Lecture: Fire Sales, Deleveraging and Asset Markets

Advanced Macroeconomics

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Introduction:

- So Far: Borrowing constraints and investment
- But no mention of asset prices
- The same mechanism that constrains investment demand also reduces asset prices
- Moreover with debt financing, asset prices create powerful feedback effects

This lecture: fire-sales, deleveraging and the asset market feedback

Asset price reactions typically exacerbate crises through the net worth channel:

- During severe crises, asset prices typically fall and this increases the distress

- Many observers emphasize **asset market feedback:**

Debt financing + Lower asset prices

$\Rightarrow$ Losses for potential investors,

$\Rightarrow$ Lower net worth and asset demand by potential investors

$\Rightarrow$ **Further reduction in prices**

$\Rightarrow$ Further reduction in net worth

$\Longrightarrow$ ...

This mechanism raises deeper questions about asset pricing

- For this mechanism to work, asset prices must respond to the distribution of net worth (in particular, the net worth of potential investors).
- Not consistent with the standard (representative consumer) asset pricing theory. Need an alternative.

Today's Plan:

- Introduction to asset fire sales (Shleifer and Vishny (1992) "Liquidation values…" Journal of Finance)
- Fire sales, investment and deleveraging (Kiyotaki and Moore (1997) "Credit cycles" JPE)

Shleifer and Vishny (1992): A simple story

- Consider a farmer that has a low cash flow and is distressed (must meet an interest payment). Suppose farmer cannot reschedule debt or borrow more. Farmer must liquidate (sell) the farm to pay back its creditors

- Who are the buyers?
  - Low valuation users (farm converted to a baseball field, or purchased by a deep pocket investor who hires another farmer),
  - High valuation users (neighbor farmer).
- It is likely that high valuation users are distressed simultaneously with the distressed farmer (e.g. industry wide shocks)
- Then, the farm will be sold at a **fire sale** price to a low valuation user.

SV identifies the key conditions that lead to a fire sale

- This story suggests that fire sales are possible under the following conditions:

1. A distressed seller
2. Heterogeneity: High valuation users (industry insiders) and low valuation users (industry outsiders). **Natural buyers are** high valuation users (similar to potential investors)
3. **Simultaneous distress** of natural buyers with the seller (industry wide shocks)

Under these conditions, assets are sold at a discount:

Fire sale discount = Value at best use – Fire sale price

Interactions between fire sales and investment

Kiyotaki and Moore (1997) combine the net worth channel with fire sales.

Key observation: Potential investors are also typically the **natural buyers** of their assets

- **One reason is specialization:** Industries and firms are highly specialized (e.g. financial institutions specialize in pricing complex securities, airlines specialize in operating aircraft etc.)

Implication: Asset market feedback

- When potential investors are hit, assets are sold to low valuation users and their price drops, which exacerbates the crisis through the net worth channel

Consider a dynamic environment with Es and Fs

- An economy with periods $t \in \{0,1,\ldots\}$ and a single consumption good (dollar)
- Two types of investors: measure one of E’s and F’s, with preferences: $\sum_t \beta^t c_t$
- Fs have a large endowment, *e* in all periods. Ensures that the interest rate is fixed: $1+r \equiv 1/\beta$
- Fixed capital supply ($\bar{k}$ units), which does not depreciate.
- Let q_t denote the price of capital and k_t and $\tilde{k}_t$ denote E’s and Fs’ capital holdings. Capital market clearing:

$$k_t + \tilde{k}_t = \bar{k}$$

E has a linear production technology, and faces a colateral constraint

- Given capital k_t , E produces: $F(k_t) = ak_t$ with **limited pledgeability**:

  - Date t+1 value of E's assets: $(a + q_{t+1})k_{t+1}$
  - Pledgeable assets: $q_{t+1}k_{t+1}$

