A MODEL OF MORAL-HAZARD CREDIT CYCLES

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Paper:

http://home.uchicago.edu/~rmyerson/research/bankers.pdf

These notes:

http://home.uchicago.edu/~rmyerson/research/banknts.pdf

Can microeconomics of banking explain macroeconomic fluctuations?

This paper shows that efficient solutions to basic forms of moral hazard in financial intermediation have destabilizing properties which can drive macro fluctuations.
Other factors are omitted in this simple model: no money, no long-term illiquid assets, stationary nonstochastic environment.
Only agents are long-lived, with moral-hazard factors uniform over their careers.

Agents' contractual positions or wealth form the state of this dynamic system.
We find that boom-and-bust credit cycles can be dynamic equilibria of our economy.
Appreciation of relational capital during agents' careers makes the system unstable.

In such cycles, when investment is weak, a bailout or stimulus that uses poor workers' taxes to subsidize rich bankers can actually make the workers better off.
Subsidies for inefficiently supervised public investment can increase current output, even if financed by taxes on current production in the private sector.

A micro model of moral hazard in financial intermediation

At each period in an **n**-period career, a financial agent can supervise one investment of any size in some broad range (billions). Agent retires in last n+1'th period.

An investment of size h at time t will return, at time t+1, $\boldsymbol{\pi_{t+1}}$h if success, else 0, with P(succ)=$\boldsymbol{\alpha}$ if supervised appropriately, else P(succ)=$\boldsymbol{\beta}$ if wrongly, where $\alpha > \beta$.

Acting wrongly yields hidden benefits worth $\boldsymbol{\gamma}$h to agent at time t.

Risk-neutral agents discount future payoffs at rate $\boldsymbol{\rho}$ per period.

With agent's rewards v from success or w from failure at time t+1, need

$\mathbf{[\alpha v + (1-\alpha)w]/(1+\rho) \ge \gamma h + [\beta v + (1-\beta)w]/(1+\rho)}$ (*incentive constraint*),

$\mathbf{v \ge 0, \; w \ge 0}$ (*limited liability*).

The incentive constaint is equivalent to $\alpha v + (1-\alpha)w \ge w + h\alpha(1+\rho)\gamma/(\alpha-\beta)$.

Let $\mathbf{M} = \alpha(1+\rho)\gamma/(\alpha-\beta)$ denote the agent's *expected moral-hazard rent* at time t+1 per unit invested at time t.

Fact 1: To invest h at t with incentive and limited-liability constraints, the agent's minimal expected reward at t+1 is $\alpha v+(1-\alpha)w = hM$, with $v = hM/\alpha$ and w=0.

Parametric assumption: *wrongful action is never worthwhile*, $\gamma h + \beta\pi_{t+1}h/(1+\rho) < h$.

In the equilibria of our macro model, we will get $\alpha\pi_{t+1}-(1+\rho) \le M$, and so we can find α and β such that wrongful action is never worthwhile iff $\mathbf{M < 1+\rho}$.

Optimal long-term contracts in the micro moral-hazard model

Fact 1: To invest h at t, the minimal expected cost of the agent's reward at t+1 is $\alpha v + (1-\alpha)w = hM$, with rewards $\mathbf{v = hM/\alpha}$ for success and $\mathbf{w = 0}$ for failure.

Let $\mathbf{r_{t+1}} = \alpha\pi_{t+1} - (1+\rho)$ denote the rate of expected surplus returns at time t+1, per unit invested at time t.

For an agent who can invest at t,...,t+n−1. retiring at t+n, consider a **career plan** with investment $\mathbf{h_0}$=1 at t, full back-loading of rewards, full punishment of failure:

at each time t+s for $s \in \{0, ..., n-1\}$, the agent supervises $\mathbf{h_s} = h_0(1+\rho)^s/\alpha^s$ if her past investments all succeeded, but she supervises nothing after any failure;

at time t+n, the agent is paid $\mathbf{V_n} = h_0 M(1+\rho)^{n-1}/\alpha^n$ if she has n successes, else 0.

This plan matches the optimal incentive-compatible plan at each period:

if successfully supervising h_s at t+s, the agent's expected career rewards at t+s+1 will be worth $\boldsymbol{\alpha^{n-s-1}V_n/(1+\rho)^{n-s-1} = h_sM/\alpha}$ if h_s succeeds, but 0 if it fails.

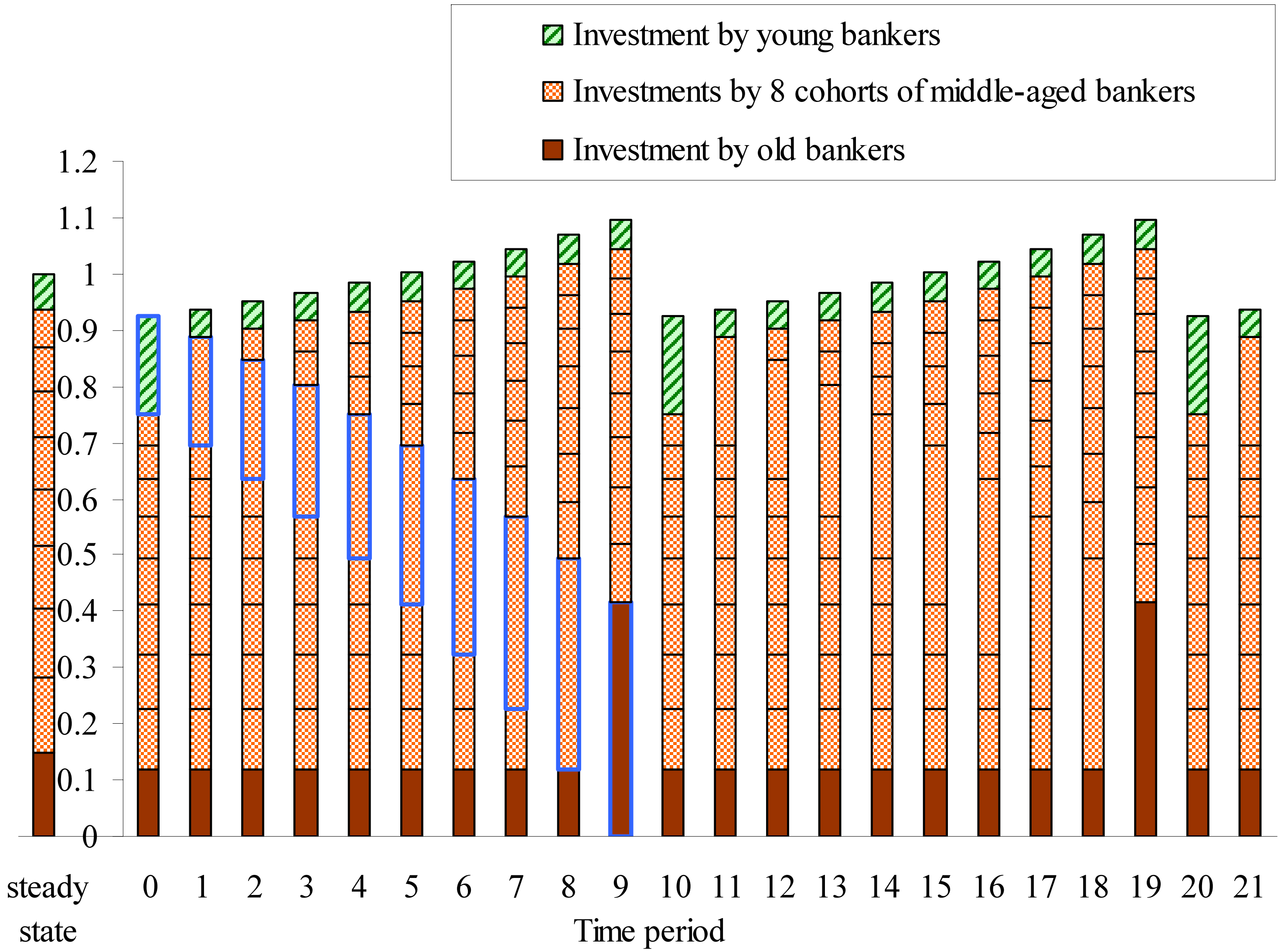
The *expected t-discounted value of investors' profits* under this plan is:

