1 + r_t^d\right) e_t^D$ to the depositors.

Entrepreneurs require credit from banks in the amount needed to finance their investment demand and we assume that there is no credit rationing. As a result, no credit application is rejected[5], and $I_t = k_{t+1} - e_t^E$. Investment (in production technology) takes place at the end of period t.[6] Within the period $t+1$ all entrepreneurs repay to the banks $(1-p)\, B_{t+1} = (1-p)\,(1 + r_t^c)I_t$.

If in the period $t+1$ total repayments from entrepreneurs to banks do

[4] To prove these properties it suffices to find respective derivatives of the implicit savings and factor demand functions, given by the first-order conditions. For simplicity the possibility of corner solutions is excluded, otherwise some partial derivatives can be zero, which however would not change the analysis.

[5] Indeed, homogeneity of entrepreneurs implies that their credit applications are of equal quality, and there is no criterion according to which some of the applications could be rejected.

[6] It can be also viewed as though entrepreneurs of the generation t create their production facilities along the period t, investing in total k_{t+1}. The investment process ends at the end of the period t. This implies that all credits are allocated by the banks during the period t under the interest rate r_t^c.

not cover the total obligations of the banks, the banks experience deficits

$$d_{t+1} = (1-p)\, B_{t+1} - p\left(1 + r_t^d\right) e_t^D < 0 \tag{8}$$

If $d_{t+1} < 0$, the banks start the period $t+1$ with this non-zero deficit. If in some period $d_{t+1} > 0$, we shall call it banks' surplus.

Banks operate in a competitive environment so that neither deposit rates r_t^d nor credit rates r_t^c differ among banks and we omit any indexes corresponding to individual banks, taking interest rates as uniform in the market. Moreover, in this competitive environment either banks set the credit and deposit interest rates equal to oneanother (see e.g. Gersbach, 2003, for discussion of the case with market-side switching[7]) or take them equal as given by the market (see e.g. Baltensperger and Jordan, 1997).[8] As a result in pure competitive environment we have the equality $r_t^d = r_t^c = r_t$.

Banks are owned by all agents in the economy in equal shares, and the ownership is transferred to another periods (future generations) through bequests. Hence, the stock market for banks' shares is not considered. Dividend payments could shift intertemporal budget constraints in the utility maximization problems solved by the agents, but we assume them to be negligibly small, and they are not presented in optimization problems (1) and (2) of the agents above.[9]

[7] As noted before, the framework of the current paper can be extended to the case of heteregeneous agents, in which entrepreneurs decide, whether they apply for the credits in order to invest into the production technology or they deposit their savings with the banks. This decision of entrepreneurs depends on their respective quality. See Gersbach and Wenzelburger (2002 a and b) for details.

[8] Competition in the banking sector implies that the profit of the banks is equal to zero, which induces the equality between the two interest rates.

[9] This point deserves some further discussion. Indeed, if we assume that the capital of the banks is negligeably small, then all the agents will receive infinitely small dividend payments, so that they do not influence consumption-savings decisions. Put another way, we could also assume that the banks belong only to depositors, and resemble in this sense mutual funds, so that there is no capital, which would differ from the deposits. Alternatively we could assume that dividend payments are made with the rate equal to deposit ineterest rate, so that the banks' capital could be considered as being equivalent to deposits. It is important to note that the (possible) dividends are paid out only in case the banks work with surplus, $d_t > 0$; otherwise, any possible banks' profit is used to cover deficits. As we focus on the case $d_t \leq 0$, dividend payments do not play a role in the model.

2.3 Macroeconomic shock

The economy is assumed to experience a negative macroeconomic shock, which influences the deficits in the banks in the period $t+1$. We assume the shock to increase the deficits in the banks proportionally to the amount repaid by the entrepreneurs

$$d_{t+1} = d_t - (1 - q_{t+1})(1-p)B_{t+1} \tag{9}$$

The shock parameter q_{t+1} has the following distribution:

$$q_{t+1} = \left\{ \begin{array}{cc} 1 & \text{if } t \neq \tau \\ q^* < 1 & \text{if } t = \tau \end{array} \right\} \tag{10}$$

Equation (9) can be rewritten for the period $\tau + 1$:

$$d_{\tau+1} = d_\tau - (1 - q^*)(1-p)B_{\tau+1} = -(1 - q^*)(1-p)B_{\tau+1}$$

since d_τ is zero before the shock.

The shock is effectively unpredictable so that banks do not create any reserves against the shock.