- This is similar to the limited pledgeability in the earlier lecture. Here it comes from a different friction:
- Inalienability of human capital (Hart and Moore (1994)): Es cannot commit to work.
- This generates a **collateral constraint (CC):**

$$b_{t+1} \leq q_{t+1}k_{t+1}$$

E chooses her borrowing, consumption, and investment

- E also faces a **flow of funds** constraint **(FF):**

$$c_t + q_t k_{t+1} = n_t + \frac{1}{1+r} b_{t+1} \text{ for each } t \geq 0$$

Where her net worth is given by:

$$n_t = (a + q_t) k_t - b_t$$

Net worth is endogenous because it depends on the asset price and past investment decisions

E's problem: Given the initial condition (a_0, b_0, k_0) and the price sequence $\{q_t\}_{t=0}^{\infty}$ choose $\{c_t, k_{t+1}, b_{t+1}\}_{t=0}^{\infty}$ to maximize

$\sum_{t=0}^{\infty} \beta^t c_t$ s.t. (FF) and (CC). (We allow $a_0 \neq a$. Will consider shocks to this)

F's technology and problem

- Fs have a backyard production technology $\tilde{y}_{t+1} = G(\tilde{k}_t)$ where $G(\cdot)$ is strictly increasing, concave and satisfies Inada conditions:

$$G'(0) = \infty \text{ and } G'(\bar{k}) < a$$

- Fs' flow of funds constraint:

$$\tilde{c}_t + q_t(\tilde{k}_{t+1} - \tilde{k}_t) = e + b_t - \frac{1}{1+r} b_{t+1} + G(\tilde{k}_t) \text{for each } t \geq 0$$

Fs choose $\{\tilde{c}_t, \tilde{k}_{t+1}\}_{t=0}^{\infty}$ to maximize $\sum_{t=0}^{\infty} \left(\frac{1}{1+r}\right)^t \tilde{c}_t$ s.t. this constraint

Since *e* is large (by assumption), Fs always have $\tilde{c}_t > 0$ and is unconstrained in choosing $\tilde{k}_{t+1}$. FOC implies

$$q_t - \frac{1}{1+r} q_{t+1} = \frac{1}{1+r} G'(\tilde{k}_{t+1})$$

Fs are the low valuation users of Schleifer-Vishny

- Using capital market clearing, F's FOC yields a **downward sloping residual demand equation (DE)**

$$q_t - \frac{1}{1+r} q_{t+1} = \frac{1}{1+r} G'\left(\overline{k} - k_{t+1}\right)$$

The lhs is the rental rate (user cost) of capital and $\left(\overline{k} - k_{t+1}\right)$ is the residual demand by F

The more has to be sold to F, the lower is the price

- Note that this is equivalent to the following asset pricing equation

$$q_t = \sum_{j=1}^{\infty} \left(\frac{1}{1+r}\right)^j G'\left(\overline{k} - k_{t+j}\right)$$

Fs are very passive in the model and they can be replaced by the demand equation above

Definition of equilibrium

Definition

An equilibrium is a collection of allocations $\{c_t, k_{t+1}, b_{t+1}\}_{t=0}^{\infty}$ and prices $\{q_t\}_{t=0}^{\infty}$ such that E chooses her allocation optimally s.t. (FF) and (CC), and prices satisfy the (DE)(which captures F’s optimization plus capital market clearing)

Next:

- Benchmark without financial frictions
- Equilibrium with frictions and asset market feedback

Frictionless benchmark features a constant investment and price asset

- First consider the benchmark with no fricitons (no collateral constraint)
- FOC for E’s problem

$$q_t - \frac{1}{1+r} q_{t+1} = \frac{1}{1+r} a$$

Combining this with the (DE), the unconstrained capital level is uniquely solved as $k_{t+1} = k^*$ that satisfies

$$a = G'\left(\bar{k} - k^*\right)$$

- Rolling over the FOC above get the unconstrained price level

$$q^* = \frac{a}{r}$$

Es’ initial net worth has no effect on investment or asset price

Characterizing the equilibrium with constraints

- Suppose $k_0 < k^*$ and conjecture an equilibrium in which:

1. E is constrained for periods $t < T^{cons}$ (T^{cons} can be zero). In these periods, E consumes nothing (i.e. $c_t = 0$) and borrows as much as possible (i.e. $b_{t+1} = q_{t+1}k_{t+1}$) to invest in the asset. In this range, $k_{t+1} < k^*$. Moreover, k_t and q_t are strictly increasing in *t.*

