Endogenous Credit and Investment Cycles with Asset Price Volatility

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Question

- ▶ Can credit market frictions be a source of aggregate fluctuations?
 - ▶ Financial sector perturbations vs. amplifications
- ▶ We study the influence of limited commitment on the emergence of indeterminacy and sunspots.
 - ▶ With limited commitment asset prices can jump to accommodate for changes in expectations.
 - ▶ Fluctuations in macroeconomic outcomes and asset prices are tied to aggregate shifts in market expectations.

The Environment

- ▶ $t = 1, 2, \dots$
- ▶ Two goods: capital good, consumption good.
- ▶ Each period :
 - Perfectly Competitive sector $Y_t = F(K_t, L_t)$, where F linearly homogeneous.
 - Capital used in production fully depreciates.
 - New capital is produced,
- ▶ Consumption is non storable

Agents and endowments

- ▶ 2 types of agents: $\begin{cases} \alpha & \text{workers} \\ 1 - \alpha & \text{entrepreneurs} \end{cases}$

- ▶ Workers

- 1 unit of time in day and work for the representative firm receiving a wage w_t .

- ▶ Entrepreneurs

- No time (Don't work)
 - Capital producing technology

$$\underbrace{x_t}_{\text{time } t \text{ consumption}} \rightarrow \underbrace{(x_t)^\nu}_{\text{time } t+1 \text{ capital}}$$

- ▶ Assume $1 > \nu > 0$.
- ▶ Workers can not operate this technology but buy claims on next period capital.

Credit markets

Every period, a *competitive* credit market opens.

- ▶ Entrepreneurs and workers can trade claims (bonds) on future capital
- ▶ q_t price of each bond: consumption goods needed at time t to purchase a claim on 1 unit of capital at time $t + 1$
- ▶ k_{t+1}^W and k_{t+1}^E denote workers and entrepreneurs net demand for bonds
- ▶ Limited commitment: entrepreneurs can repudiate their debt and divert resources from their investment technology.

Workers problem

- Recursive formulation of worker's problem:

$$U_t(k_t^W) = \max_{(c_t^W, k_{t+1}^W)} \log(c_t^W) + \beta E_t \left[U_{t+1}(k_{t+1}^W) \right]$$
$$s.t. \quad c_t^W + q_t k_{t+1}^W = w_t + r_t k_t^W$$

Entrepreneur's limited commitment

- ▶ Entrepreneurs can divert resources and consume after credit market closes
- ▶ Hidden consumption yields $(1 - \theta)$ utility for each unit of consumption
- ▶ Upon default, assume perpetual exclusion from credit markets.
- ▶ Entrepreneurs deviation payoff:

$$\tilde{V}_t(s_t^E, k_{t+1}^E)$$

Entrepreneur's problem

- Recursive formulation of entrepreneur's problem:

$$\begin{aligned} V_t(k_t^E, x_{t-1}) = & \max_{(c_t^E, x_t, k_{t+1}^E) \in \mathfrak{R}_+^2 \times \mathfrak{R}} & c_t^E + \gamma E_t \left[V_{t+1}(k_{t+1}^E, x_t) \right] \\ \text{s.t.} & & c_t^E + q_t k_{t+1}^E + x_t = r_t [x_{t-1}^v + k_t^E] \\ & & q_t k_{t+1}^E + x_t \geq 0 \\ & & \gamma E_t \left[V_{t+1}(k_{t+1}^E, x_t) \right] \geq \tilde{V}_t(S_t^E, k_{t+1}^E) \end{aligned}$$

Equilibrium

Definition

An equilibrium with limited commitment consists in sequences $(c_t^W, k_{t+1}^W)_{t=0}^\infty$, $(c_t^E, k_{t+1}^E, x_t)_{t=0}^\infty$, $(q_t, r_t, w_t)_{t=0}^\infty$ such that

- ▶ $(c_t^W, k_{t+1}^W)_{t=0}^\infty$ and $(c_t^E, k_{t+1}^E, x_t)_{t=0}^\infty$ solve workers and entrepreneurs problem respectively;
- ▶ Capital and labor earn their marginal product;
- ▶ Credit market clears

$$\alpha k_{t+1}^W + (1 - \alpha)k_{t+1}^E = 0$$

- ▶ Capital evolves according with

$$K_{t+1} = (1 - \alpha)x_t^v$$

Stationary Equilibria

- ▶ Workers and entrepreneurs trade bonds
 - ▶ No default constraint is slack, and $S^E = 0$. ▶ FB
 - ▶ No default constraint binds, and $S^E = 0$. ▶ BNC
 - ▶ No default constraint binds, and $S^E > 0$. ▶ BC
- ▶ Workers and entrepreneurs do not trade bonds, and $S_t^E > 0$. ▶ NB

Stationary equilibria

First Best Local Dynamics

- ▶ The price of new capital is a function of x_t :

$$q_t \equiv q[x_t] = \frac{1}{\nu x_t^{\nu-1}}$$

- ▶ In the end, the dynamics of the system in the first best are:

$$\begin{aligned}\frac{E_t(c_{t+1}^W)}{c_t^W} &= \frac{\beta f'(z[x_t])}{q[x_t]} \\ c_t^W + q[x_t]k_W[x_t] &= f(z[x_{t-1}]) - z[x_{t-1}]f'(z[x_{t-1}]) \\ &\quad + f'(z[x_{t-1}])k_W[x_{t-1}]\end{aligned}$$

- ▶ Investment is a predetermined variable, consumption is a non-predetermined variable.
- ▶ Only if the steady state is a sink, we will have indeterminacy.

