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Abstract

Financial intermediaries may increase economic efficiency through intertemporal risk smoothing. However without an adequate regulation, intermediation may fail to do this. This paper studies the effects of a production shock in a closed economy and compares abilities of market-based and bank-based financial systems in processing the shock. Unregulated banking system may collapse in absence of a proper regulation. The paper studies several types of regulatory interventions, which may improve the performance of the banking system.

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1 Introduction

A special interest in financial intermediation arose in 80-90's years of the last century due to a sequence of financial distortions and crises. Financial intermediation is called one of the possible reasons for these disturbances. Sachs (1998) analyses the sources of financial crises and distinguishes between four triggering mechanisms of financial, exchange and banking crises: exogenous shock, policy shock, exhaustion of borrowing limits and a self-fulfilling panics. Since Diamond and Dybvig (1983), the self-fulfilling banking panic is perhaps the most often studied phenomenon among the triggering mechanisms. The current paper focuses on shock-triggered banking crises and their relation to the exhaustion of borrowing resources.

In their comprehensive review of the theory of financial intermediation, Gorton and Winton (2003) stress the distinction between banking panics and crises, triggered by a common shock, which "brings the soundness of the banking system into question". Still, as they note, "most of the vast literature on bank regulation is within the paradigm of panics, deposit insurance, and moral hazard." However, empirical findings show that a theoretically optimal regulation does not necessarily prevent crises. For example, Demirgüc-Kunt and Detragiache (2000) question whether deposit insurance increases banking system stability; Barth, Caprio and Levine (2004) raise the same question with respect to tight regulation and direct government supervision.

Policy implications depend crucially on the role banks play in a macroeconomic environment. During the last two decades, the literature usually justified the existence of financial intermediation through its role in the reduction of transaction costs (Benston and Smith, 1975), in liquidity provision (Diamond and Dybvig, 1983) and in information provision (Diamond, 1984). Chemmanur and Fulghieri (1994) show that debt renegotiation can make financial intermediation superior to financial markets. These functions of the intermediation determine the structure of models focusing at macroeconomic effects of the intermediation. So, Bernanke and Gertler (1987) embed the banking sector into a stylized general equilibrium framework to show that banks matter to real activity mainly because they provide the only available conduit between savers and investment projects, which require intensive evaluation and auditing. Bencivenga and Smith (1991) suggest a Diamond-Dybvig (1983) based theoretical framework for studying various financial regulations of the financial system in the context of macroeconomic growth.

Distinct from these studies, Allen and Gale (1997) present a macroeconomic model, in which banks perform intertemporal risk smoothing and thus provide a macroeconomy with a Pareto-optimal allocation, whereas the latter cannot be achieved through a market-based financial system because of the incomplete participation constraint. Allen and Gale (1997) stress that in order to provide intertemporal smoothing, an intermediary needs some degree of market power, which "may be the result of government intervention. For example, the government may give the intermediary an exclusive license in order to achieve an ex ante Pareto improvement." In a similar macroeconomic framework with stochastic shocks, Gersbach and Wenzelburger (2006) show that the competitive banking system may collapse in a finite number of periods.

The current paper contributes to the study of the intertemporal smoothing role of banks. Intermediaries are embedded into an overlapping generations economy, which creates an incomplete participation problem. The latter is seen as a metaphor for other sources of market incompleteness, as in Allen and Gale (1997). The stochastic component of the model is transferred from dividends directly to the production technology, as in Gersbach and Wenzelburger (2006). The economy is extended to include the labor market in addition to capital and goods markets. The shock is shown to have multiple transmission channels, and even if a market channel does not destroy the stability of the system, it is the balance sheet channel in the intermediated system, which may magnify the impact of the shock and lead to a collapse.

The major difference of the current paper from the both above is the reduction of the stochastic component to a single temporary negative production shock. This is a special case of a shock distribution function, which allows one to study subsequent events generated by the shock. This issue is out of the focus of both Allen and Gale (1997) and Gersbach and Wenzelburger (2006). The degenerated shock distribution may be seen as a metaphor for a long enough sequence of negative shocks in a stochastic process with zero mean.

Finally, the current paper focuses on the study of a set of policy measures needed for the intertemporal smoothing to sustain. In this sense, the current paper contributes to the literature on optimal anti-crisis regulation.

The paper proceeds as follows. Section 2 describes the general macroeconomic environment and discusses the nature of the shock. Sections 3 and 4 study the market-based economy and the intermediated economy respectively. Section 5 discusses possible regulatory interventions. Section 6 provides a discussion of welfare issues. The paper concludes with the summary of results.

2 Macroeconomic Environment

The description will follow, as close as possible, the notation of Diamond (1965), whose model is a good departure for the analysis. One thing should be noticed in advance: in the current paper, productive firms are not assumed to exist infinitely long. Still, the problem of intergenerational lending does not arise: any debtor-creditor relationships only appear between the members of one generation. This is an important issue, since it underlines that although banks are long-living institutions, they are not critical for the existence and functionning of the economy.

2.1 Agents, Preferences and Technologies

The economy consists of overlapping generations. Each generation is distributed over the interval $[0, 1]$ and divided into two groups: workers and entrepreneurs with η - the share of workers in each generation. All agents live for two periods and are endowed with one unit of labor in the beginning of their lives. Entrepreneurs are distinct from workers in that they have access to a production technology in the second period of their lives. The whole young generation works, consumes and saves. The old generation consumes (if workers) or produces and consumes (if entrepreneurs).

All agents of each generation $t \geq 1$ have identical intertemporal utility functions $u_t\left(c^0, c^1\right)$ with c^0 = consumption of an agent of generation t when young, and c^1 = his consumption when old. The time index denotes the beginning of the period: generation t is born at moment t when period t begins, is young till moment $t+1$, is old in period $t+1$ and dies in moment $t+2$, which ends period $t+1$. The utility function is continuous, twice differentiable, strictly increasing, quasi-concave and satisfies

$$\lim_{c^0 \to 0} \frac{\frac{\partial u_t}{\partial c^0}}{\frac{\partial u_t}{\partial c^1}} = \infty; \lim_{c^1 \to 0} \frac{\frac{\partial u_t}{\partial c^0}}{\frac{\partial u_t}{\partial c^1}} = 0$$

Utility functions are identical among generations. The utility level of an agent born in period t will hereinafter be represented through $u\left(c_t^0, c_{t+1}^1\right)$.

The production technology produces a consumption/capital good. The technology is identical among entrepreneurs and among periods and is given by $f(k,l)$, where $k =$ physical capital and $l =$ the amount of labor used for production. The production function is continuous, twice differentiable, increasing, concave and satisfies $f(0,0) = 0$ and

$$\lim_{l\to 0}\frac{\frac{\partial f}{\partial l}}{\frac{\partial f}{\partial k}} = \infty; \lim_{k\to 0}\frac{\frac{\partial f}{\partial l}}{\frac{\partial f}{\partial k}} = 0$$

All generations are identical, except the old generation of period $t = 1$, which lives only for one period and is initially endowed with some amount of savings used for production. This generation will be neglected in the analysis.

2.2 Shock

The economy may suffer from a production shock. Often, economics deals with technology shocks, which are events that change a production function in macroeconomic models. Technology shocks are permanent and mostly considered to be positive (see e.g. Galí, 2004, for some discussion). In contrast to technology shocks, production (or productivity) shocks can be negative. Another common type of shock in economics is a supply shock, which can be a consequence of a technology shock (and then the supply shock is mostly positive) or not (most negative supply shocks are not technology-driven and are not necessarily productivity-driven). In a dynamic framework, the literature distinguishes between permanent and non-permanent shocks (see e.g. Hall, 1988). It is also necessary to distinguish between the shock impact (instantaneous effects of the shock) and the subsequent effects (some discussion can be found in de Jong and Penzer, 1998). The shock in the current paper is taken to be a sharp unexpected temporary change in production.

Assume that an entrepreneur of generation t employs k_{t+1} units of capital and l_{t+1} units of labor. The production technology should produce $f(k_{t+1}, l_{t+1})$ units of consumption/capital good. Let the actual output in period $t+1$ be $\widetilde{f}_{t+1}$. A shock parameter q_{t+1} can be introduced as follows:

$$q_{t+1} = \frac{\widetilde{f}_{t+1}}{f(k_{t+1}, l_{t+1})} \tag{1}$$

The analysis here focuses on a negative shock, therefore $q_{t+1} \in [0,1]$. Furthermore, the shock is assumed to be unpredictable and temporary. If the shock has its impact in period $\tau + 1$, the distribution of the shock parameter in time can be written as

$$q_{t+1} = \begin{cases} 1 & \text{if } t \neq \tau \\ q^* < 1 & \text{if } t = \tau \end{cases} \tag{2}$$

The shock may equally happen in any period, therefore the probability of the shock is given by $\Pr(q_{t+1} = q^*) = \frac{1}{T} \underset{T\to\infty}{\longrightarrow} 0$. The latter is infinitesimal since the number T of periods in the model is infinitely large.

2.3 Decision-making and Priority of Payments

Consider a typical generation $t \geq 1$. Each member of this generation may be employed by some old entrepreneur, who offers the wage rate of w_t. Since the production facilities of this entrepreneurs are affected by shock q_t, actual wage payment per unit of labor $\widehat{w}_t$ may differ from w_t. The value of $\widehat{w}_t$ is determined below.