Recall that without the shock, the banks' deficits would be

$$d_{\tau+1} = (1-p)B_{\tau+1} - p\left(1 + r_\tau^d\right)e_\tau^D = 0$$

and hence we can equivalently write

$$d_{t+1} = -(1-q)\,p\left(1 + r_t^d\right)e_t^D \tag{11}$$

We assume that the shock is exogenous and directly influences the deficits of the banks. The case of a production shock is considered in Vinogradov (2003), in which three degrees of shock are introduced: (1) an insignificant production shock, which still leaves entrepreneurs able to repay their obligations; (2) a significant production shock, which influences repayments to the banks, but does not influence wage repayments to the workers; and (3) an extreme shock, which reduces repayments to the banks to zero and leaves workers underpaid. If no shock occurs ($q = 1$), then deficits in the banks stay at zero level. If the production shock destroys the economy ($q = 0$), then deficits of the banks are equal to the whole amount due to the depositors $d_{t+1} = -p\left(1 + r_t^d\right)e_t^D$, exactly as in (11).

The transfer of the shock from production technology directly to deficits simplifies the description of the model and allows for the study of non-production shocks. One example for this could be a sharp decrease in stock market prices, which leads to the value of banks' assets below the value of liabilities, and hence to deficits. Since we do not model the stock market explicitly, and have no securities at the assets side of banks' balance sheets, we prefer to say that the exogenous shock influences deficits directly. Introduction of a stock market would possibly give a more reasonable explanation for the shock (e.g. through expectations of agents), but would still leave us with an exogenous disturbance exactly as in case of the deficit shock, and would not qualitatively change the results. An alternative treatment of the shock is discussed in the Appendix.

The shock happens therefore *after* the entrepreneurs have paid their debts out, but *before* the banks have realised these repayments on their balance-sheets. Intuitively this could be understood as something like iceberg.type transaction costs, which are proportional to the amount of transaction and appear just once. This is why we refer to the shock as to a payments shock. Implicitly it is a generalisation of a production shock mentioned above.

3 Markets and equilibrium

So far, the model so far describes two markets: one for capital and one for labour. We define the [temporary] equilibrium in the economy in any period t as a price vector $\left\{r_t^{d*}, r_t^{c*}, w_{t+1}^*\right\}$ and an allocation $\left\{k_{t+1}^*, l_{t+1}^*, e_t^{E*}, e_t^{D*}\right\}$ under parameters $\{w_t, d_t\}$, which provide that:

1. The capital market is cleared, i.e. aggregate demand for capital equals aggregate supply of it: $(1-p)\,k\left(r_t^c, w_{t+1}\right) = pe_t^D + d_t + (1-p)\,e_t^E$. In other words, aggregate demand for credits equals aggregate supply:
$$(1-p)\left(k_{t+1} - e_t^E\right) = pe_t^D + d_t \tag{12}$$

2. The labour market is cleared, i.e. aggregate demand for labour, which is created by old entrepreneurs, equals the aggregate supply of labour, created by old workers and the whole young generation (both young workers and young entrepreneurs, who have not yet started their businesses):
$$(1-p)\,l\left(r_t^c, w_{t+1}\right) = 1 \tag{13}$$

3. No agents have incentives to make any changes in their choices (this condition is met by the optimal choice of agents).

Proposition 1 *The general equilibrium, given by definition above, exists and is unique for any period* $t > 0$*. It can be represented in the* (w_{t+1}, r_t)*-plane with an intercept of LM-line and CM-line, depicting equilibria in markets for labour and for capital respectively. LM-line and CM-line are characterized with*

$$\frac{\partial r_t^{CM}}{\partial w_{t+1}} > \frac{\partial r_t^{LM}}{\partial w_{t+1}} \text{ and } \frac{\partial r_t^{LM}}{\partial w_{t+1}} < 0 \tag{14}$$

Proof.

For the Proof see Vinogradov (2003)

■

3.1 Analysis of the Equilibrium

The proposition above allows one to represent the general equilibrium in terms of two lines in the (w_{t+1}, r_t)-plane: LM depicting equilibria in labour market and CM depicting equilibria in credit market. Note also that changes in the deficit level influence only the CM-line and not the LM-line, although general equilibrium would differ for different values of d_t. An increase in deficits (or equivalently decrease in surplus, i.e. d_t falls below zero) increases equilibrium interest rate as defined by the credit market for any wage level w_{t+1} so that CM-line shifts upwards in (w_{t+1}, r_t)-plane[10]:

$$\frac{\partial r_t^{CM}}{\partial d_t} < 0 \tag{15}$$

Proposition 2 *The equilibrium interest rate and the equilibrium wage level depend on the deficits in the banking sector so that the equilibrium interest rate increases and the equilibrium wage level decreases with an increase in deficits (fall in surplus):*

[10]The sign "<" in the formula is due to the fact that an "increase" in deficits means an increase in absolute value of d_t.