First Best System Local Dynamics

Proposition

If the no default constraint is slack, the stationary equilibrium with bonds is a saddle.

Corollary

There is a unique convergent path to the steady state. The dynamic model is locally determinate, so that endogenous fluctuations do not emerge.

Local dynamics with a binding no-default constraint, bonds, and $S^E = 0$

- Investment is now pinned down by a forward looking no-default constraint:

$$(1 - \theta)x_t = E_t\{\gamma c_{t+1}^E + \gamma(1 - \theta)x_{t+1}\}$$

and the price is no-longer linked to fundamentals

$$q_t = q_t(c_{t+1}^W, x_t, x_{t+1})$$

Dynamical System

- We finally obtain

$$(1 - \theta)x_t = E_t \left\{ \gamma r(x_t) \left[x_t^v - \frac{\alpha}{1 - \alpha} \frac{c_{t+1}^W + \frac{1-\alpha}{\alpha} x_{t+1} - w(x_t)}{r(x_t)} \right] + \gamma(1 - \theta)x_{t+1} \right\}$$
$$E_t \left\{ \frac{c_{t+1}^W}{c_t^W} - \frac{\beta \alpha \left[c_{t+1}^W + \frac{1-\alpha}{\alpha} x_{t+1} - w_{t+1}[x_t] \right]}{(1 - \alpha)x_t} \right\} = 0$$

- Both consumption and investment are non-predetermined variables.

Local dynamics with a binding no-default constraint,
bonds, and $S^E = 0$

Proposition

Assume that $\gamma \geq \min\{s, (1 - \theta)\beta\}$. Then the limited commitment steady state with bonds and no collateral is a saddle.

Corollary

The limited commitment steady state with bonds and no collateral is always locally indeterminate.

Idea

- ▶ There are an infinite number of combinations of initial values for both state variables such that
 - ▶ The system is on the stable arm,
 - ▶ The system will always converge to the steady state.
- ▶ Given an initial value x_0 , investment converges to a unique steady state x_{BNC} and consumption to c_{BNC}^W .
- ▶ However sunspots matter

Sunspot equilibria

- ▶ Starting from the steady state, a forecasting error hits the economy.
- ▶ x and c are tied by so that the economy comes back to the stable arm, guaranteeing convergence to the steady state.
- ▶ Stochastic bounded equilibrium trajectories driven by expectations shocks are possible when the steady state is a saddle.

Sunspot equilibria

- ▶ Add forecasting errors $e_{t+1} = \tilde{x}_{t+1} - E_t(\tilde{x}_{t+1})$, with $E_t(e_{t+1}) = 0$
- ▶ Local sunspot equilibria can be obtained by considering that e_{t+1} follows an i.i.d. stochastic process of bounded support with small variance

Simulation Exercise

Parameter	Value
β	0.99
γ	0.92
σ	2.5
s	0.33
θ	0.60
ν	0.98
σ_e	0.0185

- ▶ Sunspot shocks $\mathcal{N}(0, \sigma_e)$ i.i.d.
- ▶ σ_e chosen to match variance in consumption growth

Findings

- ▶ 500 draws of σ_e^t , compute average standard deviation of series.
- ▶ $\sigma_x > \sigma_{c^w}$: Investment more volatile than consumption
- ▶ $\sigma_x > 3.1 \cdot \sigma_y$: Investment more volatile than output
- ▶ Changes in marginal productivity make r countercyclical, w pro cyclical.
- ▶ $\sigma_{k^w} = 2.65 \cdot \sigma_x$

Simulated Series

Volatility of q_t

- ▶ $\sigma_q = 8.05 \cdot \sigma_y$
- ▶ Because $\nu \approx 1$, without limited commitment

$$q_t^{FB} = \frac{1}{\nu x^{\nu-1}} \approx 1$$

- ▶ All the variability comes from the binding no-default constraint.
- ▶ Moody's BAA Corporate Bond Yield index: $\sigma_q = 5.37 \cdot \sigma_y$

Simulated Series

Conclusions

- ▶ Developed a framework to study dynamics in lending, production, and investment, with capital and limited commitment.
- ▶ With perfect credit markets, prices are pinned down by technology.
- ▶ With limited commitment
 - ▶ Prices no longer pinned down by technology, but depend on expectations of future market conditions.

Conclusions

Limited commitment introduces the possibility of

- ▶ Indeterminacy
- ▶ Endogenous fluctuations in credit, investment etc, driven by self fulfilling prophecies.
- ▶ Bond price volatility, consistent with data, in response to shifts in expectations.

Conclusions

Policy recommendations?

- ▶ Changes in ν and θ can move the economy away from the indeterminacy region.
- ▶ What policy parameters can influence ν and θ ?