$$\sum_{s\in\{1,\ldots,n\}} \boldsymbol{\alpha^{s-1}r_{t+s}h_{s-1}/(1+\rho)^s - \alpha^n V_n/(1+\rho)^n = h_0(r_{t+1}+\ldots+r_{t+n} - M)/(1+\rho)}.$$

Facts 2-4: If $r_{t+1}+\ldots+r_{t+n} \leq M$, this plan maximizes the investors' expected value subject to incentive compatibility, limited liability, and h_0=1.

Under this plan, the agent's expected investment grows by a factor 1+ρ each period, and investors can expect to break even iff $r_{t+1}+\ldots+r_{t+n} = M$.

Preview: Investments handled by different cohorts of bankers with 10-period careers, starting with bankers investing only 80% of steady-state amounts.



(Parameters: $n=10$, $\rho=0.1$, $M=0.33$, $A=0.36$, $b=0.327$.).

Overview of the dynamic macro model

There is one commodity (grain) which can be consumed or invested for one period.

We consider an island on which investments can only be made under the supervision of a local banker. Many new young bankers are born on the island every period.

Individuals live n+1 periods, and so each banker can invest up to n periods.

Investors can form consortiums that hire bankers with long-term contracts.

Investors and bankers are risk neutral, with time discount rate ρ.

A banker who supervises an investment h at time t must expect moral-hazard rents worth Mh at time t+1. Here $M < 1+\rho$.

Expected returns to investments will depend on aggregate investment in the island according to an investment-demand function **R(•)**.

For an investment h at time t, when aggregate investment on the island is I_t, the expected return at time t+1 will be $(1+\rho + R(I_t))h$.

So the expected surplus return rate at t+1 is $r_{t+1} = R(I_t)$.

Here R is continuous and decreasing with $R(0) > M$ and $\lim_{I\to\infty} R(I) = 0$.

Global supply of funds for investment is infinitely elastic at the interest rate ρ.

If the expected sum of n future surplus rates $r_{t+1}+...+r_{t+n}$ were strictly greater than M, then investors could get strictly positive expected discounted values from hiring new young bankers under the n-period career plan described above.

So in equilibrium, we must have $r_{t+1}+...+r_{t+n} \leq M$ *at any time t.*

Equilibria of the dynamic economy

In equilibrium, we must have $r_{t+1}+\ldots+r_{t+n} \leq M$ at any time t, because global investors' elastically supplied funds cannot earn positive expected profits.

Investors will be just willing to hire new young bankers for investment at time t only when $r_{t+1}+\ldots+r_{t+n} = M$, and then only under the optimal career plan in which the agents' expected investments grow by factor $1+\rho$ each period.

Let $\mathbf{J_t}$ denote the total investments handled by new young bankers at time t.

This cohort will invest $J_t(1+\rho)^s$ at time t+s, $\forall s\in\{0,\ldots,n-1\}$, until they retire at t+n.

In **equilibrium**, we must have, at every time period $t\geq 0$:

$\mathbf{r_{t+1} = R(I_t), \quad I_t = \sum_{s\in\{0,1,\ldots,n-1\}} J_{t-s}(1+\rho)^s,}$

$\mathbf{\sum_{s\in\{1,\ldots,n\}} r_{t+s} \leq M \;\text{ and }\; J_t \geq 0, \;\text{ with }\; \sum_{s\in\{1,\ldots,n\}} r_{t+s} = M \;\text{ if }\; J_t > 0.}$

Initial conditions at time 0 are specified by the given contractual responsibilities of n−1 cohorts of midcareer bankers: $\mathbf{\theta_s = J_{-s}(1+\rho)^s \;\; \forall s\in\{1,\ldots,n-1\}}$.

An equilibrium cannot have $J_t=0$ at all $t\in\{0,\ldots,n-1\}$ (else get $I_{n-1}=0$, $r_n=R(0)>M$).

When $J_t>0$ and $J_{t+1}>0$, we get $r_{t+1} + r_{t+2}+\ldots+r_{t+n} = M = r_{t+2}+\ldots+r_{t+n} + r_{t+1+n}$, and so $r_{t+1} = r_{t+1+n}$.

Fact 5: In any equilibrium, $\exists T\leq n-1$ such that $\sum_{s\in\{1,\ldots,n\}} r_{t+s} = M$ for all $t\geq T$.

If $T>0$ then $J_t=0$ for all $0\leq t<T$.

Surplus rates then cycle $r_{t+1} = r_{t+1+n}$ for all $t\geq T$.

General properties of equilibria

Fact 5: In any equilibrium, $\exists T \leq n-1$ such that $\sum_{s\in\{1,\ldots,n\}} r_{t+s} = M$ for all $t \geq T$.
If $T>0$, $J_t=0$ for all $0 \leq t<T$. Surplus rates then cycle $r_{t+1} = r_{t+1+n}$ for all $t \geq T$.