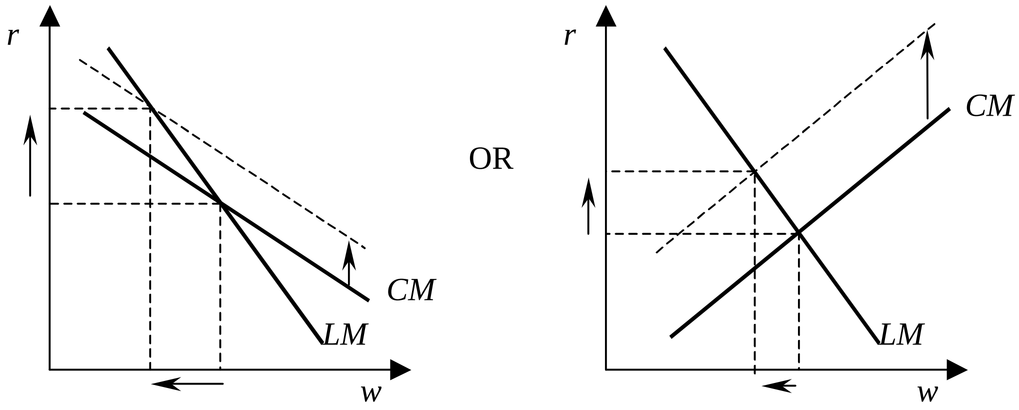

Figure 1: Effect of an increase in banks' deficits ($d \downarrow$, i.e. banks experience larger lack of funds) on general equilibrium.

$$\frac{\partial r_t^*}{\partial d_t} < 0; \frac{\partial w_{t+1}^*}{\partial d_t} > 0 \tag{16}$$

Proof.

Intuition behind this is as follows. According to (15) and due to the labour market equilibrium independence from the deficits in banking system, the equilibrium interest rate and wage level are determined by the movement of general equilibrium point along the LM-line, as shown in figure (Fig. 1). Since both CM- and LM-lines are continuous, this reasoning will be valid for any possible combinations of interest rate and wage level, which proves the statement.

■

The effect on the general equilibrium of banks deficits falling below zero is shown in Fig. 1. Since the slope of CM-line can be either negative or positive (but never smaller than the slope of the LM-line), both cases are presented in the diagram.

3.2 Evolution of the economy

The sequence of events in the economy with financial intermediation is presented in the Figure 2.

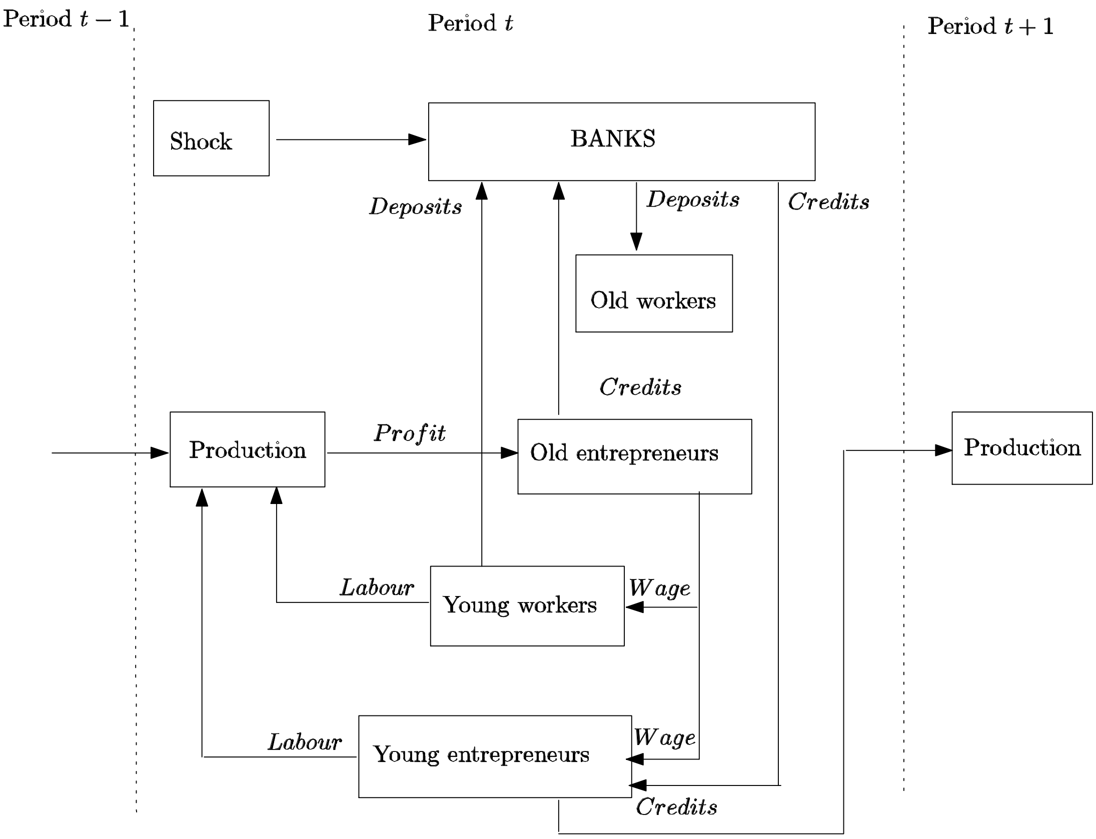

Figure 2: Sequence of events in intermediated economy

3.2.1 Before the shock

If $t < \tau$, the shock parameter q is always $q = 1$. The economy has an equilibrium with zero deficits in the banks. This equilibrium is stationary until the shock occurs.