Potential entrepreneurs of generation t solve, when young, their intertemporal utility maximization problem, which determines their consumption c_t^0 and savings s_t^E in period t, as well as their consumption c_{t+1}^1 in period $t + 1$. They face the following first-period budget constraint:

$$c_t^0 + s_t^E = \widehat{w}_t l_t^E$$

Here $l_t^E \in [0, 1]$ is the part of the unit labor endowment of an agent, which he wishes to be employed. Since unemployed labor delivers no utility to the agent, but the employed labor strictly increases his consumption, it is optimal for him to supply $l_t^E = 1$ units of labor.[1]

The second-period budget constraint of the entrepreneur restricts his second-period consumption to the profit of the firm. The entrepreneur uses his savings s_t^E of the first period of his life to acquire a part of capital stock k_{t+1} used in production. The rest $\left(k_{t+1} - s_t^E\right)$ is financed through credit.[2] When old, the entrepreneur employs l_{t+1} units of labor for production in period $t + 1$. Given the price system with the price of goods normalized to unity, the real wage rate in period $t + 1$ equal to w_{t+1}, and the real gross interest rate r_{t+1}, which applies to credit granted to entrepreneurs in period t and repaid in period $t + 1$, the entrepreneur pays $w_{t+1} l_{t+1}$ for the labor,

[1] If $\widehat{w}_t = 0$, the agent is indifferent with regards of how much labor $l_t^E \in [0, 1]$ he supplies.

[2] In general, the difference $k_{t+1} - s_t^E$ might be negative. In an equilibrium (see section 3), this is impossible, otherwise the demand for credit is zero, but the supply of loanable funds is strictly positive.

and $r_{t+1}\left(k_{t+1}-s_t^E\right)$ for the capital employed in the production. It will be assumed that entrepreneurs have perfect foresight regarding the future wage rate w_{t+1}. The entrepreneur enjoys limited liability, and his expected profit is

$$E_{t+1}=\max\left[q_{t+1}f\left(k_{t+1},l_{t+1}\right)-r_{t+1}\left(k_{t+1}-s_t^E\right)-w_{t+1}l_{t+1},0\right] \tag{3}$$

For the case his revenue is not high enough to cover the expenditures, there exists a *priority of payments*: workers have the highest priority, the creditors have lower priority, and the entrepreneur himself has the lowest priority. Agents with higher priority are repaid before the agents with lower priority. Therefore, the total wage expenditures of the entrepreneur are either wage payoffs at the rate w_{t+1} per unit of labor, or the entire production if it does not exceed the total wage payoff due:

$$e_{t+1}=\min\left[w_{t+1}l_{t+1},q_{t+1}f\left(k_{t+1},l_{t+1}\right)\right] \tag{4}$$

The rest is used to repay on credit:

$$b_{t+1}=\min\left[r_{t+1}\left(k_{t+1}-s_t^E\right),q_{t+1}f\left(k_{t+1},l_{t+1}\right)-e_{t+1}\right] \tag{5}$$

Equation (4) identifies the actual wage payment per unit of labor $\widehat{w}_{t+1}$:

$$\widehat{w}_{t+1}=\min\left[w_{t+1},\frac{q_{t+1}f\left(k_{t+1},l_{t+1}\right)}{l_{t+1}}\right] \tag{6}$$

To proceed with the description of the optimization problem of an entrepreneur of generation t, one can formulate his second period budget constraint as

$$c_{t+1}^1=\max\left[q_{t+1}f\left(k_{t+1},l_{t+1}\right)-r_{t+1}\left(k_{t+1}-s_t^E\right)-w_{t+1}l_{t+1},0\right]$$

Summarizing and substututing for $l_t^E=1$, one obtains the expected utility maximization problem of entrepreneurs[3] in the form

$$\begin{aligned}\max_{c_t,c_{t+1}} \quad & \mathbf{E}_t\left[u\left(c_t^0,c_{t+1}^1\right)\right] \\ \text{subject to} \quad & c_t^0=\widehat{w}_t-s_t^E \\ & c_{t+1}^1=\max\left[q_{t+1}f\left(k_{t+1},l_{t+1}\right)-r_{t+1}\left(k_{t+1}-s_t^E\right)-w_{t+1}l_{t+1},0\right]\end{aligned} \tag{7}$$

Separately from the utility maximization (due to Fisher's separation theorem), entrepreneurs

[3] Entrepreneurs might choose whether they invest their savings s_t^E into their firms or act as creditors in the credit market. If the entrepreneurs opt not to produce, their optimization problem is identical to that of the workers. However, this case is irrelevant for the analysis. The equilibrium outcome would guarantee that the credit interest rate is below the expected profitability of the firms. Otherwise, all entrepreneurs avoid running firms and the demand for credit is zero whilst the credit supply is positive.

solve the expected profit maximization problem of the firm. Since the shock is effectively unanticipated, the problem reduces to

$$\max_{k_{t+1},l_{t+1}} f\left(k_{t+1}, l_{t+1}\right) - r_{t+1}\left(k_{t+1} - s_t^E\right) - w_{t+1}l_{t+1} \tag{8}$$

The properties of the production function guarantee that there are no corner solutions to the problem. The internal solution produces the demand functions for capital $k\left(r_{t+1}, w_{t+1}\right)$ and for labor $l\left(r_{t+1}, w_{t+1}\right)$. The solution of the expected utility maximization problem determines the savings function of entrepreneurs $s_t^E = s^E\left(\widehat{w}_t, w_{t+1}, r_{t+1}\right)$. As in Diamond (1965), $0 < \frac{\partial s^E}{\partial \widehat{w}_t} < 1$ (one cannot save more than one unit from a one unit increase in endowment); additionally, it can be shown that $\frac{\partial s^E}{\partial w_{t+1}} < 0$ and $\frac{\partial s^E}{\partial r_{t+1}} > 0$.

Workers of generation t solve, when young, the intertemporal utility maximization problem similar to that of entrepreneurs. This determines their consumption c_t^0 and savings s_t^W in period t, as well as the consumption c_{t+1}^1 in period $t+1$.

The budget constraint of a typical worker of generation t for the first period of his life is

$$c_t^0 + s_t^W = \widehat{w}_t l_t^W$$

As in the case of entrepreneurs, $l_t^W = 1$ in the worker's individual optimum.

Workers use their savings s_t^W to credit young entrepreneurs at the rate r_{t+1}. If after the realization of shock q_{t+1} in period $t+1$ the actual credit payoff to an individual worker is less than $r_{t+1}s_t^W$, the worker (creditor) experiences a deficit.

Definition 1 ***Deficit*** *of an individual creditor in period* $t+1$ *is*

$$d_{t+1}^W = \frac{1-\eta}{\eta} b_{t+1} - r_{t+1}s_t^W \tag{9}$$

The second-period budget constraint of the worker restricts the second-period consumption to be equal to the yields from crediting adjusted with a possible deficit:

$$c_{t+1}^1 = r_{t+1}s_t^W + d_{t+1}^W$$

Since d_{t+1}^W is conditioned on q_{t+1}, consumption in the second period is uncertain. Substituting for $l_t^W = 1$ and summarizing, one can write the expected utility maximization problem of workers of this generation as follows:[4]

$$\max_{c_t,c_{t+1},s_t^W} \quad \mathbf{E}_t\left[u\left(c_t^0,c_{t+1}^1\right)\right] \tag{10}$$
$$\text{subject to} \quad c_t^0=\widehat{w}_t-s_t^W$$
$$c_{t+1}^1=r_{t+1}s_t^W+d_{t+1}^W$$

This problem determines the savings function of workers $s_t^W=s^W\left(\widehat{w}_t,r_{t+1}\right)$. As in the case of entrepreneurs, $0<\frac{\partial s^W}{\partial \widehat{w}_t}<1$ and $\frac{\partial s^W}{\partial r_{t+1}}>0$;

2.4 Degrees of Shock

One can determine two critical values of the shock parameter. First, $\overline{q}$ such that values of q_{t+1} above $\overline{q}$ ensure that total production of an individual entrepreneur covers all his production expences:

$$\overline{q}=\frac{r_{t+1}\left(k_{t+1}-s_t^E\right)+w_{t+1}l_{t+1}}{f\left(k_{t+1},l_{t+1}\right)}$$

Second, $\underline{q}$ such that for any values of q_{t+1} above $\underline{q}$, total production covers at least wage expences:

$$\underline{q}=\frac{w_{t+1}l_{t+1}}{f\left(k_{t+1},l_{t+1}\right)}$$

Given the priority of payments, and the two critical values above, one can distinguish between four degrees of shock:

1. *Small shock:* $q^*\in\left[\overline{q},1\right]$. Both employees and creditors are repaid in full.
2. *Middle-sized shock:* $q^*\in\left[\underline{q},\overline{q}\right)$. Entrepreneurs are bankrupts, employees are repayed in full, and creditors obtain the residual. Payoff to workers from each entrepreneur is $e_{t+1}=w_{t+1}l_{t+1}$, debt repayment is $b_{t+1}=q^*f\left(k_{t+1t},l_{t+1}\right)-w_{t+1}l_{t+1}$.
3. *Severe shock:* $q^*\in\left(0,\underline{q}\right)$. Entrepreneurs are bankrupt, the value of production does not suffice to repay workers in full. Debt repayments are zero, $b_{t+1}=0$, the wage payment is $e_{t+1}=q^*f\left(k_{t+1},l_{t+1}\right)$
4. *Extreme shock* $q^*=0$ corresponds to a complete destruction of production facilities. Entrepreneurs have zero revenue, wage payment and credit repayment is zero.

[4] Formally, there are two stochastic components in the budget constraints: first, it is $\widehat{w}_t$, which is determined by the realization of the shock in period t, and second, it is d_{t+1}^W, determined by the realization of the shock in period $t+1$. The model describes the world with (almost) safe production technology and no alternative assets. It could be extended for the case with a safe asset. Particularly, this would imply strictly positive real interest rates in equilibrium.

Note that the degrees of the shock are relative to economic conditions, which determine $\overline{q}$ and $\underline{q}$. Appendix A provides a further discussion of the degrees of the shock.

3 Market Equilibrium

The following summarizes the life cycle of a typical generation $t > 1$. All agents of this generation exchange their unit labor endowment for $\widehat{w}_t$ units of goods. Out of this amount, workers and entrepreneurs create their savings s_t^W and s_t^E respectively. In the end of period t, entrepreneurs of generation t need to acquire an additional capital stock $I_t = k_{t+1} - s_t^E$ to run firms. Investment in the production technology takes place in the end of period t.[5] There exists a credit market, in which workers can trade their savings against promissory notes of entrepreneurs. Credit market clears in period t with the interest rate r_{t+1}.