The cohort-decomposition of investment implies $(1+\rho)I_t - I_{t+1} = (1+\rho)^n J_{t+1-n} - J_{t+1}$.
So in a cyclical equilibrium with $J_{t+1} = J_{t+1-n}$, we must have

$J_{t+1} = [(1+\rho)I_t - I_{t+1}]/[(1+\rho)^n - 1] \geq 0.$

Thus equilibrium growth rates are bounded above, $I_{t+1} \leq (1+\rho)I_t$,.

Fact 6: For any $(r_1,\ldots, r_n)$, a cyclical equilibrium with $r_{t+1+n} = r_{t+1}$ $\forall t \geq 0$ can exist iff:
$\mathbf{r_1 \geq 0, \ldots, r_n \geq 0}$, and $\mathbf{r_1+\ldots+r_n = M}$,
and there are corresponding investment levels $(I_0,I_1,I_2,\ldots)$ such that
$r_{t+1} = R(I_t)$, $I_{t+n} = I_t$, and $\mathbf{I_{t+1} \leq (1+\rho)I_t}$ for all $t \geq 0$.

Fact 7. For any given initial conditions $(J_{-1}, \ldots, J_{-(n-1)})$, an equilibrium exists.

Fact 8. In a steady-state equilibrium, the surplus return rate r and aggregate investment I always satisfy $r = M/n = R(I)$.
This steady-state equilibrium applies when the initial conditions are
$J_{-1} = J_{-2} = \ldots = J_{-(n-1)} = \rho I/[(1+\rho)^n-1]$.
The economy has no tendency toward steady state from other initial conditions.
(With risk-averse agents, the steady state can become locally unstable...)

Interpreting the investment-demand function

The downward slope of the investment-demand function R indicates increasing costs to investors that can yield income and utility to other economic agents.

For example, consider a linear function of the form $R(I) = \max\{A-bI, 0\}$.

With any $I \leq A/b$, the cost bI may be interpreted as wages for workers.

Suppose an investment I_t at time t requires labor for harvesting at time t+1, and the **workers' total cost of effort in harvesting $\mathbf{I_t}$ is $\mathbf{0.5bI_t^2}$.**

Then in a competitive labor market, investors' cost rate for harvest labor at t+1 would be the workers' marginal cost rate $\mathbf{w_{t+1} = bI_t}$.

So total wage income would be $W_{t+1} = w_{t+1}I_t = bI_t^2$.

Workers' total utility of employment, after subtracting their cost of effort, would be $\mathbf{w_{t+1}I_t - 0.5bI_t^2 = 0.5W_{t+1}}$.

Consider any case where $R(I) = 0$ when $I \geq I^*$, for some I^*. (Above, $I^*=A/b$.)

In any period when $R(I_t) = 0$, we may suppose that investors would limit actual investment in this island to I^*, and the surplus funds $I_t - I^*$ would be invested by their bankers in a global bond market at the risk-free interest rate ρ.

For mid-career bankers handling such risk-free bonds, there would be no question of success or failure; but their investment responsibilities and their promised rewards for past successes would simply grow by the factor $1+\rho$ next period.

An example

Consider discount rate $\rho = 0.1$, moral-hazard rent coefficient $M = 0.33$,
investment-demand function $R(I) = \max\{0, A - bI\} = \max\{0, 0.36 - 0.327\, I\}$.
(M can be derived from $\alpha = 0.95$, $\beta = 0.57$, $\gamma = 0.12$.)

Steady states depend on career length n as follows:

surplus rate $r = M/n = 0.33/n$,
investment $I = (A-r)/b = 1.10-1.01/n$,
interest on investment $\rho I = 0.110-0.101/n$,
banking surplus $rI = 0.363/n - 0.333/n^2$.
total wages $W = bI^2 = 0.396 - 0.727/n + 0.333/n^2$.

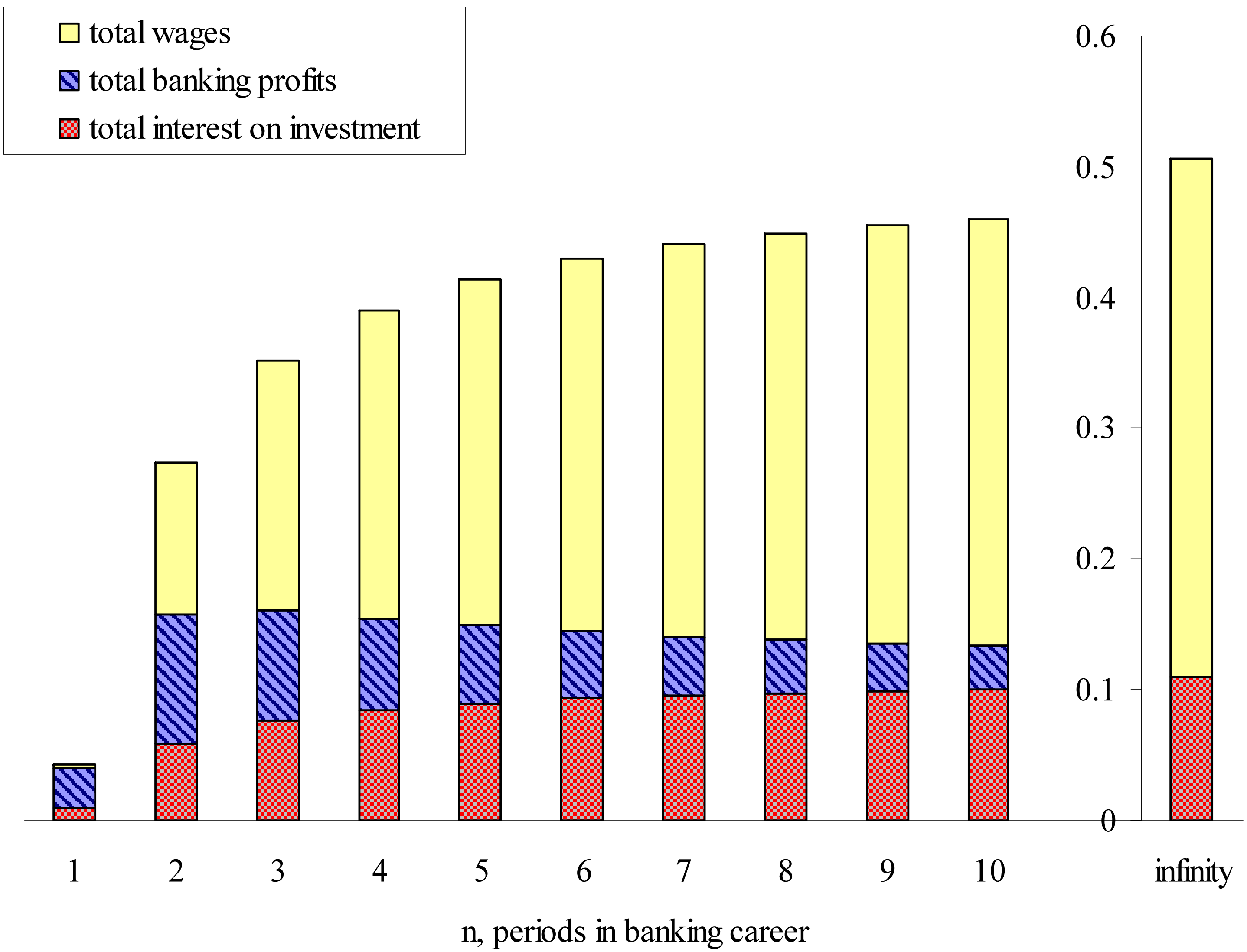
(See Figure 1.)