The system of equilibrium conditions (12-13) together with the definition of deficits (8) determines a dynamic system with respect to w and d:

$\Phi(w_t, d_t) \rightarrow (w_{t+1}, d_{t+1})$ with map $\Phi(w_t, d_t)$ given implicitly by the system

$$\Phi(w_t, d_t) : \begin{cases} (1-p)l_{t+1} = 1 \\ (1-p)I_t = pe_t^D + d_t \\ d_{t+1} = (1-p)B_{t+1} - p(1+r_t^d)e_t^D \\ I_t = k_{t+1} - e_t^E \\ B_{t+1} = \min\left(f(k_{t+1}, l_{t+1}); (1+r_t^c)I_t\right) \\ k_{t+1} = k(r_t, w_{t+1}) \\ l_{t+1} = l(r_t, w_{t+1}) \\ e_t^E = e^E(w_t, w_{t+1}, r_t^c) \\ e_t^D = e^D\left(w_t, w_{t+1}, r_t^d\right) \end{cases} \quad (17)$$

Proposition 3 *The dynamic system (17) has a steady state (stationary) with $d = 0$ and $w = \widehat{w}$, which does not depend on initial conditions.*

Proof.

The map for deficits in (17), together with the credit market equilibrium condition (12) for period t, implies

$$d_{t+1} = (1+r_t^d)d_t$$

which, under a positive deposit interest rate, is true iff

$$d_{t+1} = d_t = 0 = d$$

The first part of the statement is hence proved.

Now consider the modified map $\Phi_0(w_t) \equiv \Phi(w_t, 0)$:

$$\Phi_0(w_t) : \begin{cases} (1-p)l_{t+1} = 1 \\ (1-p)I_t = pe_t^D \end{cases} \quad (18)$$

with the rest defined as in (17). To prove the existence of the stationary point it suffices to prove the existence of a solution to

$$w_{t+1} = \Phi_0(w_t) = w_t$$

Substitute now w_{t+1} instead of w_t into the labour demand, the credit demand and savings functions in (18). This reduces the problem to the case of finding the equilibrium. The slope of LM-line stays unchanged, since it depends only on w_{t+1}, and the slope of LM-line is always flatter than that of the LM-line (see 14). As a result, the general equilibrium exists for any value of w_t, and in particular for some value $\widehat{w}$, for which the condition $\Phi_0(\widehat{w}) = \widehat{w}$ is met. By construction, this steady state does not depend on initial conditions.

■

3.2.2 After the shock

Consider now the evolution of the economy after the shock $q = q^* < 1$, i.e. for $t \geq \tau$. In this case, banks experience deficits $d_{\tau+1} = -(1-q^*)(1-p)B_\tau = -(1-q^*)\,p\left(1+r^d_\tau\right)e^D_\tau < 0$, with which they start the period $\tau+1$. A change in deficits (d falls from $d_\tau = 0$ to a negative level $d_{\tau+1} < 0$) causes CM-line to shift upwards (for any wage level, the credit market will clear with a higher interest rate). Consequently the change in general equilibrium is given by the LM-line, and the equilibrium wage level $w_{\tau+2}$ is lower than $w_{\tau+1} = w_\tau$. Furthermore, the equilibrium interest rate increases from r_τ to $r_{\tau+1}$. No new shocks and no changes in the behavior of the agents occur. State guarantees on deposits insure that there is no panics among depositors after the shock, and there are no incentives for workers to deposit less than prescribed by the solution to the optimisation problem (1). Further dynamics of the deficits in banks is given by

$$d_{\tau+k+1} = (1-p)\left(1+r^c_{\tau+k}\right)\left(k_{\tau+k+1} - e^E_{\tau+k}\right) - p\left(1+r^d_{\tau+k}\right)e^D_{\tau+k} \qquad (19)$$

Since the credit market is in equilibrium (12) and since $r^c_{\tau+k} = r^d_{\tau+k} = r^*_{\tau+k}$ due to competition in banking sector, we obtain

$$d_{\tau+k+1} = \left(1+r^*_{\tau+k}\right)d_{\tau+k} \qquad (20)$$

which is valid for any $k \in N$. As soon as $r^*_{\tau+k} > 0$, deficits in banks increase until banking system is bankrupt, i.e. $d_{\tau+k} = \underline{d_{\tau+k}} = -pe^D_{\tau+k}$. This last condition means that the newly accumulated deposits just cover the deficits in banking system so that no new credits can be granted. Hence, banks obtain zero repayments at the end of the period, and cannot meet their obligations with respect to deposits anymore.