There also exists a labor market in each period t. Entrepreneurs of generation t employ members of generation $t+1$ for production in period $t+1$ at the wage rate w_{t+1}. Since the supply of labor is fixed at unity, the equilibrium wage rate only depends on the labor demand. Therefore, the labor market of period $t+1$ clears at the wage rate w_{t+1}, which is known already in period t.

Period $t+1$ starts and the shock parameter q_{t+1} is realized. Each entrepreneur's wage expenditures are e_{t+1}, and each member of generation $t+1$ obtains $\widehat{w}_{t+1}$ per unit of labor. Capital payoffs from entrepreneurs of generation t to workers of the same generation take place within period $t+1$ and amount to b_{t+1} from each individual entrepreneur. Workers realize deficit of $d_{t+1}^W = \frac{1-\eta}{\eta} b_{t+1} - r_{t+1} s_t^W$.

The analysis focuses on temporary equilibria in each period t conditioned on the realization of the shock parameter q_t (Markov equilibria). Each period's t temporary equilibrium is parametrized on $\widehat{w}_t$ inherited from the previous period according to (6). In the very first period $\widehat{w}_t$ is given by the initial condition w_1.

Definition 2 *A (Markov) equilibrium in the shock-exposed market economy in period $t \geq 1$ under the parameter $\widehat{w}_t$ is an array of the price vector $\left\{r_{t+1}^*, w_{t+1}^*\right\}$ and of the allocation vector $\left\{k_{t+1}^*, l_{t+1}^*, s_t^{E*}, s_t^{W*}\right\}$, which for a given q_t provides that the credit and labor markets clear:*

[5] It can also be viewed as though entrepreneurs of generation t create their production facilities along the period t, investing in amount of k_{t+1} so that the investment process ends at the end of period t.

1. $(1-\eta)\left(k_{t+1}-s_t^E\right)=\eta s_t^W$

2. $(1-\eta)\, l_{t+1}=1$

Knowing the equilibrium of period t, and the realization of the shock q_{t+1}, one can determine relized deficit in period $t+1$: $d_{t+1}^W=\frac{1-\eta}{\eta}b_{t+1}-r_{t+1}s_t^W$.

Note that the equilibrium of period t is not conditioned on the level of deficits d_t^W. This is the distinctive property of the market economy. The level of deficits d_t^W is only relevant for the level of consumption of old workers in period t, but not for the future equilibria.

Proposition 1 *The equilibrium exists and is unique for any period $t \geq 1$ if $\widehat{w}_t > 0$.*

The proof of the proposition is based on Arrow and Debreu (1954), see Appendix B. Note that an extreme shock ($q_t = 0$) implies $\widehat{w}_t = 0$ and hence violates the existence of the equilibrium. The equilibrium may be represented in terms of two lines in the (w_{t+1}, r_{t+1})-plane: LM depicting equilibria in the labor market and CM depicting equilibria in the credit market (see Fig. 1). Since the slope of the CM-line can be either negative or positive (but never smaller than the slope of the LM-line, see Lemma 3 in Appendix B), both cases are presented in the diagram. Since both cases lead to identical results, only one of them will be considered in the rest of the paper.

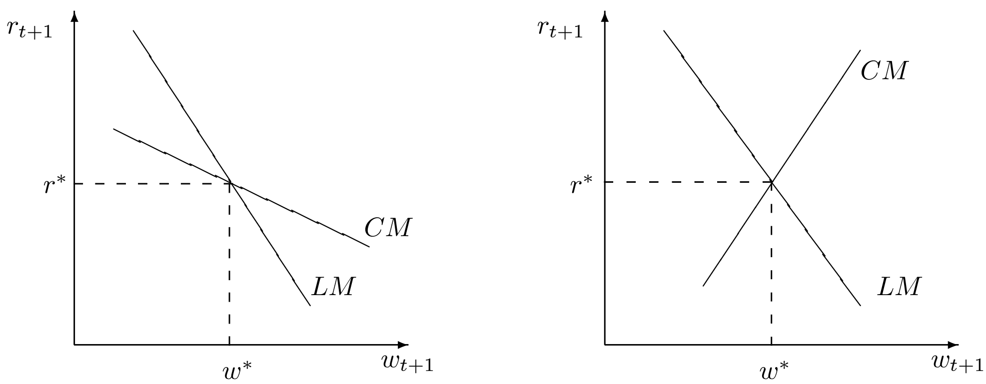

Figure 1. Market Equilibrium

Now consider the economy without shocks with an initial condition $w_1 > 0$. Assume there exists such path of equilibrium price systems $\{w_{t+1}, r_{t+1}\}_{t=0}^{\infty}$ that $w_{t+1} = w_t$ at least for all $t \geq \tau$. In the absence of shocks ($q_{t+1} = 1$) we obtain $\widehat{w}_{t+1} = w_{t+1}$. If the wage level stays unchanged, so does the actual wage payment $\widehat{w}_{t+1}$, and the interest rate level r_{t+1}. The existence of a single stable steady state is an assumption in Diamond (1965). The objective of the current paper is to track out the difference between the market and the intermediated economy. It is easier done, if the shockless market economy possesses a single stable steady state. This assumption may be relaxed, in which case however it would not be obvious, what drives the instability of the steady state in the intermediated economy below. The instability might in that case be either a specific property of the intermediated economy or the heritage from the basic market economy model. To exclude the latter, it is convenient to deal with a market economy which possesses a single stable stationary equilibrium.

Consider now the market economy in its stationary equilibrium in some period τ and assume it is heated by the shock in period $\tau + 1$: $q_{\tau+1} = q^* < 1$.

If the shock is small, $q^* \in [\overline{q}, 1]$, entrepreneurs are able to fully pay both wages and debts in period $\tau+1$. Next period starts with the same equilibrium as before the shock. The only population that suffers from the shock, are entrepreneurs of generation τ.

If the shock is middle-sized, $q^* \in \left[\underline{q}, \overline{q}\right)$, entrepreneurs are able to fully pay wages, but are not able to fully repay on their debts. Old workers experience in this case deficits

$$d_{\tau+1}^W = \frac{1-\eta}{\eta} \left(q^* f\left(k_{\tau+1}, l_{\tau+1}\right) - w_{\tau+1} l_{\tau+1}\right) - r_{\tau+1} s_\tau^W < 0$$

To prove the inequality it suffices to note that if $q_{\tau+1}$ would stay at the unity level, the stationary steady state would persist, and hence $d_{\tau+1}^W$ would be zero. The fall in production causes deficits to change (d^W falls from $d_\tau^W = 0$ to some $d_{\tau+1}^W < 0$). Still, this does not change anything in the equilibrium path, since the old workers do not participate in the clearing of the new credit market. The only generation, which suffers from the shock, is the old generation. Young agents obtain the endowment of $\widehat{w}_{\tau+1} = w_{\tau+1} = w_\tau$, which allows them to clear credit and labor markets with the same prices and allocations as in the stationary equilibrium before.

The case of a severe shock, $q^* \in \left(0, \underline{q}\right)$, differs from the above in that the initial change in deficits is larger (since creditors receive nothing from entrepreneurs), and the wages to the young generation cannot be paid in full. Instead, generation $\tau+1$ obtains the endowment of $\widehat{w}_{\tau+1} < w_{\tau+1} = w_\tau$. As a result, savings of the young generation, $s^W_{\tau+1}$, are smaller than those of the previous generation s^W_τ. This causes CM-line to shift upwards (for any new wage level, credit market clears with a higher interest rate, see Fig. 2). The resulting equilibrium wage level $w^*_{\tau+2}$ is lower than $w^*_{\tau+1} = w^*_\tau$. Along with that, the equilibrium interest rate increases from $r^*_{\tau+1}$ to $r^*_{\tau+2}$.

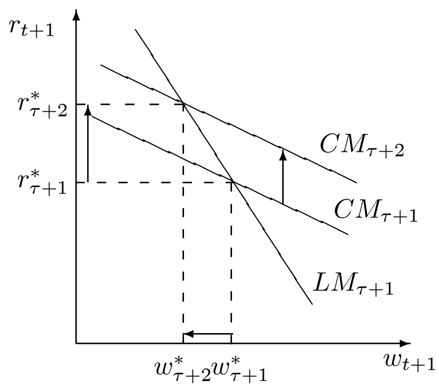

Figure 2. Changes in the market equilibrium

Since the clearing of the credit market does not involve old workers, the deficit is not transferred to the next period:

$$d^W_{\tau+n+1} = \frac{1-\eta}{\eta} r_{\tau+n+1}\left(k_{\tau+n+1} - s^E_{\tau+n}\right) - r_{\tau+n+1}s^W_{\tau+n} = 0 \tag{11}$$

which is valid for any $n \in \mathbb{N}$. Since there are no new shocks, the economy recovers to the stationary steady state, as soon as $q^* > 0$. Otherwise, the economy collapses in the shock period. The existence of the equilibrium is violated: $q_{\tau+1} = 0$ implies $\widehat{w}_{\tau+1} = 0$, and hence $s^E_{\tau+1} = s^W_{\tau+1} = 0$, though the credit demand is strictly positive.

This can be summarized in the following result.

Proposition 2 *Assume there exists a single stable stationary equilibrium in absence of shocks. The evolution of the market economy in presence of a shock depends on the degree of the latter:*

1. *If $q_{\tau+1} \geq \underline{q}$, then the market economy does not deviate from the steady state equilibrium path.*

2. *If $q_{\tau+1} < \underline{q}$, then the market economy recovers to the steady state.*

Proposition 2 shows that the concept of stability in a shockless economy may be extended to the case of the economy exposed to shocks. Note that the burden of the shock is borne by the old generation of the shock period. If the shock is severe, the whole old generation of the shock period suffers from zero consumption, whereas the young generation of that period experiences wage payoffs below those in the steady state.