When $n=10$, steady state $r = 0.033$, $I = 1$, $W = 0.327$.
Each period, new young bankers supervise $J = \rho I/[(1+\rho)^{10}-1] = 0.063$.
With $\Theta_s = J(1+\rho)^s$, investments by older age cohorts are:

$$(\Theta_1,\ldots,\Theta_9) = (0.069, 0.076, 0.084, 0.092, 0.101, 0.111, 0.122, 0.135, 0.148).$$

This state vector reproduces itself, uniquely in $\mathbb{R}^{n-1}$.

Figure 1. Output shares in steady state, with $\rho=0.1$, $M=0.33$, $A=0.36$, $b=0.327$. (*Differences resemble those of development.*)



Example: dynamics of a financial crisis

At any time t, the aggregate investments $\theta_s(t) = J_{t-s}(1+\rho)^s$ handled by bankers of ages s=1,...,n−1 define inherited the state of the economy.

Consider the above example with n=10, with bankers of ages 1 to 9 handling time-0 investments θ_s that are 80% of the steady-state values Θ_s:
$(\theta_1,...,\theta_9) = (0.055, 0.061, 0.067, 0.073, 0.081, 0.089, 0.098, 0.108, 0.118)$.

The resulting 10-period equilibrium credit cycle is shown in Figure 2 below.

A large cohort of young bankers enter to invest $J_0 = 0.176$, with $r_1=0.057$, but time-1 output is 7.5% below steady state, wage income is 14% below.

In the shadow of J_0, subsequent cohorts of young bankers are smaller: $J_t = 0.050$.

The economy gradually grows, just reaching steady-state output at time 6.

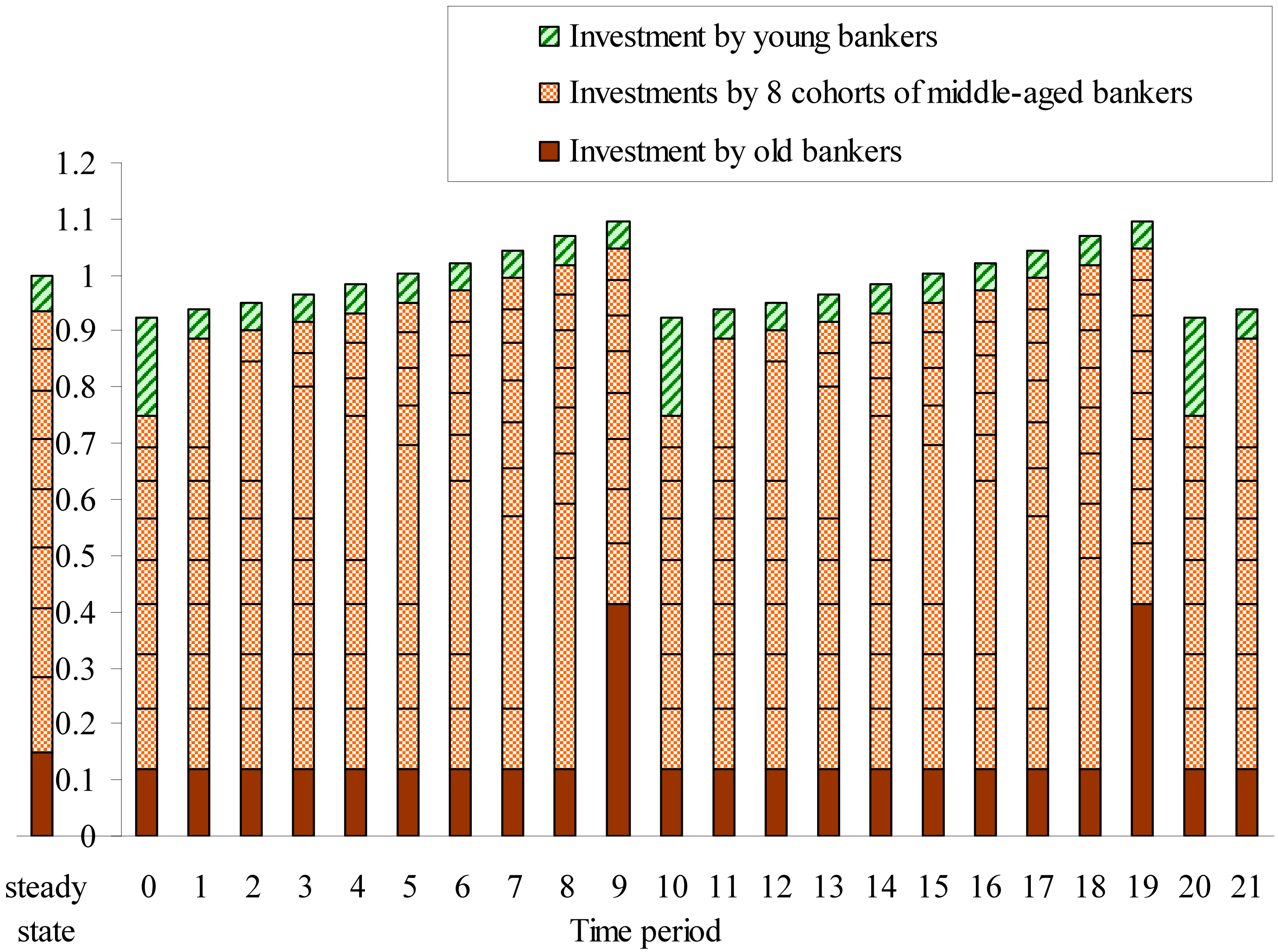
Thereafter, growing investments of the large generation-0 bankers put the economy into a boom, reaching peak at time 10, when output 9.6% is above steady state, wage income is 20% above steady state, and $r_{10} =0.0016$.