2. E is unconstrained for periods $t \geq T^{cons}$. The price of capital and the level of investment in these periods given by:

$$q_t = q^* = \frac{a}{r} \text{ and } k_{t+1} = k^*$$

Note that T^{cons} is the first period in which the entrepreneur is able to invest the unconstrained level, k^*

In the constrained region, E makes a leveraged investment in the asset

- Under the conjectured allocation, $c_t = 0$ and $b_{t+1} = q_{t+1} k_{t+1}$ for $t < T^{cons}$

- Plugging these into (FF) implies that E makes a leveraged investment:

$$\underbrace{\left(q_t - \frac{1}{1+r} q_{t+1} \right)}_{\text{Downpayment per unit of investment}} k_{t+1} = \underbrace{n_t}_{\text{Net worth}}$$

In the constrained region, E’s investment is increasing in her net worth

- **Observation**: with the colateral constraint, the required downpayment happens to be the same as the rental rate of capital (in general these are different objects)

- In view of this observation, plug in the (DE) into the previous equation to get

$$\frac{1}{1+r} G'\left(\bar{k} - k_{t+1}\right) k_{t+1} = n_t \text{ for } t < T^{cons} \qquad (*)$$

- This equation defines implicitly a unique function $k^{next}(n_t)$. Note that $k^{next}(n_t)$ is increasing in n_t.

Equilibrium is characterized by considering two key equations that relate initial investment and initial price

Equilibrium is the intersection of two equations that relate k_1 and q_0:

1. **Net worth relation (backward looking)**: Plugging in the initial level of net worth, $n_0 = a_0 + q_0 k_0 - b_0$, initial investment is given by

$$k_1 = k^{next}\left(a_0 + q_0 k_0 - b_0\right)$$

This is an increasing relation.

2. **Asset pricing relation (forward looking):** that caracterizes q_0 in terms of k_1 :

$$q_0^{pricing}\left(k_1\right)$$

To characterize the asset pricing relation, we first need to characterize the evolution of capital for a given level of k_1

Starting from constrained level, capital grows and reaches the unconstrained level

- Consider the evolution of capital given an initial investment level, k_1.
- Note that (CC) is binding for each $t < T^{cons}$, which implies:

$$n_t = (a + q_t)k_t - b_t = ak_t$$

Using this expression and the definition of T^{cons}, the evolution of capital is

$$k_{t+1} = \min\left(k^{next}(ak_t), k^*\right), \text{ for each } t \geq 1 \qquad (**)$$

Using eq. (*) and the steady state equation $a = G'\left(\overline{k} - k^*\right)$, prove the folowing:

$$1.\ \text{If } k_t \geq k^* \big/ (1+r) \text{ then } k^{next}\left(ak^*\right) \geq k^* \text{ and } k_{t+1} = k^*$$

$$2.\ \text{If } k_t < k^* \big/ (1+r) \text{ then } k^{next}(ak_t) \in \left((1+r)k_t, k^*\right)$$

These imply that, given any $k_1 < k^*$, capital level grows (at a minimum rate *r*) and eventually reaches k^*

Asset pricing relation also provides an increasing relation between initial price and investment

- Given an initial investment level, k_1.
- Eq. (**) uniquely defines the path of capital, $\{k_t\}_{t=1}^{\infty}$. Moreover, increasing k_1 increases each k_t

- Using the expression for the asset price

$$q_0^{pricing}(k_1) = \sum_{j=1}^{\infty} \left(\frac{1}{1+r} \right)^j G'\left(\bar{k} - k_j\right)$$