It is important that the old generation cannot smoothen the burden of the shock through borrowing from the young generation: the old generation cannot physically repay on such borrowings in the next period, since it dies in the end of the current period. This incomplete participation problem could be solved with help of a long-lived financial intermediary.

4 Intermediated Economy

Financial intermediation is present in the economy through banks, which collect savings from workers in the form of deposits, and offer credit to entrepreneurs. I assume the capital of financial intermediaries to be zero. It might be seen, e.g., as though financial intermediaries possess negligibly small capital and belong to old workers in each period t. The ownership is then transferred from one generation to another through bequests and no market for banks' stocks is needed. The ownership could change budget constraints in (10) through dividend payments, but due to the exogeneity of dividends for workers, the consumption-savings decision of the latter is unchanged. The banking system is assumed to be homogeneous and is further considered as a whole.

The sequence of events is the same as in the market economy, except for the credit market, which is now splitted into two parts: the deposit market and the credit market per se.

The collection of deposits starts in period t, when workers of generation t create their savings s_t^W. In the end of period t, entrepreneurs apply for credit to start their businesses. Payoffs of entrepreneurs to banks take place within period $t+1$. The value of deposits made with the banks is equal to the value of aggregate savings of workers ηs_t^W. In period $t+1$ banks have to repay the total of $\eta r_{t+1}^D s_t^W$ to depositors.

It is assumed that no credit rationing takes place, and therefore no credit application is rejected. The amount of credit granted totals $(1-\eta)\left(k_{t+1}-s_t^E\right)$. Within period $t+1$ all entrepreneurs repay to banks the total of $B_{t+1}=(1-\eta)\,b_{t+1}$, with b_{t+1} defined as above.

Since the decision-making repeats the one in the market economy, the savings functions and the demand for production factors are the same. The only differences, which appear now, concern the distinction between the credit and deposit markets. The savings function of entrepreneurs and their demand for production factors in period t depend now on the credit interest rate r_{t+1}^C. The savings function of workers depends on the deposit interest rate r_{t+1}^D.

If in period $t+1$ the total payoff of entrepreneurs to banks does not cover total obligations of banks before their depositors, banks experience a deficit. Numerically, it is equal to the aggregate deficit of all workers in the market economy above.

Definition 3 ***Deficit*** *in the banking system in period* $t+1$ *is*

$$d_{t+1}=(1-\eta)\,b_{t+1}-\eta r_{t+1}^D s_t^W \tag{12}$$

Banks are credible institutions and can use newly accumulated deposits to repay current withdrawals.[6] As a result, the aggregated balance sheet of banks is:

$$(1-\eta)\left(k_{t+1}-s_t^E\right)=\eta s_t^W+d_t \tag{13}$$

Since banks operate in a competitive environment, neither deposit rates r_{t+1}^D nor credit rates r_{t+1}^C differ among banks, therefore interest rates are taken as uniform in the market.

Proposition 3 *Competition in the banking system implies* $r_{t+1}^D=r_{t+1}^C=r_{t+1}$

The proof of the proposition follows from the fact that the expected profit of banks is equal to zero under competition in the banking system.

Now we can define a competitive equilibrium in the intermediated economy exposed to shocks:

Definition 4 *A (Markov) equilibrium in the shock-exposed intermediated economy in period* $t\geq 1$ *under parameters* $\{\widehat{w}_t,d_t\}$ *is an array of the price vector* $\left\{r_{t+1}^{C*},r_{t+1}^{D*},w_{t+1}^*\right\}$ *and of the allocation vector* $\left\{k_{t+1}^*,l_{t+1}^*,s_t^{E*},s_t^{W*}\right\}$, *which provides that*

[6] Wagner (1857) based his "theory of banking sediment" (Bodensatztheorie) upon a similar idea.

1. $(1-\eta)\left(k_{t+1}-s_t^E\right)=\eta s_t^W+d_t$

2. $(1-\eta)\,l_{t+1}=1$

3. $r_{t+1}^C=r_{t+1}^D=r_{t+1}$

The last condition is the competitive outcome for credit and deposit interest rates. The link between the deposit and the credit market is given by the balance sheet equation of the banks (condition 1 in definition 4).

As soon as new period $t+1$ starts, the shock realization q_{t+1} determines parameters $\{\widehat{w}_{t+1}, d_{t+1}\}$ of the new equilibrium:

1. $d_{t+1}=(1-\eta)\,b_{t+1}-\eta r_{t+1}s_t^W$
   with $b_{t+1}=\min\left[r_{t+1}\left(k_{t+1}-s_t^E\right), q_{t+1}f\left(k_{t+1}, l_{t+1}\right)-e_{t+1}\right]$
   and $e_{t+1}=\min\left[w_{t+1}l_{t+1}, q_{t+1}f\left(k_{t+1}, l_{t+1}\right)\right]$
2. $\widehat{w}_{t+1}=\min\left[w_{t+1}, \frac{q_{t+1}f(k_{t+1},l_{t+1})}{l_{t+1}}\right]$

Note that changes in the deficit level influence only the CM-line, and do not influence the LM-line, although the resulting temporary equilibrium would differ for different values of d_t. An increase in the absolute value of deficits increases the equilibrium interest rate as defined by the credit market for any wage level w_{t+1} so that the CM-line shifts upwards in (w_{t+1}, r_{t+1})-plane (straightforward from the equilibrium condition for the credit market):

$$\frac{\partial r_{t+1}^{CM}}{\partial d_t}<0 \tag{14}$$

The sign "<" in enequality (14) is due to the fact that $d_t\leq 0$, and increase in its absolute value corresponds to the decrease in d_t.

Lemma 1 *The equilibrium interest rate and the equilibrium wage rate depend on the deficit in the banking sector: the equilibrium interest rate increases and the equilibrium wage level decreases with the absolute value of the deficit:*

$$\frac{\partial r_{t+1}^{*}}{\partial d_t}<0;\frac{\partial w_{t+1}^{*}}{\partial d_t}>0 \tag{15}$$

The intuition behind this lemma is obvious. According to (14) and due to the independence of the labor market equilibrium of the deficit in the banking system, the equilibrium interest rate and the wage level are determined by the movement of the equilibrium point along the LM-line. Graphically, changes in the equilibrium in response to an increase in the absolute value of the deficit are the same as shown in Figure 2.

Proposition 4 *If $q_{t+1} = 1$ for any $t \geq 1$, then the intermediated economy replicates the market economy.*

This result ensures that if the market economy converges to the steady state, so does the intermediated economy. The result is due to zero deficits in the banking system, which leads to the identity in the balance sheets of the market economy and of the intermediated one. It is important that there is no risk in any form. This allows one to neglect the crucial difference between direct debt contracts and indirect lending through deposit contracts: the debt contract presumes limited liability of the issuer and the deposit contract presumes unlimited liability of the bank under the assumption that the bank may finance deficits through borrowing frm future generations.

Now assume again that in period τ the economy is in the steady state equilibrium, and the shock parameter takes the value of $q^* < 1$ in period $\tau + 1$.

Proposition 5 *The evolution of the intermediated economy depends on the degree of the shock:*

1. *If $q^* \in [\overline{q}, 1]$, then the economy converges to the steady state with $d = 0$.*
2. *If $q^* \in \left[\underline{q}, \overline{q}\right)$, then under positive real interest rates the economy collapses in a finite number of periods, otherwise it converges to the steady state with $d = 0$ (if real interest rates are negative) or transfers deficits to future periods (if real interest rates are zero).*
3. *If $q^* \in \left(0, \underline{q}\right)$, the banking system is bankrupt in the period of the shock.*

The intuition behind proposition 5 is as follows. If $q^* \geq \overline{q}$ then old entrepreneurs repay their debt in full and no deficits in the banking system appear. According to proposition 4, the intermediated economy replicates the market one, which converges to the steady state. If $q^* < \overline{q}$, then necessarily $d_{\tau+1} < 0$ since entrepreneurs default on their debts. Banks may exercise their intertemporal smoothing role and repay to old creditors in foll, covering the deficit through borrowing from the next generation of depositors. This augments deficits with factor $r_{\tau+2}$, since this is the interest rate to be paid on newly accumulated deposits. Due to the competition, the net profit of banks is zero and cannot reduce the deficit. As a result, the deficit follows the development path: $d_{t+1} = r^*_{t+1} d_t$, $t > \tau$. This equation together with (15) and the assumption of positive real interest rates[7], gives rise to a following diagrammatic interpretation in a phase plane (see Fig. 3). In a finite number of periods, the deficit in the banking system cannot be covered anymore with newly accumulated deposits, and therefore, the banking system is bankrupt: $d_{\tau+n} \leq \underline{d_{\tau+n}} = -\eta s^W_{\tau+n}$. If $q^* < \underline{q}$, this happens immediately after the shock, since entrepreneurs fully default on their debts, and underpay workers compared to the steady state. As a result, newly accumulated deposits cannot cover the deficit.