At time 10, the generation-0 bankers retire to consume their moral-hazard rents, thus creating a scarcity of investment intermediaries and a recession as at time 0.

(See Figure 2.)

In steady state: $r=0.033$, $I = 1$, $J=0.063$, $W=0.327$,
$(\Theta_1,...,\Theta_9) = (0.069, 0.076, 0.084, 0.092, 0.101, 0.111, 0.122, 0.135, 0.148)$.

Figure 2. Investments handled by different cohorts of bankers over a 10-period cycle, with continuing bankers' investments at time 0 being 80% of steady state. (Parameters: $n=10$, $\rho=0.1$, $M=0.33$, $R(I)= \max\{0, 0.36 - 0.327\, I\}$.)



Benefits of bank bailouts for macroeconomic stabilization

To reach steady-state stability in this example, investments by mid-career bankers of each age s from 1 to 9 must be increased from the given $\theta_s=0.8\Theta_s$ to Θ_s.

But new investments for age-s bankers need a **subsidy** to cover their expected loss $(\Theta_s-\theta_s)[M-(n-s)r]/(1+\rho) = (\Theta_s-\theta_s)(sM/n)/(1+\rho)$.

Summing this over s from 1 to 9, the total subsidy required at time 0 is 0.032.

This subsidy could be financed by bonds that are repaid by 0.035 in taxes at time 1.

The cost of this subsidy is less than the increase in wage income 0.327–0.280 = 0.047 that the workers would get from the stabilization at time 1.

Utility gains are only half of wage gains, but wage gains continue 5 periods.

At time 1, discounted values of future **utility gains** from stabilization for workers who have 1 to 10 periods of employment remaining are respectively: (0.0023, 0.0041, 0.0054, 0.0062, 0.0066, 0.0065, 0.0061, 0.0053, 0.0042, 0.0029).

Middle-aged workers gain the most here. Old workers have less future time to gain, and stabilization eliminates benefits of a future boom for young workers.

Aggregating, we find that time-1 workers' total long-run utility gains from stabilization (0.049) exceed its cost (0.035) here.

Effects of a small short-term balanced fiscal stimulus

A more realistic stimulus would subsidize investment by short-term intermediaries that is financed by taxes on output.

Short-term financial agents are less efficient and thus require a subsidy, but they increase production now and will not compete in future banking.

In our model, subsidized investment with such inefficient short-term supervision may be called *Keynesian*.

Even when this Keynesian investment is financed by taxes on the output of current investment, the net effect can be to increase current investment.

In the above example, a tax rate $\tau = 0.015$ (on output at time 1, per unit invested at time 0) would decrease J_0 but would finance more Keynesian investment, for a net increase of investment at time 0 (6.6% below steady state, instead of 7.5%).

Then next period J_1 would increase by the same amount that J_0 decreased.

Peak investment at period 9 would be 8.7% above steady state (instead of 9.6%).

Equations. Given $(J_{-1}, \ldots, J_{-(n-1)})$:

$I_0 = \sum_{s \in \{0,1,\ldots,n-1\}} J_{-s}(1+\rho)^s$, $(M - r_1)K_0 = \tau I_0$, $r_1 = R(K_0 + I_0)$,

$(r_1 - \tau) + r_2 + \ldots + r_n = M = r_2 + \ldots + r_n + r_{n+1}$,

$\forall t \geq 2$: $r_t = R(I_{t-1})$, $I_{t-1} = \sum_{s \in \{1,2,\ldots,n\}} J_{t-s}(1+\rho)^{s-1}$, $J_t = J_{t-n}$, $\sum_{s \in \{1,2,\ldots,n\}} r_{t+s} = M$.

Figure 3. Investments supervised by cohorts of bankers, with continuing bankers' investments at time 0 being 80% of steady state, but with a short-term balanced fiscal stimulus at time 0 with tax rate $\tau = 0.015$. (Same parameters as Figure 2.)