Note: This is also an increasing relation

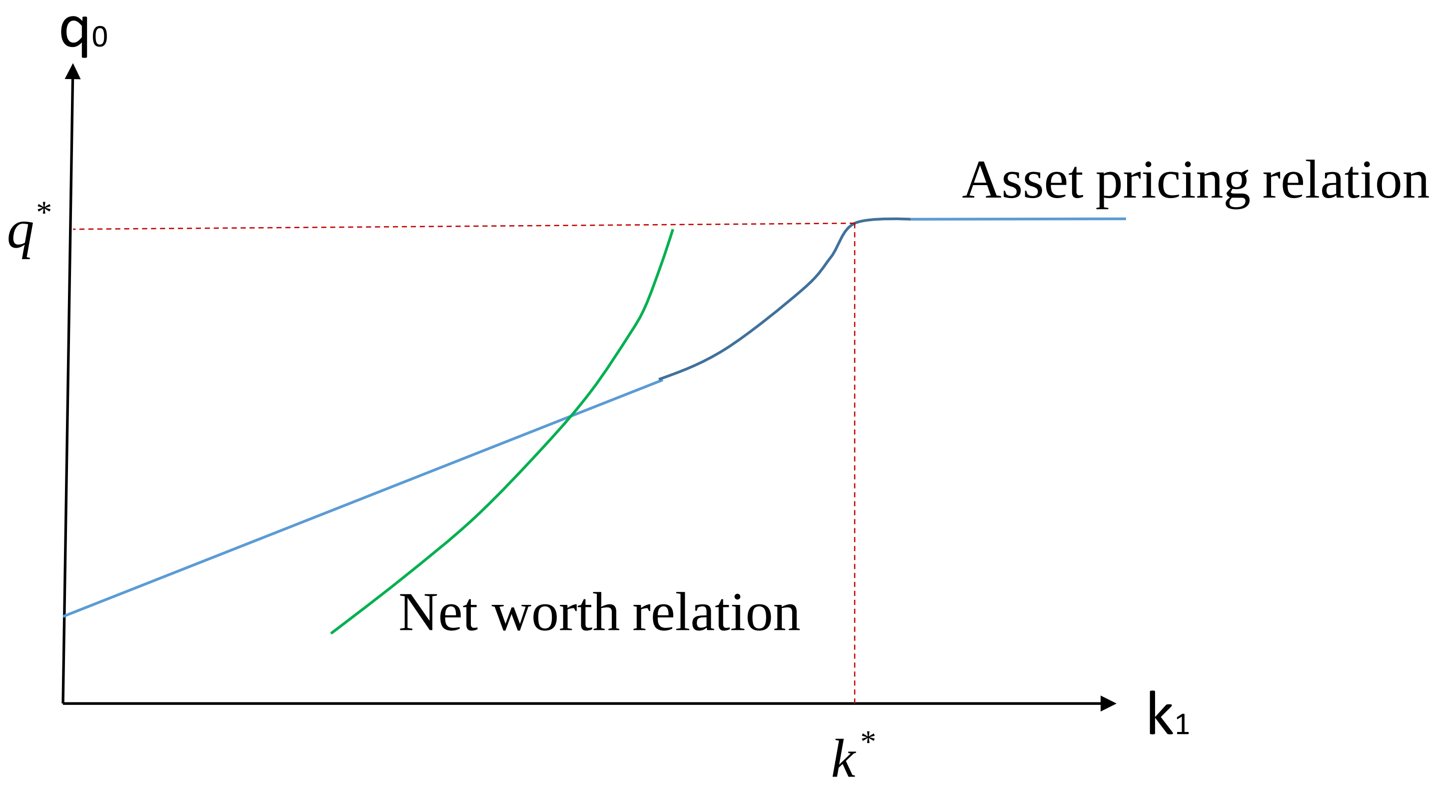
Any intersection of the net worth and asset pricing relations corresponds to an equilibrium

Proposition

Suppose there exists (q_0, k_1) with $k_1 < k^*$ such that $q_0 = q_0^{pricing}(k_1)$ and $k_1 = k^{next}(q_0 k_0 - b_0)$. Then there exists an equilibrium in which the path of capital, $\{k_t\}_{t=1}^{\infty}$, is characterized by (**) and the asset price is given by the equation above.