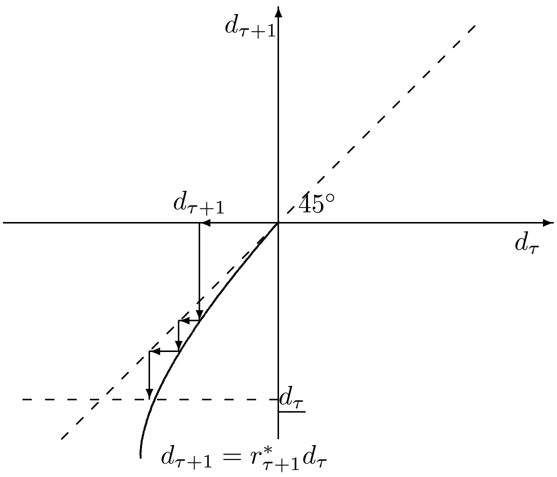

Figure 3. Evolution of the deficit in the banking system

This result underlines the role of the competition in the banking sector. Indeed, if the competition is not intense, banks are able to exploit positive profit margin, which they could use to cover the deficit. Allen and Gale (1997) assume an intermediary to possess monopoly power, which allows it to accumulate reserves. Gersbach and Wenzelburger (2006) consider a competitive case and show that even if intermediaries enjoy positive interest rate margin, explained by a risk

[7] A negative real interest rate, would have an effect of a subsidy provided by future generations, and would shrink the deficits. If workers might choose between depositing with the bank and investing in a durable good, negative real interest rate would be impossible. This would require changes in the utility maximization problems in the beginning of the paper.

premium, banking system still may collapse, since the competition will shrink the margin. The model above shows that the development path of the intermediated economy differs from that of the market economy only if the shock is strong enough to create the deficit. The following section analyzes regulatory measures, which may improve the performance of the intermediated economy.

5 Regulation

Above, it was implicitly assumed that the regulator follows a policy of forbearance with regards to insolvency resolutions: remember, banks with deficits are technically insolvent. Along with that, banks were assumed to be credible institutions. This assumption may require some regulatory guarantees, which prevent bank runs. The crisis, which appears in the model above (the deterioration of balance sheets of banks), is distinct from banking panics, and regulatory guarantees or deposit insurance need to be complemented with other regulatory measures.

5.1 Liquidity assistance with no enforcement

Assume that the regulator possesses a stock $\overline{M}$ of liquid funds, which can only be accessed by banks experiencing deficits and is not otherwise used. For simplicity, $\overline{M}$ may be seen an assistance from abroad (e.g. from an International Lender of Last Resort), or as a stabilization fund accumulated during the periods, when the economy was in its steady state. The analysis here concentrates on the impact of liquidity injections. The question of their optimal financing is out of consideration.

If $d_t < 0$, banks may apply for a one-period loan from the regulator charged with the gross interest rate of r^M. This is a general formulation: $r^M = 0$ corresponds to the case of a subsidy; any rate of $r^M < 1$ corresponds to a subsidized loan. The total amount of loans granted by the regulator in period t has to cover the deficit in the banking sector and is therefore

$$M_t = -d_t \tag{16}$$

The credit is granted by the regulator in the end of period t, covers the deficit accrued in period t, lasts for one period and is repaid to the regulator in the end of period $t + 1$ in the total amount of $r^M M_t$.

The equilibrium condition for the credit market changes to

$$(1-\eta)\left(k_{t+1}-s_t^E\right)=\eta s_t^W+d_t+M_t \tag{17}$$

To complete the description, I assume that the interest (if any) gained on such liquidity injections is used to increase the stock $\overline{M}$. I leave therefore all possible fiscal distortions (taxes and income redistribution) aside and focus only on the bailout effect of such intervention.

Assume again the system is in its steady state in period τ, and the shock $q_{\tau+1}=q^*$ makes entrepreneurs to default in period $\tau+1$. The banking system experiences a deficit $d_{\tau+1}<0$ in period $\tau+1$. Conditions (17) and (16) imply

$$(1-\eta)\left(k_{\tau+2}-s_{\tau+1}^E\right)=\eta s_{\tau+1}^W \tag{18}$$

Effectively, the deficit is vanished from the banking system, and proposition 4 would ensure that the intermediated economy follows the same recovery path as the market economy, if deficits do not re-appear in the banking sector. Further evolution of deficits is given by

$$d_{\tau+2}=(1-\eta)\,r_{\tau+2}^C\left(k_{\tau+2}-s_{\tau+1}^E\right)-\eta r_{\tau+2}^D s_{\tau+1}^W-r^M M_{\tau+1} \tag{19}$$

If the regulator does not possess enforcement mechanisms, banks are not forced to repay the loan within period $\tau+2$.[8] The expected profit of banks for period $\tau+2$ is then

$$\Pi_{\tau+2}=(1-\eta)\,r_{\tau+2}^C\left(k_{\tau+2}-s_{\tau+1}^E\right)-\eta r_{\tau+2}^D s_{\tau+1}^W=0$$

The expected profit is equal to zero due to the competition in the banking sector. Together with (19), this implies

$$d_{\tau+2}=-r^M M_{\tau+1}=r^M d_{\tau+1} \tag{20}$$

The case of a pure subsidy ($r^M=0$) eliminates deficits, and the economy returns to the steady state. The case of subsidized loans ($r^M<1$) shrinks deficit to zero. If liquidity injections are charged with an interest rate $r^M>1$, but are not restrictive enough to change the profit expectations of banks, deficits in the banking sector deteriorate further. The unrestricted continuation of such policy repeats the above described steps, and, as in the case of unregulated dynamics, the collapse is unavoidable: the banking system is bankrupt in a finite number of periods. The stock

[8] Especially, it may be true, when bankers expect the regulator to provide the banking system with liquidity assistance during systemic crises. Unrestricted access to such liquidity source distorts profit expectations of bankers.

of liquid funds $\overline{M}$ can not be exhausted, since starting from the period $\tau + 2$ deficits in the banking system are constituted only of the debt before the regulator, so that "liquidity" injections do not actually require any transfer of liquid funds, but rather take a form of "virtual" credits, which only result in an accumulation of unpaid interest. Setting $r^M = 1$ allows the postponement of the collapse without any accumulation of debts.

The discussion above leads to the following conclusion. Liquidity injections with no enforcement either postpone the collapse (if the assistance is provided through interest-free loans) or prevent the collapse (if banks are subsidized). In both cases the burden of the shock is borne by the regulator. If the loan from the regulator is charged with a positive real interest, the banking system is bankrupt in a finite number of periods.

5.2 Liquidity Injections with enforcements

It is possible that the regulator uses enforcements, penalties or a direct control to affect profit expectations of the banks. In such a case, banks do count for the repayment of debts to the regulator:

$$\Pi_{\tau+2} = (1-\eta)\, r^C_{\tau+2} \left(k_{\tau+2} - s^E_{\tau+1}\right) - \eta r^D_{\tau+2} s^W_{\tau+1} - r^M M_{\tau+1} = 0$$

Zero expected profit (due to the competition) implies that banks set the deposit interest rate below the credit interest rate (which is fixed by condition 18) as soon as $r^M > 1$. The new level of deficits in the banking system is then $d_{\tau+2} = 0$. At the same time, the amount of deposits in the banking sector decreases due to a decrease in the deposit interest rate (hence, $s^W_{\tau+1} < s^W_\tau$) and the credit market is cleared under a higher credit interest rate. The new equilibrium results in lower wages and higher credit interest rate (see Fig. 2).

In period $\tau + 2$ there are no deficits in the economy, and the profit expectations of banks are

$$\Pi_{\tau+3} = (1-\eta)\, r^C_{\tau+3} \left(k_{\tau+3} - s^E_{\tau+2}\right) - \eta r^D_{\tau+3} s^W_{\tau+2} = 0$$

Therefore, banks set deposit and credit interest rates equal to each other: $r^C_{\tau+3} = r^D_{\tau+3}$. According to Proposition 4, the intermediated economy replicates the market one and recovers to the steady state

To summarize, short-term loans with enforcement mechanisms allow for a recovery of the system after a middle-sized production shock. The burden of the shock is borne by the population in the periods next to the shock: depositors receive deposit interest below the credit interest rate, and at the same time they obtain smaller wages due to a fall in production, which also leads to a lower consumption level of entrepreneurs.

Note that the case of liquidity injections almost completely corresponds to the case of banks borrowing from future generations. The two very principal differences are: (1) in the case of liquidity injections, the interest rate r^M is not the equilibrium outcome but rather is set by the regulator, and (2) the regulator possesses some power over banks and may make banks internalize the costs of such a bailout.

5.3 Deposit Rate Ceiling

The regulator introduces the deposit rate ceiling $r^D \leq r^{Dreg}$, which distorts the equality between deposit and credit interest rates in a following way:

$$r^D_{t+1} = \min\left(r^{Dreg}, r^C_{t+1}\right) \tag{21}$$

If $r^{Dreg} > r^C_{t+1}$, the deposit interest rate will be equal to the credit interest rate $r^C_{t+1} = r^D_{t+1} = r^*_{t+1}$ so that the regulated dynamics repeats the case of the unregulated one. After the shock, the credit interest rate increases, as shown for the case of the unregulated dynamics, and at some point τ the condition $r^{Dreg} < r^C_{\tau+1}$ holds, which fixes the deposit rate[9].

With regards to the equilibrium definition, condition (21) replaces condition 3 in Definition 4. The equilibrium condition for the labor market is not disturbed by the introduction of the regulation since it depends only on the credit interest rate. If the deposit rate is fixed by the ceiling, the equilibrium condition for the credit market changes to

$$(1-\eta)\left(k\left(w_{t+1}, r^C_{t+1}\right) - s^E\left(w_t, w_{t+1}, r^C_{t+1}\right)\right) = \eta s^W\left(w_t, w_{t+1}, r^{Dreg}\right) + d_t \tag{22}$$

Obviously, the equilibrium credit rate from (22) is negatively related to the regulated deposit rate: $\frac{\partial r^C_t}{\partial r^{Dreg}} < 0$. This is explained by the fact that a decrease in the deposit rate, which is now exogenously fixed by the regulation, leads to less deposits with banks. Therefore, the credit supply decreases, and the credit interest rate increases in order to hold the equilibrium. In other words, setting the regulated deposit rate at the level below that of the unregulated equilibrium, increases

9 Of course if the deposit rate ceiling is not set too high: $r^{Dreg} < r^{crit}$ where r^{crit} provides $d_t = -\eta s^D_t\left(\cdot, r^{crit}\right)$.

credit interest rate and hence makes the banks' profit margin positive.