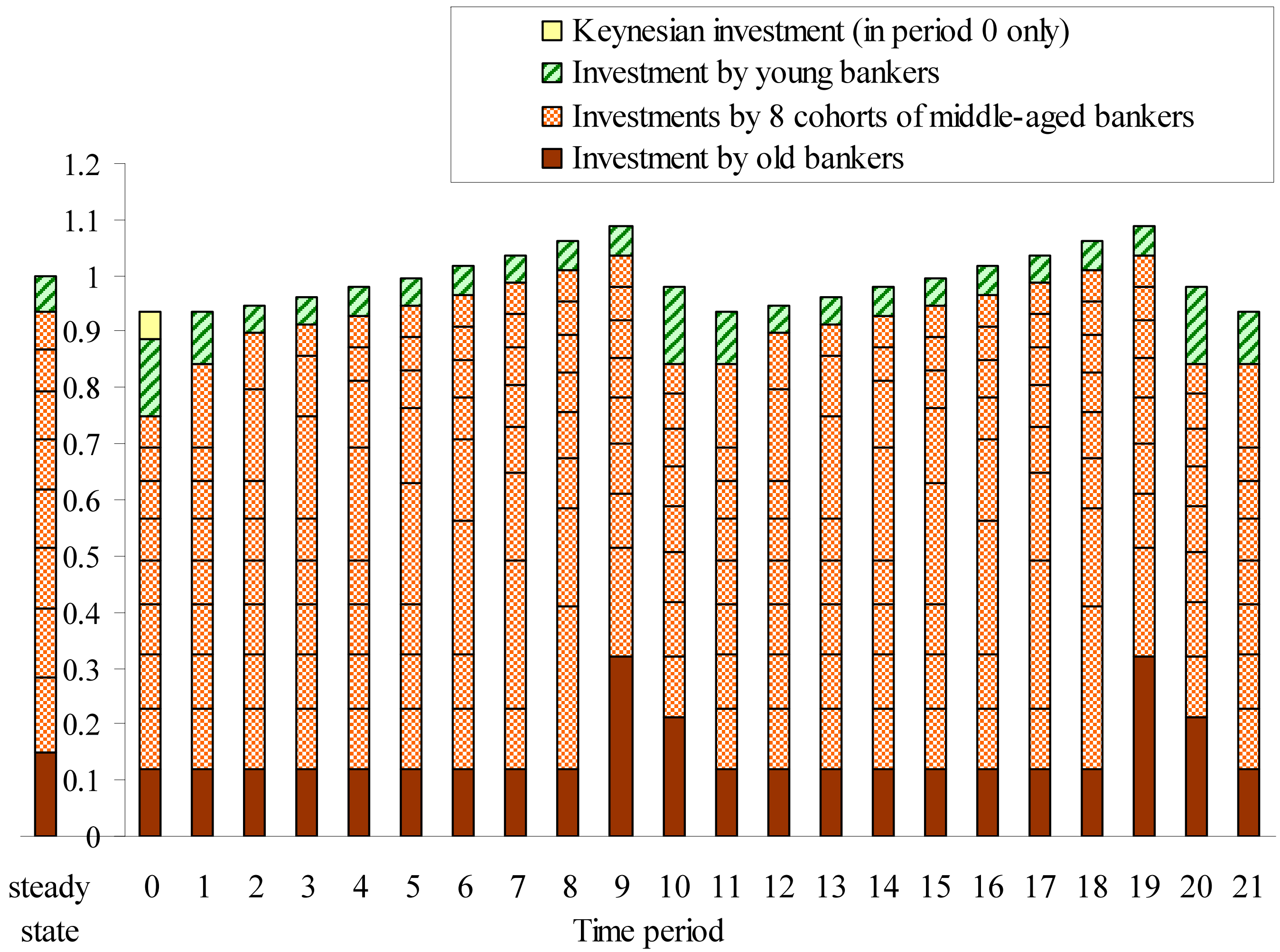
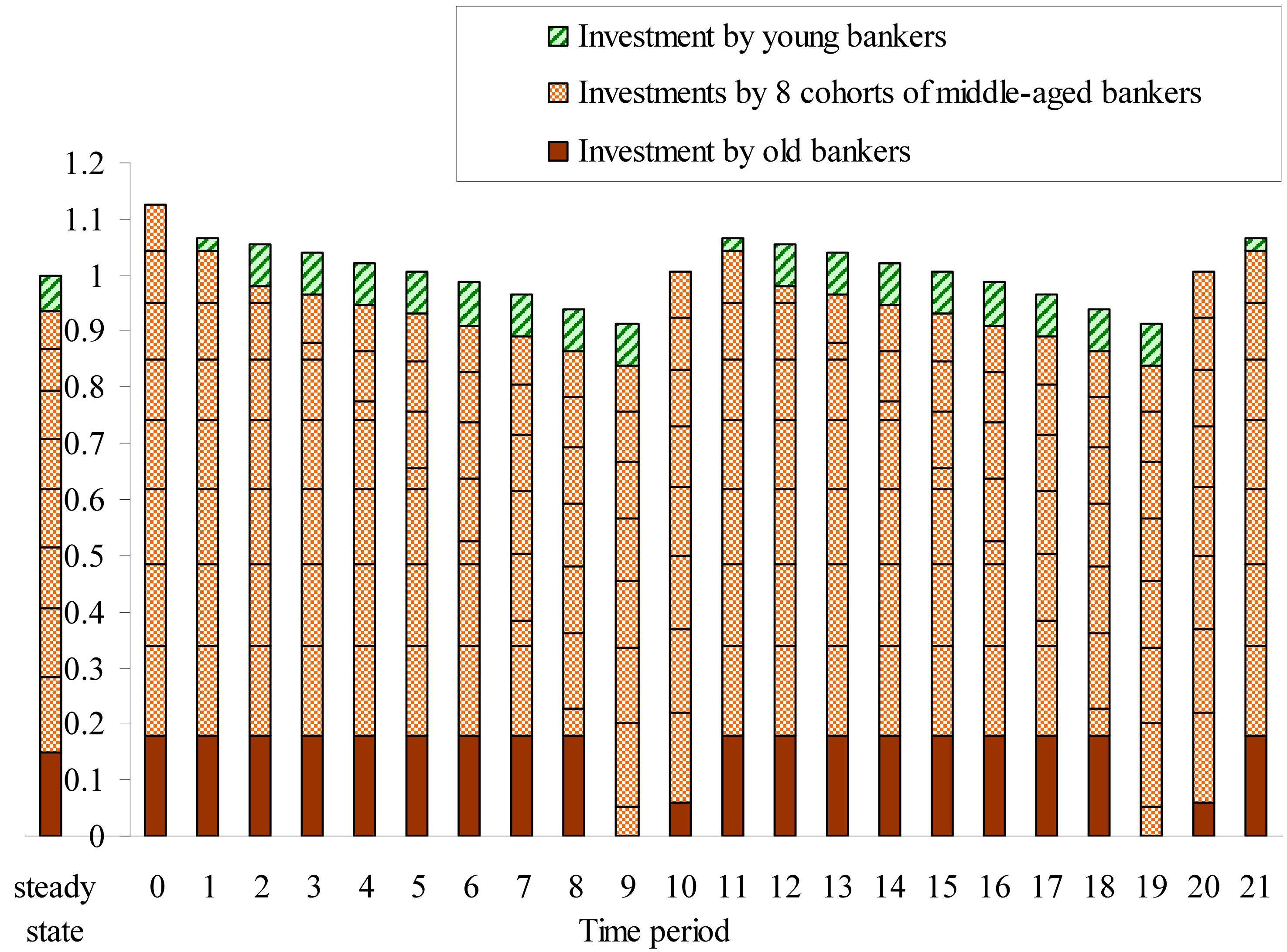


Figure 4. Investments handled by cohorts of bankers, with continuing bankers' investments at time 0 being 120% of steady state. (Same parameters as Figure 2.) High investment at time 0 is not repeated (*zombie banks*); the cycle begins at time 1.



The problem of liquidity for investors

If investors at time t+s hired an older banker who could serve only n−s periods, and they initially invested h_s, then their expected discounted value would be at most $h_s(r_{t+s+1}+\ldots+r_{t+n} - M)/(1+\rho) < 0$ with $s > 0$ and $r_{t+1} > 0$.

Thus, although all investments are short (1-period), we find a kind of illiquidity: in equilibrium, investors need long n-period relationships with bankers.

But with regulation, these equilibria can be also implemented by a system where bankers accumulate capital and invest under age-dependent leverage constraints.

To invest h_s at time t+s, with voluntary short-term participation by outside invstors, a banker of age s must contribute capital $k_s = h_s[M - (r_{t+s+1}+\ldots+r_{t+n})]/(1+\rho)$.

The expected normal returns to investors in the next period must be $(h_s-k_s)(1+\rho)$, and so the expected total capital for the banker at time t+s+1 would be

$$k_{s+1} = (1+\rho + r_{t+s+1})h_s - (h_s - k_s)(1+\rho) = k_s(1+\rho) + r_{t+s+1}h_s$$
$$= h_s[M - (r_{t+s+2} + \ldots + r_{t+n})].$$

This is exactly what is needed to finance $h_{s+1} = h_s(1+\rho)$ at time t+s+1 with the age-dependent required capital ratio $\mathbf{k_{s+1}/h_{s+1} = [M - (r_{t+s+2}+\ldots+r_{t+n})]/(1+\rho)}$.