Corollary 1 *Intermediated economy with long-lived banks and guarantees on deposits experiences a collapse of banking system in the absence of an appropriate regulation in a finite number of periods.*

4 Pure market economy

Consider now a market economy, in which savers (depositors) have direct access to the firms (entrepreneurs) and therefore, no intermediation in funds

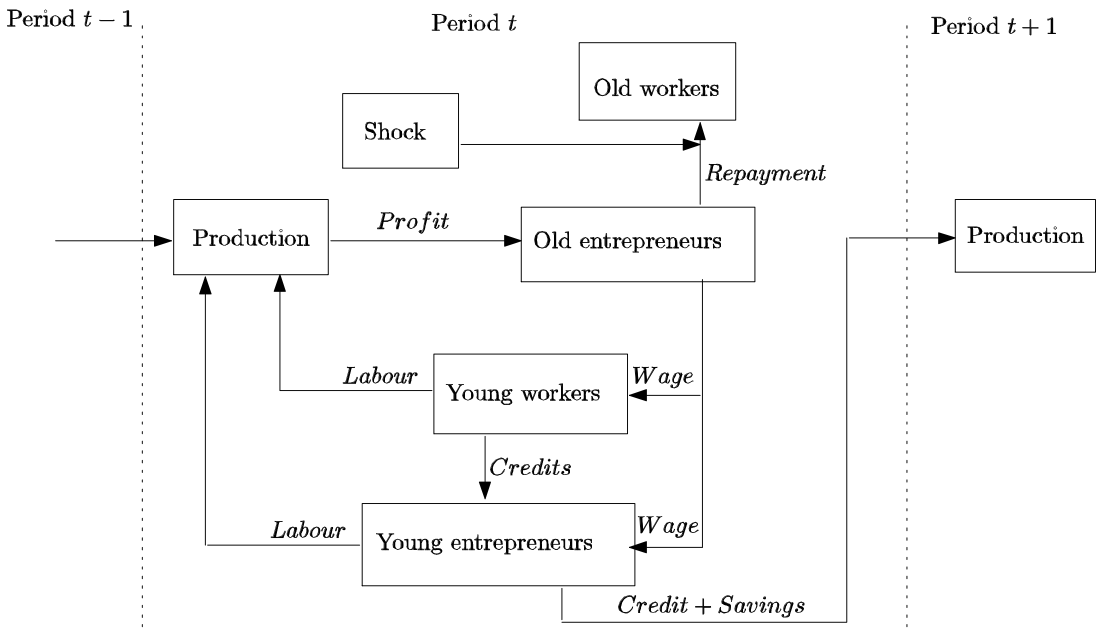

Figure 3: Sequence of events in the pure market economy

channelling occurs. The sequence of events in the pure market economy is presented in Fig. 3.

The economy without intermediation (pure market economy) exhibits the same equilibrium as in the case of intermediated economy with zero deficits in banks. Indeed, in the pure market economy aggregate demand for credits $(1-p)I_t = (1-p)\left(k_{t+1} - e_t^E\right)$ equals their aggregate supply pe_t^D and since intermediaries are not presented here, there is no space for deficits in the market equilibrium. The equilibrium in the labour market does not depend on intermediation and is the same as in intermediated case. The savings interest rate in the pure market economy is equal to the credit interest rate $r_t^d = r_t^c = r_t$, as there is only one market for them.

A temporary general equilibrium in the pure market economy in any period t is hence defined as a price vector $\left\{r_t^*, w_{t+1}^*\right\}$ and an allocation $\left\{k_{t+1}^*, l_{t+1}^*, e_t^{E*}, e_t^{D*}\right\}$ under parameter $\{w_t, d_t\}$, which provide that:

1. The credit market is cleared: $(1-p)\left(k_{t+1} - e_t^E\right) = pe_t^D$

2. The labour market is cleared: $(1-p)\, l\left(r_t^c, w_{t+1}\right) = 1$

3. No agent has an incentive to make any changes in their choices (this condition is again met by the optimal choice of agents).

Proposition 4 *A general equilibrium in the market economy, given by the definition above, exists and is unique for any period $t > 0$.*

Proof.

The proof of the proposition follows from the existence of an equilibrium for intermediated economy. It remains only to be noted that d_t now represents (in consistency with its definition) the difference between credit repayments from old entrepreneurs and the amount actually received by the old workers (reduced for the shock-induced transaction costs) and is always zero in the absence of shocks.

■

Without shocks the equilibrium in the pure market economy reaches its steady state as in the case of intermediated economy.

If the shock occurs, creditors are not repaid in full[11] and experience a deficit $d_{t+1} = -(1-q^*)pB_t$. This changes the result in the following manner:

1. Old workers, who acted as creditors, obtain less repayment than expected and their consumption in the shock period is less than needed to achieve the planned utility level. The extreme case $q^* = 0$ would leave old workers with zero consumption in the shock period.

2. Young workers do not suffer if we only consider payments shock.[12] Savings decisions of the young generation repeat those of the old one in the preceding period so that the equilibrium persists.

3. After the shock the system stays at the steady state so that the only part of population, which suffered from the shock, are old workers. Their loss in consumption is exactly $d_{t+1} = -(1-q^*)pB_t$.