Assume that $r^D_{\tau+n} = r^{Dreg}$ (if r^{Dreg} is relatively high, it may require some n periods, $n \in \mathbb{N}$, for condition 25 to be binding). Further dynamics of banking deficits is given by

$$d_{\tau+n+1} = (1-\eta)\, r^C_{\tau+n+1} \left(k_{\tau+n+1} - s^E_{\tau+n}\right) - \eta r^{Dreg} s^W_{\tau+n} \tag{23}$$

The credit market equilibrium condition yields

$$d_{\tau+n+1} = r^C_{\tau+n+1} d_{\tau+n} + \eta \left(r^C_{\tau+n+1} - r^{Dreg}\right) s^W_{\tau+n} \tag{24}$$

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

$$r^{Dreg} < 1 + \left(r^C_{\tau+n+1} - 1\right)\left(1 + \frac{d_{\tau+n}}{\eta s^W_{\tau+n}}\right) < r^C_{\tau+n+1} \tag{25}$$

Note that if $d_{\tau+n} = -\eta s^W_{\tau+n}$, the banking system is bankrupt and the equilibrium rate $r^C_{\tau+n+1}$ does not exist. Otherwise, there always exists such r^{Dreg} that provides a recovery of the banking system after a middle-sized shock $q^* \in \left[\underline{q}, \overline{q}\right)$. For example, $r^{Dreg} = 1$ would always provide a recovery since either (25) is met, or $r^C_{\tau+n+1} < 1$, which guarantees the recovery as shown in proposition 5. If the regulator delays with the intervention, the deficit augments in time, therefore a prompt intervention is desirable.

The main feature of the deposit rate ceiling is the creation of a positive profit margin for the banks, which would allow them to cover deficits. Both the enforcement mechanisms and the deposit rate ceiling distort the competitive outcome in the banking sector with regard to the relationship between the credit interest rate and the deposit interest rate.

6 Welfare Considerations

To proceed with a welfare comparison of the two economies, I assume that there exists a proper regulation scheme, which allows intermediated economy to recover after the shock.

The market economy does not generate subsequent events after a small or a middle-sized shock. In the case of a severe production shock, there are subsequent events, which are generated by the shock and transferred in the market economy to the after-shock periods. Obviously, the scale of these subsequent events is not greater than the scale of the same events in the intermediated economy (since deficits, which are generated in the banking system, create an additional obstacle for the system to recover). Therefore one can expect that the market economy, which demonstrates higher speed of recovery, would overperform the intermediated economy in sense of smaller consumption losses for the generations *after* the shock. The question is hence, whether the market economy performs better or worse than the intermediated one in the period of the shock impact? The social losses for the generations, who live in this period, are in the intermediated economy smaller or equal to those in the market economy. In terms of an intertemporal social welfare function, there always exists such a function which would attribute smaller intertemporal social losses to an intermediated economy (it suffices to count for the losses of future generations with a high enough discount factor). At the same time there would always exist social welfare functions, which would attribute better performance (in sense of intergenerational reduction of social losses) to the market economy.

Proposition 6 *If the shock is small, intermediated economy provides agents of each generation with the same utility as the market economy does. In case of a middle-sized and severe shock, the judgment upon the optimality of the financial system depends on the choice of the intergenerational social welfare function. If the shock is extreme, neither of the financial systems can prevent the collapse of the economy.*

It is not a trivial task to judge upon which system provides better arrangements against macroeconomic shocks. The judgment would crucially depend on the choice of the social welfare function. Still, as Bolton (2002) notes, the question of which type of financial system should be adopted, is of a great relevance for transitory and developing countries. One may expect that for a country in poverty and with high vulnerability to shocks it may be desirable to provide arrangements, which would rather guarantee a smoothing of the shock impact over several generations than a high speed of recovery with high burden on one generation. In this sense, the current paper suggests that a properly regulated banking system may provide such arrangements.

It should be noted that the *after-shock* generations do not experience a decrease in consumption compared to their consumption plans; their planned consumption is always achieved in equilibrium. The reduction in consumption is revealed only through a comparison with a benchmark case, which is a steady state level.

7 Conclusions

A market-based financial system may provide a recovery of the economy after a non-permanent negative production shock, if the shock is not extreme. An unregulated bank-based financial system replicates the market economy if the shock is small. A middle-sized shock leads to a collapse of the unregulated bank-based economy within a finite number of periods. This difference arises through the fact that the banking system transfers the shock into the future through its balance-sheet channel, in addition to a market channel. The balance-sheet channel allows banks experiencing deficits, to borrow from future generations of depositors in order to repay to the current depositors in full. Under competition, banks suffer from a zero profit margin and are unable to cover the deficit.

A regulatory measure should create conditions for a positive profit margin for banks. Unrestricted liquidity injections may not be usefull in preventing the collapse unless they take a form of a subsidy. A liquidity assistance may lead to the recovery if the regulator can introduce enforcement mechanisms. Another type of a regulatory intervention is an introduction of a proper deposit rate ceiling. In an economy with a properly regulated banking system the recovery is in general slower than in the market economy.

However, the market economy concentrates the burden of the shock in one period. In contrast, bank-based financial systems smoothen the shock, so that the burden of the shock for the generations in the period of the shock impact is reduced. At the same time, subsequent generations suffer from a reduced consumption due to lower wages and higher interest rates in the intermediated economy. The choice between the two types of financial systems depends on social preferences. Economies in poverty may prefer avoiding the concentration of the shock burden on one generation, and therefore establishing a sound banking system may be more desirable for them, than a market based financial system.

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Appendix A. Degrees of Shock

The shock in the model is determined by the shock parameter $q^* \in [0;1]$, and is measured by the output after the shock as a percentage of the output in steady state. This does not, however, mean that the shock of q^*, which is middle-sized or severe in one economy, would be necessarily middle-sized or severe in another economy. To discuss this issue, assume that the shock q^* occurs in the steady state. The severity of the shock depends on the steady state price system, namely on the wage and interest rate level.

The lower limit of the small shock is then

$$\overline{q} = \frac{(1+\overline{r})\left(\overline{k}-\overline{s}^E\right)+\overline{w}\overline{l}}{f\left(\overline{k},\overline{l}\right)} \tag{A-1}$$

and the lower limit of the middle-sized shock is

$$\underline{q} = \frac{\overline{w}\overline{l}}{f\left(\overline{k},\overline{l}\right)} \tag{A-2}$$

with the "barred" variables referring to the steady state.

As it can be seen, an economy with a higher share of capital in production has necessarily a smaller $\underline{q}$, and hence is less vulnerable with respect to a shock: the probability that a shock of q^* is middle-sized, but not severe, is in highly capitalized economies higher than in less capitalized economies. Indeed, the ratio $\frac{f\left(\overline{k},\overline{l}\right)}{\overline{l}}$ is the average productivity of labor $APL\left(\overline{k},\overline{l}\right)$, which increases as the capitalization of production increases. In the stationary point, profit-maximizing firms set the wage level equal to the marginal product of labor $\overline{w} = MPL\left(\overline{k},\overline{l}\right)$. Hence, equation (A-2) may be written in a form

$$\underline{q} = \frac{MPL\left(\overline{k},\overline{l}\right)}{APL\left(\overline{k},\overline{l}\right)}$$

On the one hand, the higher the average productivity of labor, the smaller the interval $\left(0,\underline{q}\right)$, which determines the area of severe shocks. On the other hand, higher capitalization leads to a higher marginal product of labor, so that the general effect may be ambiguous and depends on the substitutability between labor and capital.[10]

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[10] For a Cobb-Douglas production function $f = k^\alpha l^\beta$ $(\alpha+\beta \leq 1)$ one obtains $APL = \frac{f}{l} = k^\alpha l^{\beta-1}$ and $MPL = \beta k^\alpha l^{\beta-1}$, so that $\underline{q} = \beta < 1$. If capital and labor are perfect substitutes ($f = \alpha k + \beta l$), $MPL = \beta$, and $\underline{q} = \frac{1}{\alpha k/l+\beta}$, which decreases as capitalization increases.

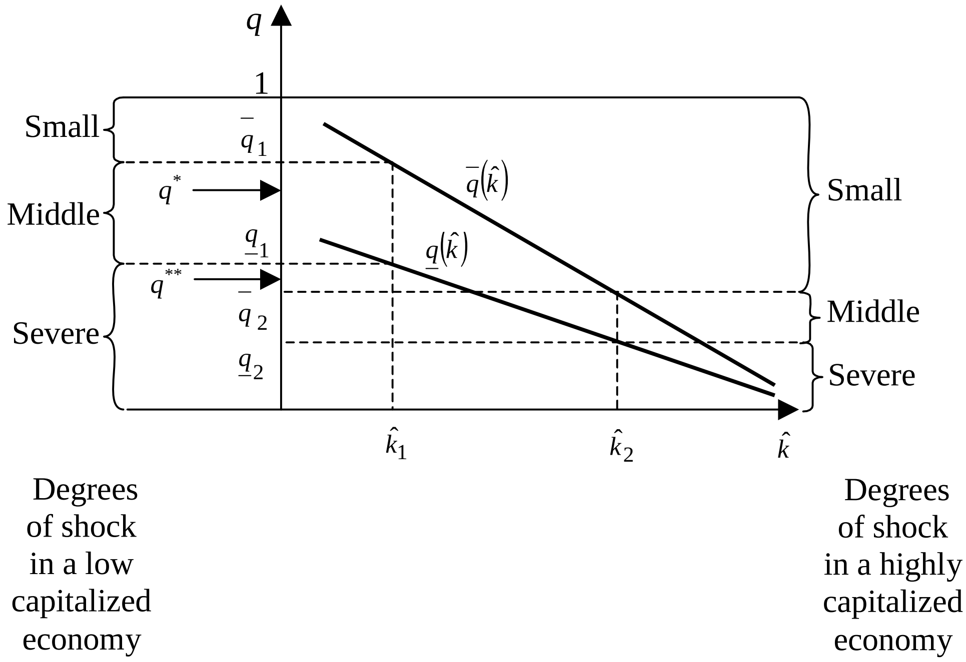

Figure 4. Degrees of Shock

Equation (A-1) may be reformulated as

$$\overline{q} = \frac{(1+\overline{r})\left(\overline{k} - \overline{s}^E\right)}{f\left(\overline{k}, \overline{l}\right)} + \underline{q}$$

so that the term $\frac{(1+\overline{r})\left(\overline{k}-\overline{s}^E\right)}{f\left(\overline{k},\overline{l}\right)}$ indicates the length of the interval $\left[\underline{q}, \overline{q}\right)$ of the middle-sized shock. Note that $\overline{s}^E$ is the internal finance provided by entrepreneurs themselves, and $\overline{k} - \overline{s}^E$ is external borrowing. The higher the share of internal capital, the higher the probability of the shock being small. Vice versa, the higher the share of the external capital, the more vulnerable is the economy to the production shock. The above reasoning also applies to the average productivity of the borrowed capital $APK_B = \frac{f\left(\overline{k},\overline{l}\right)}{\overline{k}-\overline{s}^E}$ and to the marginal productivity of capital $MPK = 1 + \overline{r}$:

$$\overline{q} - \underline{q} = \frac{MPK\left(\overline{k}, \overline{l}\right)}{APK_B\left(\overline{k}, \overline{l}\right)}$$