Regulation may be needed to ensure that bankers hold the required capital, and that capital must not include any hidden benefits (γh) from wrongful supervision.

Higher rates of return on legitimate capital then motivate appropriate behavior, even at age s=0 when the required capital is $k_0/h_0 = [M - (r_{t+1}+\ldots+r_{t+n})]/(1+\rho) = 0$.

Conclusions

Because of financial moral hazard, bankers need long-term relationships with investors, and these relationships can create complex macroeconomic dynamics.

In the recessions of our model, productive investment is reduced by a scarcity of trusted financial intermediaries.

Competitive recruitment of new bankers cannot fully remedy such undersupply, because bankers can be efficiently hired only with long-term contracts in which their responsibilities are expected to grow during their careers.

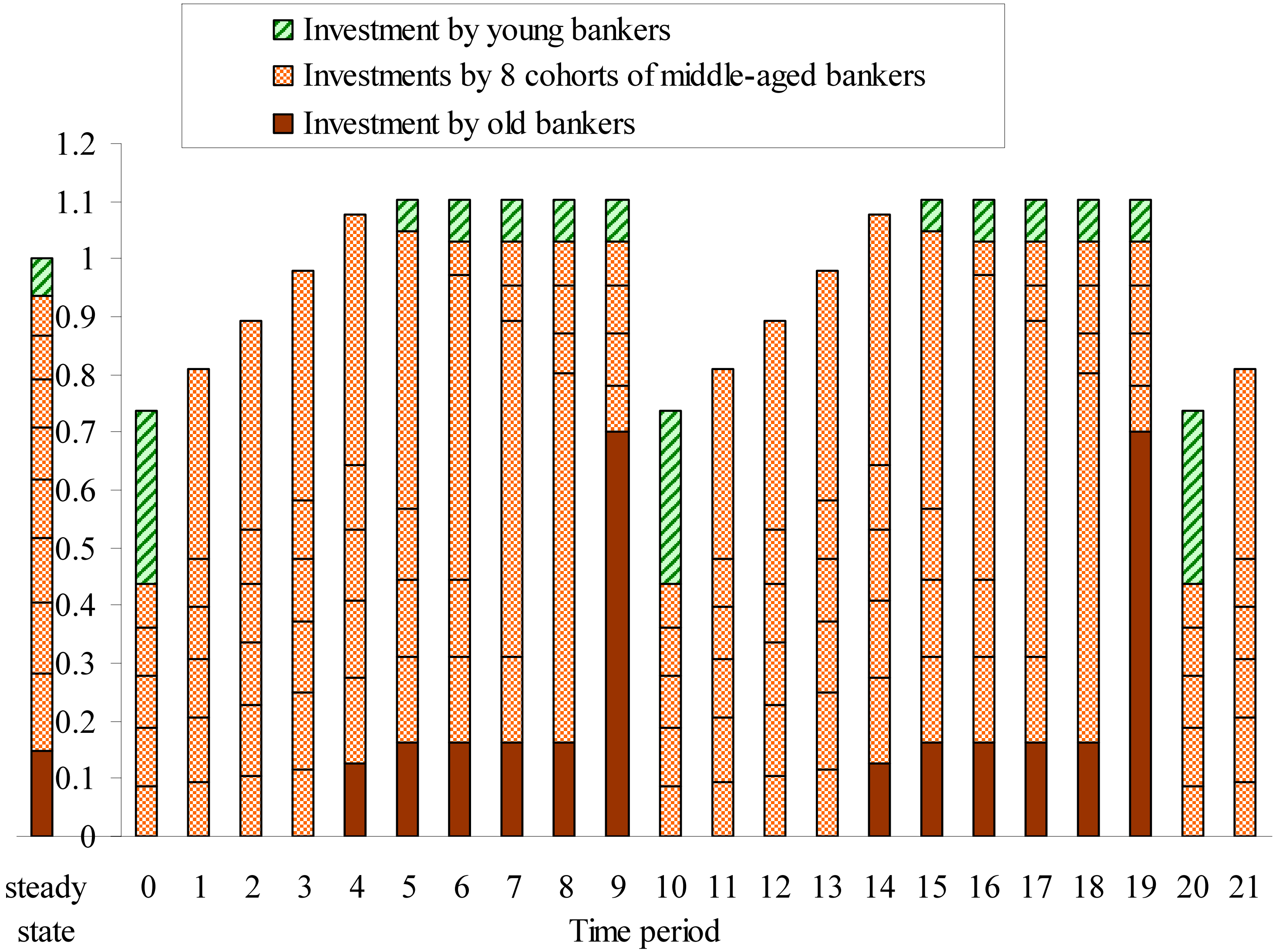
So a large adjustment to reach steady-state financial capacity in one period would create oversupply in future periods.

Thus, a financial recovery must move gradually uphill into the next boom, which in turn contains the seeds of the next recession.

A tax on workers to subsidize bankers may benefit workers by more than the tax, but some of the workers' gains are at the expense of past long-term investors.

http://home.uchicago.edu/~rmyerson/research/banknts.pdf

Figure 5. An equilibrium with the worst possible recessions for the economy with parameters n=10, ρ=0.1, M=0.33, A=0.36, b=0.327 .



Additional model: agents are risk neutral, have 2-period careers, but the agents' discount factor δ_1 is different from outside investors' discount factor δ_0.

With limited liability, risk-neutral agents' rewards will be fully back-loaded after two successes, and so the expected growth of agents' responsibilities is $G = 1/\delta_1$.

This corner solution to the agency problem does not depend on the investors' expected profit rates p_t in a neighborhood of the steady state p*.