Corollary 2 *A market-based economy recovers to the steady state within one period after the shock, leaving the burden of the shock completely on savers of this period.*

[11] This can be understood as though the shock appears when the repayment goes through the payment system, which is not explicitely modeled here.

[12] In case of a production shock it may happen that the young workers obtain reduced wage repayments, which would change their savings decisions. In this case market economy recovers slower. For the case of a production shock see Vinogradov (2003).

5 Regulation

The collapse of the intermediated economy after the shock underlines the need for a regulatory intervention to avoid the collapse. We consider two possible regulatory interventions:

1. Liquidity injections[13] to banks
2. Setting a deposit rate ceiling

In both cases we assume banks to be credible institutions (possibly under guarantees of the Regulator) so that the question of credibility and bank runs does not arise.

5.1 Liquidity injections

Assume that the Regulator possesses a stock $\overline{S}$ of liquid funds, which can only be accessed by banks experiencing deficits and are not used otherwise. If deficits occur ($d_t < 0$), banks can apply for one-period credits with interest rate r^s from the Regulator. This is a general formulation: setting $r^s = -1$ corresponds to the case of a subsidy. The total amount of credits granted by the Regulator in period t has to cover the deficits in the banking sector and is therefore

$$S_t = \begin{cases} -d_t, & \text{if } d_t < 0 \\ 0 & \text{if } d_t \geq 0 \end{cases} \tag{21}$$

Credits from the Regulator are granted at the end of period t, cover deficits accrued in period t, last for one period and are repaid at the end of period $t+1$ in total amount of $(1+r^s)S_t$.

The equilibrium condition in the credit market (12) changes to

$$(1-p)\left(k_{t+1} - e_t^E\right) = pe_t^D + d_t + S_t \tag{22}$$

To complete the description we assume that the interest (if any) gained on such liquidity injections is used to increase the stock $\overline{S}$. We do not consider possible fiscal distortions (taxes and income redistribution) and focus only on the bailout effect of such intervention.

[13] Rochet (2004) calls it a liquidity assistance.

5.2 Deposit rate ceiling

The Regulator sets a deposit rate ceiling $r^d = r^{dreg}$ as soon as the capital adequacy ratio is not fulfilled (surplus accumulated in the banks is smaller than a certain fraction of the total banking assets)[14]:

$$d_t < \alpha (1-p) \left(k_{t+1} - e_t^E\right) \tag{23}$$

In this case, two situations are possible. First, either credit rates are below the ceiling, in which case no bank is interested in setting the deposit rate above the credit rate, and hence the situation coincide with unregulated economy with $r^c = r^d = r^*$. Second, the credit rate (the interest rate determined by the credit market) is above the ceiling, which means that the deposit rate is fixed:

$$r^d = \min\left(r^{dreg}, r^c\right) \tag{24}$$

Fixing the deposit rate makes deposit supply dependant only on the wage level; the deposit market is still in equilibrium (all deposits supplied are acquired by banks). The conclusion regarding the existence and uniqueness of the general equilibrium remains unchanged.

The definition of the general equilibrium from Part 3 is valid for the regulated case as well. Moreover, the equilibrium condition for the labour market is not disturbed by introducing the regulation since it depends only on the credit interest rate:

$$(1-p)\, l\left(r_t^c, w_{t+1}\right) = 1 \tag{25}$$

The equilibrium condition in the credit market changes to

$$(1-p)\left(k\left(w_{t+1}, r_t^c\right) - e^E\left(w_t, w_{t+1}, r_t^c\right)\right) = pe^D\left(w_t, w_{t+1}, r^{dreg}\right) + d_t \tag{26}$$

so that the right-hand side no longer depends on the credit interest rate. Obviously the equilibrium credit rate is negatively related with regulated deposit rate, since the left-hand side negatively depends on the credit rate: $\frac{\partial r_t^c}{\partial r^{dreg}} < 0$. This is easily explained by the fact that decreasing deposit rate

[14] This is again a general formulation. In the economy considered in this paper banks' surplus is zero due to competition. Therefore a deposit rate ceiling is introduced from the beginning.

leads to less deposits in the banks and therefore to lower supply of credits, which become more expensive in order to hold the equilibrium. Hence, setting the regulated deposit rate at the level below that of the unregulated equilibrium increases the credit interest rate. This makes banks' profit margin positive (since in unregulated case the rates are equal). Graphically this corresponds to the shift of CM-line upwards as soon as the regulated deposit interest rate is set below the equilibrium level, similarly to the case of an increase in deficits, which is depicted in Fig. 1.

6 Intermediated economy: regulated dynamics

Assume the economy has settled in the steady state with $d_t = 0$. Consider the manner in which the above mentioned regulatory interventions affect the economy after the shock. This will exlain, whether theses interventions prevent the bankruptcy of the banking system, which happened in unregulated case.