One may expect that in economies with high capitalization and low costs of capital (due to decreasing marginal productivity, high capitalization implies low MPK and therefore low equilibrium borrowing costs), the difference $\overline{q} - \underline{q}$ shrinks.

If one assumes that both $\overline{q}$ and $\overline{q} - \underline{q}$ are decreasing functions of $\overline{k}$, the following schematic representation is possible (see Fig. 4).[11] In the figure, it is shown that a shock q^* may be seen as a middle-sized shock for a smaller economy, whereas it is a small shock for a large (highly capitalized) economy. Moreover, it is also possible that a shock q^{**}, which is small for a highly developed economy, is severe for a less developed economy.[12] For example, a loss of 10% GDP (the shock parameter $q^* = 0.9$) may represent a small shock for an economy developed economy, but be a middle-sized (or even severe) shock for an underdeveloped labor-intense economy with low average productivity of labor. This discussion suggests that the results of the current paper may be of different significance for developed and underdeveloped economies.

Countries with more labor-intensive production seem to be more vulnerable to stronger shocks, whereas developed countries seem to be less vulnerable to the degrees of the shock, which may demonstrate the difference between the market-based and bank-based financial systems. This qualitative remark may be another fact in favor of establishing bank-oriented financial systems in emerging economies, due to their smaller capitalization and poorer technological development. On the contrary, in developed economies the probability of middle-sized shocks is lower, and the advantages of the banking system in intertemporal smoothing of exogenous negative shocks may be less noticeable.

[11] The purpose of the diagram is only to illustrate the possibility of different treatment of the same shock by different economies. A detailed analysis of the shock-response functions is not the focus of this paper.

[12] Here, the development is understood in sense of the marginal product - average product ratios introduced above. I do not focus on this issue further, since the degree of the development is not the principal issue in the analysis here. Still, it is important to note that the relevance of the analysis *may* be different for different economies.

Appendix B. Proofs

PROOF of Proposition 1

Proof.

Existence

Preferences and production technology satisfy the assumptions of the competitive equilibrium existence theorem (Arrow and Debreu, 1954), which ensures the existence of the equilibrium:[13]

1. the set of available consumption vectors (c_t, c_{t+1}) for each generation t is closed and bounded from below
2. the preferences of consumers of each generation t are represented by continuous, monotonically increasing, quasi-concave utility functions of (c_t, c_{t+1})
3. the initial endowment of the individuals is strictly positive at least in one component (in the model, each individual in each generation is endowed with one unit of labor, which is converted into $\widehat{w}_t > 0$ units of initial endowment in goods)
4. production technologies belong to a part of each generation and are given by a continuous strictly increasing and concave production functions with no output at zero input.

Uniqueness

Consider first labor market (LM). The LM-equilibrium condition is

$$l\left(r_{t+1}, w_{t+1}\right) = \frac{1}{1-\eta} \tag{B-1}$$

Function $l\left(r_{t+1}, w_{t+1}\right)$ decreases in both interest rate and wage level ($\frac{\partial l}{\partial r_{t+1}} < 0, \frac{\partial l}{\partial w_{t+1}} < 0$). The implicit function theorem guarantees that equation (B-1) defines a unique function $r_{t+1}\left(w_{t+1}\right)$ with $\frac{\partial r_{t+1}}{\partial w_{t+1}} < 0$. This means that for any given interest rate established in the credit market, there will always exist only one equilibrium wage level in the labor market.

[13] Arrow and Debreu (1954) consider multiproduct technologies with an assumption that in the absence of factor restrictions, the production of any good may be increased without a decrease in the production of other goods. The model in the current paper is based upon a one-product technology.

Consider now the equilibrium in the credit market (CM):

$$(1-\eta)\left(k_{t+1}-s_t^E\right)=\eta s_t^W \tag{B-2}$$

Optimal choice of the entrepreneurs implies $\frac{\partial k}{\partial r_{t+1}}<0$, $\frac{\partial k}{\partial w_{t+1}}<0$, $\frac{\partial s_t^E}{\partial w_{t+1}}>0$ and $\frac{\partial s_t^E}{\partial r_{t+1}}>0$. Optimal choice of the workers implies $\frac{\partial s_t^W}{\partial w_{t+1}}<0$ and $\frac{\partial s_t^W}{\partial r_{t+1}}>0$. The sum and the difference of differentiable functions are differentiable. Hence, equation (B-2) also implicitly yields a differentiable function $r_{t+1}\left(w_{t+1}\right)$ which is unique.

Combining $r_{t+1}^{CM}\left(w_{t+1}\right)$, defined in the credit market, with $r_{t+1}^{LM}\left(w_{t+1}\right)$, defined in the labor market, we obtain an equilibrium interest rate and wage level, which exist. Assume that there are several equilibria and choose the one with the smallest $w_{t+1}=\underline{w}$. Consider now the difference $r_{t+1}^{CM}\left(w_{t+1}\right)-r_{t+1}^{LM}\left(w_{t+1}\right)$, which is zero in the equilibrium chosen. This difference increases as w_{t+1} increases (see Lemma 2 below):

$$\frac{\partial r_{t+1}^{CM}}{\partial w_{t+1}}-\frac{\partial r_{t+1}^{LM}}{\partial w_{t+1}}>0 \tag{B-3}$$

Hence, the difference $r_{t+1}^{CM}\left(w_{t+1}\right)-r_{t+1}^{LM}\left(w_{t+1}\right)$ is positive for any $w_{t+1}>\underline{w}$. This means there are no equilibria with $w_{t+1}>\underline{w}$. Because of the choice of $\underline{w}$, there are also no equilibria with $w_{t+1}<\underline{w}$, This proves the uniqueness of the equilibrium point ($w_{t+1}^*=\underline{w}$, $r_{t+1}^*=r_{t+1}^{LM}\left(\underline{w}\right)=r_{t+1}^{CM}\left(\underline{w}\right)$)

■

Lemma 2 *Equilibrium gap $r_{t+1}^{CM}\left(w_{t+1}\right)-r_{t+1}^{LM}\left(w_{t+1}\right)$ increases in w_{t+1}*

Proof. The slope of the equilibrium line in the credit market can be found through implicit differentiation:

$$\frac{\partial r_{t+1}}{\partial w_{t+1}}=-\frac{\eta\frac{\partial s_t^W}{\partial w_{t+1}}-(1-\eta)\left(\frac{\partial k}{\partial w_{t+1}}-\frac{\partial s_t^E}{\partial w_{t+1}}\right)}{\eta\frac{\partial s_t^W}{\partial r_{t+1}}-(1-\eta)\left(\frac{\partial k}{\partial r_{t+1}}-\frac{\partial s_t^E}{\partial r_{t+1}}\right)} \tag{B-4}$$

The denominator in this fraction is always positive. Since (B-4) is valid for any value of parameter $\eta\in[0,1]$, we can check, whether it is positive or negative for its upper and lower limits:

$$\left\{\frac{\partial r_{t+1}}{\partial w_{t+1}}\right\}^{CM}_{\eta=0} = -\frac{\frac{\partial k}{\partial w_{t+1}} - \frac{\partial s^E_t}{\partial w_{t+1}}}{\frac{\partial k}{\partial r_{t+1}} - \frac{\partial s^E_t}{\partial r_{t+1}}} < 0 \tag{B-5}$$

$$\left\{\frac{\partial r_{t+1}}{\partial w_{t+1}}\right\}^{CM}_{\eta=1} = -\frac{\frac{\partial s^W_t}{\partial w_{t+1}}}{\frac{\partial s^W_t}{\partial r_{t+1}}} > 0 \tag{B-6}$$

This means that for all possible functions k, s^E and s^W, setting $\eta = 0$ (and close to it) guarantees that CM-line is monotonically decreasing in w_{t+1}; and setting $\eta = 1$ (and close to it) guarantees that CM-line is monotonically increasing in w_{t+1} for any given wage parameter w_t.