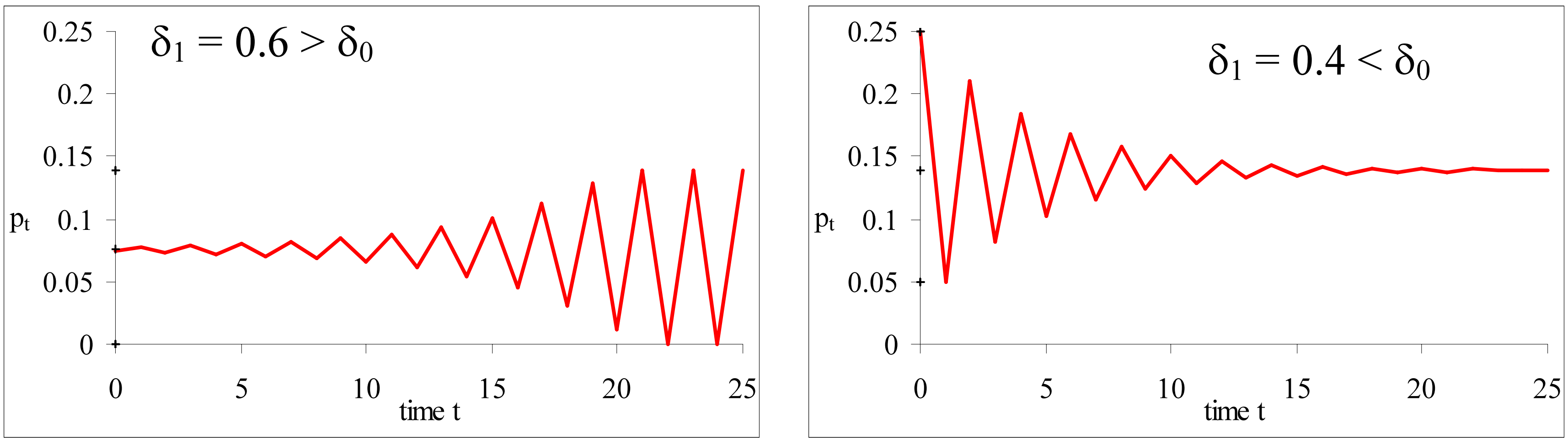
In equilibrium, the 0-profit condition for investors to hire new agents at period t yields $p_t + \delta_0 G p_{t+1} = p^* + \delta_0 G p^*$, which implies $p_{t+1} - p^* = -(\delta_1/\delta_0)(p_t - p^*)$.

Thus, we get constant cycling of returns p_t around the steady state t* if $\delta_1 = \delta_0$.

Deviations of p_t from p* tend to shrink over time if $\delta_1 < \delta_0$.

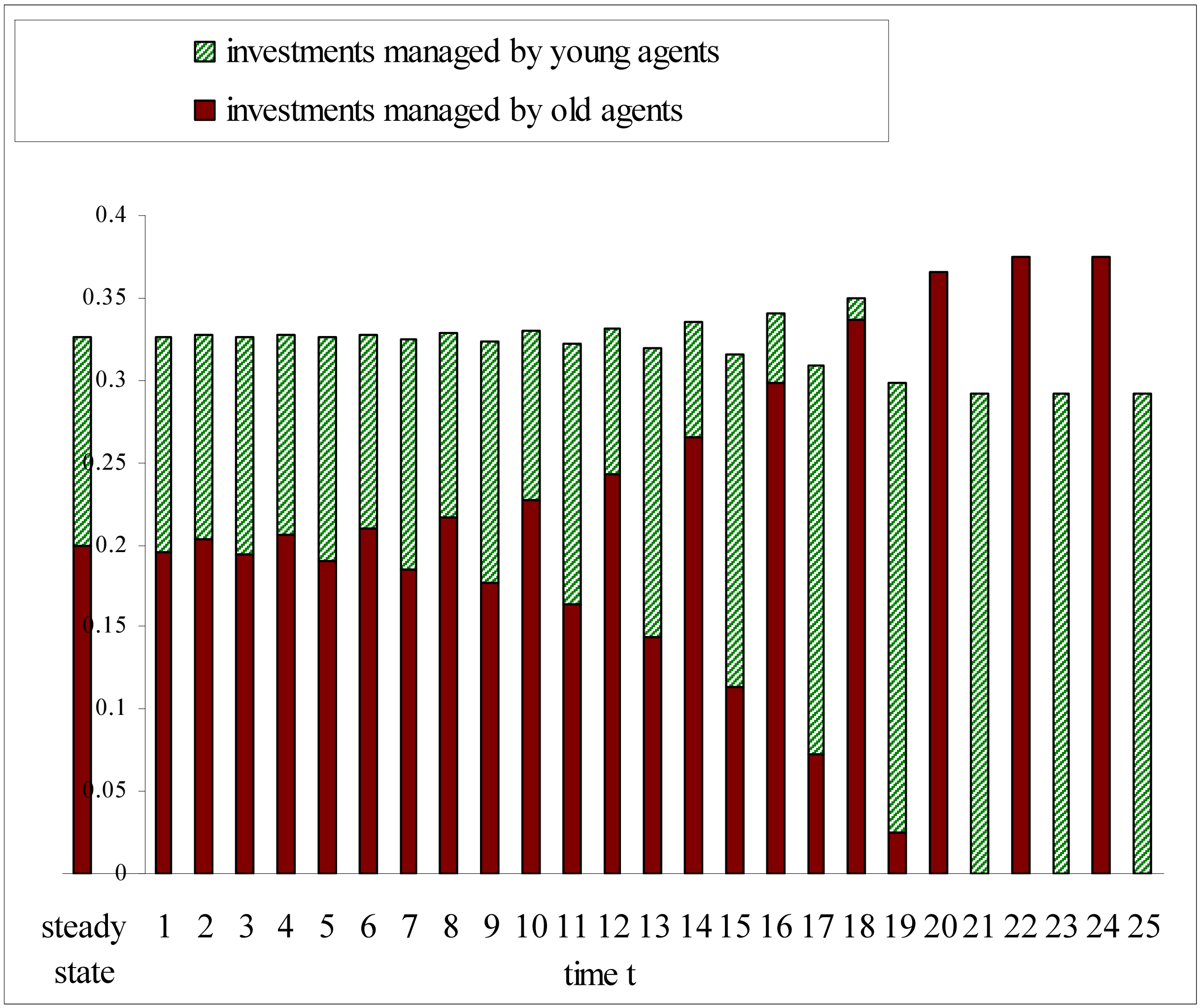
If $\delta_1 > \delta_0$, deviations from p* grow as long as new agents are hired each period.

With δ_0=0.5, α=0.5, β=0, γ=0.2, I(p)=0.5−p, p_t-dynamics depend on δ_1:



Risk aversion decreases agents' responsibility growth below $1/\delta_0$, like $\delta_1 > \delta_0$.

Figure 6. With risk aversion ($u_t = c_t^{0.5}$), development of generational inequalities between investments managed by young agents J_t and old agents $I_t – J_t$ over time. (Parameters: δ=0.5, α=0.5, β=0, γ = 0.2, R(I) = 0.5–I.) http://home.uchicago.edu/~rmyerson/research/rabankers.pdf



Compare to Preview:

The usual assumptions about depreciation of capital do not yield such instability.
(Here capital depreciates 10% per year, scrapped after 10; initial 20% shortage.)