6.1 Liquidity injections

Assume a payments shock affects the deficits in the banking system in period τ, so that the banking system starts period $\tau+1$ with deficits $d_{\tau+1} < 0$. Credit market equilibrium condition (22) implies

$$(1-p)\left(k_{\tau+2} - e^E_{\tau+1}\right) = pe^D_{\tau+1} + d_{\tau+1} + S_{\tau+1} \tag{27}$$

Since subsidy (credits) from the Regulator exactly covers the deficits, $S_{\tau+1} = -d_{\tau+1}$, the equilibrium in the credit market is unchanged, and hence the credit interest rate as well as the wage stay at their stationary levels. Further change in deficits is given now by

$$d_{\tau+2} = (1-p)\left(1+r^c_{\tau+1}\right)\left(k_{\tau+2} - e^E_{\tau+1}\right) - p\left(1+r^d_{\tau+1}\right)e^D_{\tau+1} - (1+r^s)\,S_{\tau+1} \tag{28}$$

From this point two scenarios are possible:

1. The liquidity injection does not change profit expectations of the banks (for whatever reason). The expected profit of the banks for the period

$\tau + 2$ does not account for the repayment of liquidity injection to the Regulator:

$$\Pi^e_{\tau+2} = (1-p)\left(1+r^c_{\tau+1}\right)\left(k_{\tau+2} - e^E_{\tau+1}\right) - p\left(1+r^d_{\tau+1}\right)e^D_{\tau+1} = 0$$

The expected profit is equal to zero due to competition in the banking sector. This implies

$$d_{\tau+2} = -\left(1+r^s\right)S_{\tau+1} = \left(1+r^s\right)d_{\tau+1} \qquad (29)$$

Hence, with $r^s > 0$, deficits in banking sector increase further. Unrestricted continuation of the liquidity injections policy repeats the above described steps and, as in the case of unregulated dynamics, a collapse is unavoidable; the banking system is bankrupt. The stock of liquid funds $\overline{S}$ can not be exhausted, since starting in period $\tau + 2$ deficits in the banking system are constituted only of the debt before the Regulator so that the "liquidity" injections do not actually require the transfer of liquid funds, but rather take a form of "virtual" credits, which only result in accumulation of unpaid interest. Setting $r^s = 0$ allows one to postpone the collapse without accumulation of debt. However in any case, such forbearance policy[15] does not create any incentives for banks to repay their debt to the Regulator since the banks expect the deficits to be continuously covered by new liquidity injections from the Regulator without any restrictions and do not account for the repayments in their profit expectations.[16]

2. The liquidity injection changes profit expectations of the banks. Expected profit of the banks for period $\tau + 2$ accounts for the repayment of credit to the Regulator:

$$\Pi^e_{\tau+2} = (1-p)\left(1+r^c_{\tau+1}\right)\left(k_{\tau+2} - e^E_{\tau+1}\right) - p\left(1+r^d_{\tau+1}\right)e^D_{\tau+1} - \left(1+r^s\right)S_{\tau+1} = 0$$

Zero expected profit (due to competition) implies that the banks set the deposit interest rate below the credit one, which is fixed by credit

[15] Remember, banks are formally bankrupts, since their assets are below their liabilities.

[16] The case of subsidy ($r^s < 0$) would prevent collapse but requires substantial changes in the model to meet budget constraints; it is assumed there are no external inflow of funds into the economy.

market equilibrium (27), as soon as $r^s > -1$. The new level of deficits in banking system is

$$d_{\tau+2} = 0$$

At the same time, the amount of deposits in the banking sector decreases due to a decrease in deposit interest rate ($e^D_{\tau+1} < e^D_\tau$) and the credit market is cleared with a higher credit interest rate for any wage level: $(1-p)\left(k_{\tau+2} - e^E_{\tau+1}\right) = pe^D_{\tau+1}$. This corresponds to an upward shift of CM-line in Fig. 1. The new equilibrium is achieved at the level $r^c_{\tau+1} > r^c_\tau$, $w_{\tau+2} < w_{\tau+1}$.

In period $\tau + 2$, the economy returns to the steady state since competition implies

$$\Pi^e_{\tau+3} = (1-p)\left(1 + r^c_{\tau+2}\right)\left(k_{\tau+3} - e^E_{\tau+2}\right) - p\left(1 + r^d_{\tau+2}\right)e^D_{\tau+2} = 0$$

and, therefore, the deposit and credit interest rates are equal: $r^c_{\tau+2} = r^d_{\tau+2}$.