Furthermore, for each set of functions k, s^E and s^W, the slope of the CM-line monotonically increases in η as η changes from 0 to 1:

$$\frac{\partial}{\partial \eta}\left\{\frac{\partial r_{t+1}}{\partial w_{t+1}}\right\}^{CM} = -\frac{\frac{\partial s^W_t}{\partial r_{t+1}}\frac{\partial k}{\partial w_{t+1}} - \frac{\partial s^W_t}{\partial w_{t+1}}\frac{\partial k}{\partial r_{t+1}}}{\left[\eta\frac{\partial s^W_t}{\partial r_{t+1}} - (1-\eta)\left(\frac{\partial k}{\partial r_{t+1}} - \frac{\partial s^E_t}{\partial r_{t+1}}\right)\right]^2} > 0 \tag{B-7}$$

This ensures that at any point w_{t+1} the derivative $\frac{\partial r_{t+1}}{\partial w_{t+1}}$ is always bounded by (B-5) from below and by (B-6) from above. Since $\left\{\frac{\partial r_{t+1}}{\partial w_{t+1}}\right\}^{LM} < \left\{\frac{\partial r_{t+1}}{\partial w_{t+1}}\right\}^{CM}_{\eta=0}$ (for proof see Lemma 3 below), the slope of the LM-line is smaller than the smallest possible slope of the CM-line in any point w_{t+1}, so that the gap $r^{CM}_{t+1} - r^{LM}_{t+1}$ increases in w_{t+1}.[14]

■

Lemma 3 *The slopes of the LM- and CM-lines are related with*

$$\left\{\frac{\partial r_{t+1}}{\partial w_{t+1}}\right\}^{LM} < \left\{\frac{\partial r_{t+1}}{\partial w_{t+1}}\right\}^{CM}_{\eta=0} \tag{B-8}$$

Proof. The slope of the LM-line is given by

$$\left\{\frac{\partial r_{t+1}}{\partial w_{t+1}}\right\}^{LM} = -\frac{\frac{\partial l}{\partial w_{t+1}}}{\frac{\partial l}{\partial r_{t+1}}} \tag{B-9}$$

The slope of the CM-line is given by

$$\left\{\frac{\partial r_{t+1}}{\partial w_{t+1}}\right\}^{CM} = -\frac{\eta\frac{\partial s^W_t}{\partial w_{t+1}} - (1-\eta)\left(\frac{\partial k}{\partial w_{t+1}} - \frac{\partial s^E_t}{\partial w_{t+1}}\right)}{\eta\frac{\partial s^W_t}{\partial r_{t+1}} - (1-\eta)\left(\frac{\partial k}{\partial r_{t+1}} - \frac{\partial s^E_t}{\partial r_{t+1}}\right)} \tag{B-10}$$

[14] It suffices to consider the derivative of this gap.

Choose $\eta = 0$. We need to prove that

$$-\frac{l_w}{l_r} < -\frac{k_w - s_w^E}{k_r - s_r^E} \tag{B-11}$$

where k_w, l_w, s_w^E, k_r, l_r, and s_r^E denote derivatives of the respective functions.

This last condition is fulfilled as soon as

$$l_w k_r - l_w s_r^E > k_w l_r - s_w^E l_r \tag{B-12}$$

Consider the properties of factor demands[15]:

$$l_w = \frac{f_{kk}}{f_{kk} f_{ll} - (f_{kl})^2} < 0 \tag{B-13}$$

$$k_w = l_r = \frac{-f_{kl}}{f_{kk} f_{ll} - (f_{kl})^2} < 0 \tag{B-14}$$

$$k_r = \frac{f_{ll}}{f_{kk} f_{ll} - (f_{kl})^2} < 0 \tag{B-15}$$

Hence

$$k_w l_r - l_w k_r = \frac{(f_{lk})^2 - f_{kk} f_{ll}}{\left[f_{kk} f_{ll} - (f_{kl})^2\right]^2} < 0 \tag{B-16}$$

Combining this with $s_w^E < 0$ and $s_r^E > 0$, we obtain

$$-l_w s_r^E > k_w l_r - l_w k_r - s_w^E l_r \tag{B-17}$$

The latter inequality is true, since the left-hand side is positive and the right-hand side is negative. This proves B-12 and consequently the statement of the Lemma.

■

Proof of Proposition 6

Proof.

Assume that the economy in period τ is in the steady state equilibrium, and in period $\tau + 1$ the shock parameter takes the value of $q_{\tau+1} = q^*$. First, consider the shock impact.

1. Small shock. In both systems only one group of agents suffers from the shock: namely, the entrepreneurs of generation τ suffer from lower consumption when old.

15 The denominator $f_{kk} f_{ll} - (f_{kl})^2$ is positive due to the concavity assumption.

Social losses are

$$\Delta_{\tau+1}^{M}=\Delta_{\tau+1}^{I}=(1-\eta)\left(c_{\tau+1}^{E}-q^{*}f\left(k_{\tau+1},l_{\tau+1}\right)\right)$$

Consumption of the entrepreneurs $c_{\tau+1}^{E}$ is $c_{\tau+1}^{E}=f\left(k_{\tau+1},l_{\tau+1}\right)-r_{\tau+1}\left(k_{\tau+1}-s_{\tau}^{E}\right)-w_{\tau+1}l_{\tau+1}$, hence

$$\Delta_{\tau+1}^{M}=\Delta_{\tau+1}^{I}=(1-\eta)\left((1-q^{*})\,f\left(k_{\tau+1},l_{\tau+1}\right)-(r_{\tau+1})\left(k_{\tau+1}-s_{\tau}^{E}\right)-w_{\tau+1}l_{\tau+1}\right)$$

and the difference in social losses of the first period is zero:

$$\Delta_{\tau+1}^{M}-\Delta_{\tau+1}^{I}=0$$

Both the market economy and the intermediated one return to the steady state, and there is no welfare difference between the two intertemorally.

2. Middle-sized shock. In the market economy, entrepreneurs of generation τ are bankrupts, and their consumption in period $\tau+1$ is zero, so that their losses equal to the total planned consumption $f\left(k_{\tau+1},l_{\tau+1}\right)-r_{\tau+1}\left(k_{\tau+1}-s_{\tau}^{E}\right)-w_{\tau+1}l_{\tau+1}$. Creditors (old workers) of generation τ suffer from the insufficient loan repayments $r_{\tau+1}\left(k_{\tau+1}-s_{\tau}^{E}\right)-q^{*}f\left(k_{\tau+1},l_{\tau+1}\right)$. Young generation receives their wage payment in full and does not suffer from the shock. Social losses are in this case

$$\begin{aligned}\Delta_{\tau+1}^{M} &= (1-\eta)\left(f\left(k_{\tau+1},l_{\tau+1}\right)-r_{\tau+1}\left(k_{\tau+1}-s_{\tau}^{E}\right)-w_{\tau+1}l_{\tau+1}\right)+\\ &\quad+\eta\left(r_{\tau+1}\left(k_{\tau+1}-s_{\tau}^{E}\right)-q^{*}f\left(k_{\tau+1},l_{\tau+1}\right)\right)\end{aligned}$$

In the intermediated economy, entrepreneurs of generation τ are bankrupts and their consumption is zero. Banks experience deficits, but manage to repay all debts to depositors, so that no losses on the side of depositors occur. Social losses in period $\tau+1$ are

$$\Delta_{\tau+1}^{I}=(1-\eta)\left(f\left(k_{\tau+1},l_{\tau+1}\right)-r_{\tau+1}\left(k_{\tau+1}-s_{\tau}^{E}\right)-w_{\tau+1}l_{\tau+1}\right)$$

There are indirect losses associated with the increase in credit interest rate and decrease both in deposit interest rate and wage level, so that few next generations can not enjoy from consumption at the steady state level. But no other direct social losses occur in the shock period. With due regulation economy recovers to the stationary state.

Comparing both cases, we obtain:

$$\Delta_{\tau+1}^{M}-\Delta_{\tau+1}^{I}=\eta\left(r_{\tau+1}\left(k_{\tau+1}-s_{\tau}^{E}\right)-q^{*}f\left(k_{\tau+1},l_{\tau+1}\right)\right)>0$$

3. Severe shock. In the market economy, entrepreneurs of generation τ are bankrupts with zero consumption. Creditors (old workers) of generation τ receive zero loan repayments and their individual losses amount to $r_{\tau+1}s_{\tau}^{W}$. The young generation receives reduced wage repayments and their losses are $w_{\tau+1}l_{\tau+1}-q^{*}f\left(k_{\tau+1},l_{\tau+1}\right)$. Total social losses are in this case

$$\begin{aligned}\Delta_{\tau+1}^{M} &= (1-\eta)\left(f\left(k_{\tau+1},l_{\tau+1}\right)-\left(r_{\tau+1}\right)\left(k_{\tau+1}-s_{\tau}^{E}\right)-w_{\tau+1}l_{\tau+1}\right)+\\ &\quad +\eta r_{\tau+1}s_{\tau}^{W}+w_{\tau+1}l_{\tau+1}-q^{*}f\left(k_{\tau+1},l_{\tau+1}\right)\end{aligned}$$

In the intermediated economy, entrepreneurs of generation τ are bankrupts, and the young generation receives reduced wage repayments

$$\Delta_{\tau+1}^{M}-\Delta_{\tau+1}^{I}=0$$

Now assume that the intertemporal social welfare function implies the following social losses function ($k\in\{I,M\}$):

$$\Xi^{k}=\sum_{n=1}^{\infty}\xi_{\tau+n}\Delta_{\tau+n}^{k}$$

with τ denoting the period of the shock, $\xi_{\tau+n}$ - a weight coefficient, and $\Delta_{\tau+n}^{I}$ social losses of period $\tau+n$ computed as the difference between the social welfare in the steady state and the actual social welfare.

If we choose $\xi_{\tau}=1$ and $\xi_{\tau+n}=0$ for all $n>1$, we obtain the case of no intergenerational altruism, which would attribute better performance to the intermediated economy, since it outperforms the market economy in the period of the shock. If we choose $\xi_{\tau+n}=0$ for all $1<n\leq m$, and $\xi_{\tau+n}=1$ for all $n\geq m+1$, we obtain the case of an extreme intergenerational altruism, where the generation τ cares only about the welfare of their ancestors of degrees m and higher. In this case it would be possible to find such m that the social losses function attributes better performance to the market economy, since the market economy possesses a higher speed of convergence to the steady state.

■