The discussion above leads to the following conclusions:

Corollary 3 *Liquidity injections after the payments shock can have different effects depending on the arrangements:*

1. *The forbearance policy of the Regulator, in which the banks believe to be credited and are credited each time they face deficits, either postpones the collapse (if injections are made in form of credits with zero interest rate) or prevents the collapse (in case of the subsidy). In both cases the burden of payments shock is borne by the Regulator.*

2. *Short-term crediting with sufficient restrictions on further access for banks to the liquid funds of the Regulators shifts the profit expectations of the banks and prevents a collapse. The burden of the payments shock is borne by the population in the period following the shock: depositors receive deposit interest below credit interest rate. At the same time they receive lower wages due to a fall in production, which also leads to lower consumption level of entrepreneurs.*

6.2 Deposit rate ceiling

If the banking system starts with zero deficits, the intervention rule (23) is fulfilled, and regulation is introduced from the beginning. If $r^{dreg} > r^c$, the deposit interest rate will be equal to credit interest rate $r^c = r^d = r^*$ so that regulated dynamics yields the same results as the unregulated case. After the shock, however, the credit interest rate increases, as shown for the case of unregulated dynamics. At some point the condition $r^{dreg} < r^c$ will be met. This induces that the deposit rate is fixed by the regulation[17].

Assume that this happens at $t = \tau + k$, so that $r^d_{\tau+k} = r^{dreg}$ $(k \in N)$. The dynamics of the deficits in banks is then given by

$$d_{\tau+k+1} = (1-p)\left(1 + r^c_{\tau+k}\right)\left(k_{\tau+k+1} - e^E_{\tau+k}\right) - p\left(1 + r^{dreg}\right)e^D_{\tau+k} \tag{30}$$

Due to $r^{dreg} < r^c_{\tau+k}$ and credit market equilibrium condition (12)

$$d_{\tau+k+1} = \left(1 + r^c_{\tau+k}\right)d_{\tau+k} + p\left(r^c_{\tau+k} - r^{dreg}\right)e^D_{\tau+k} \tag{31}$$

To provide reduction in deficits, i.e. $d_{\tau+k+1} > d_{\tau+k}$, it is necessary that

$$r^{dreg} < r^c_{\tau+k}\left(1 + \frac{d_{\tau+k}}{pe^D_{\tau+k}}\right) < r^c_{\tau+k} \tag{32}$$

The simplest way to meet this criterion is to set $r^{dreg} = 0$. However, this sharp measure is only needed in case the system nears bankruptcy, i.e. when $(-d_{\tau+k}) \to pe^D_{\tau+k}$. In all other cases this criterion can be met with strictly positive values of deposit rate ceiling. Since the equilibrium credit interest rate increases with the increase in bank deficits, deposit rate ceiling can be established at the level of stationary credit interest rate, observed in a pre-shock economy: $r^{dreg} = r^c|_{d=0}$.

Corollary 4 *An economy with appropriately chosen (in sense of inequality 32) deposit rate ceiling recovers after the shock to a steady state with* $d = 0$.

[17] Of course, this is only true, if the deposit rate ceiling is not set too high: $r^{dreg} < r^{crit}$ where $r^{crit} = \arg\left[d_t = -pe^D\left(\cdot, r^{crit}\right)\right]$. This is the critical value of the market interest rate, when the banking system is bankrupt, and no further development occurs.

7 Conclusions

The dynamic model in this paper incorporates both labour and capital markets and describes the role of financial intermediation in the evolution of the economy after a macroeconomic shock. As stated in the analysis, a prevention of the bank runs through state guarantees (deposit insurance) alone can not help to avoid a macroeconomic collapse. This result is valid even if the deposit insurance (bailout guarantees) cannot change the banks' risk incentives (since there is no possibility for shift in investment decisions of the banks in the model). The model provides a tool for analyzing the regulatory interventions as well as studying their efficiency in returning to the steady state after a shock.

We can conclude that the existence of developed financial markets and market-oriented financial system in a country would accelerate the recovery after a sharp macroeconomic shock (in this paper it is the payments shock). However, from the institutional perspective, establishing a market-oriented financial system is a much more difficult task, especially in emerging and developing economies. A banking system is easier to establish, but needs proper regulation and intervention mechanisms in times of crisis to avoid collapse. With the market-based financial system the burden of the crisis is borne by the population immediately after the macroeconomic shock, and other (perhaps fiscal) measures may be needed to smoothen this burden.

Banking system allows for postponment and smoothing of the negative effects of the crisis. Postponment can be achieved through liquidity injections, and smoothing through regulatory intervention leading to a positive banks' profit margine (marge). In the first case, the burden of the crisis can be shared by depositors and the Regulator and, in the second case, it is shared between several generations of population. Moreover, a liquidity injection similar to a subsidy immediately after the shock can lead to the quick recovery exactly as in the case of the market-based system. But this kind of injection (which could be implemented e.g. through a deposit-insurance system) was not explicitly modeled here.

The model helps also to distinguish between the roles played by the Deposit Insurer and the Regulator. The first provides the economy with the means to avoid bank panics after the shock and the troubled financial institutions with subsides. But subsidization as a kind of liquidity injection can not lead to the intertemporal smoothing of shock. At the same time a regulatory intervention such as establishment of deposit rate ceiling provides necessary environment to avoid the collapse and to smoothen the shock over several generations.

A development of this model is presented in Mavrotas and Vinogradov (2005), who compare the above results with the empirical data regarding the financial crisis in Russia in 1998.

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