For the proof, it only remains to check our conjecture that it is optimal for entrepreneurs to choose $c_t = 0$ and $b_{t+1} = q_{t+1} k_{t+1}$ (invest as much as possible) for $t < T^{cons}$

Picture of a (stable) equilibrium



Consider a shock to E's net worth

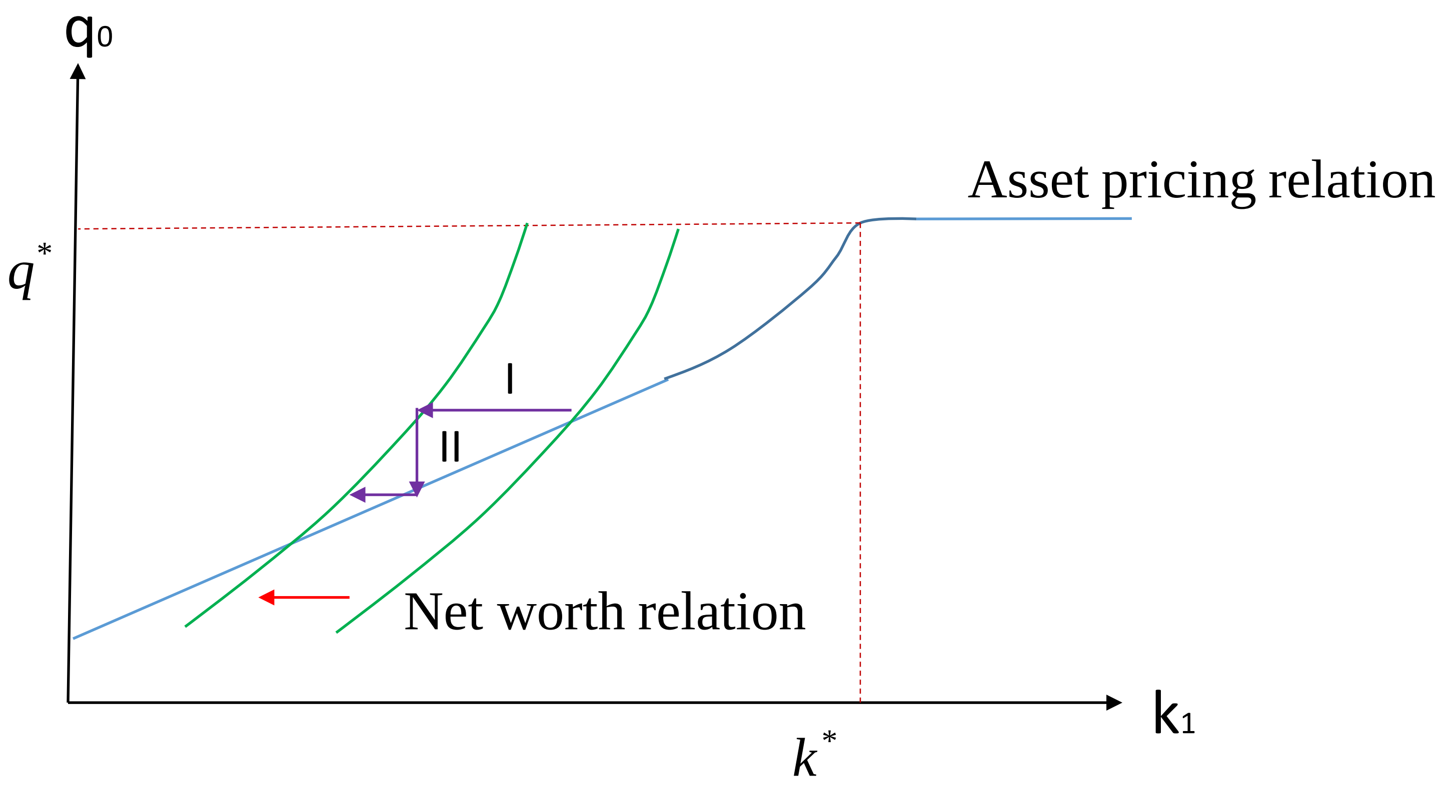
What happens if there a multiple intersections?

Next: Assume there is a unique intersection (or consider the local neighborhood of an intersection) and consider the effect of a financial shock:

- A temporary shock that lowers output *t*=0 from $a_0 = a$ to $a_0 = a - \Delta a$ Equivalently, can consider a debt-deflation that increases b_0 to $b_0 + \Delta b$

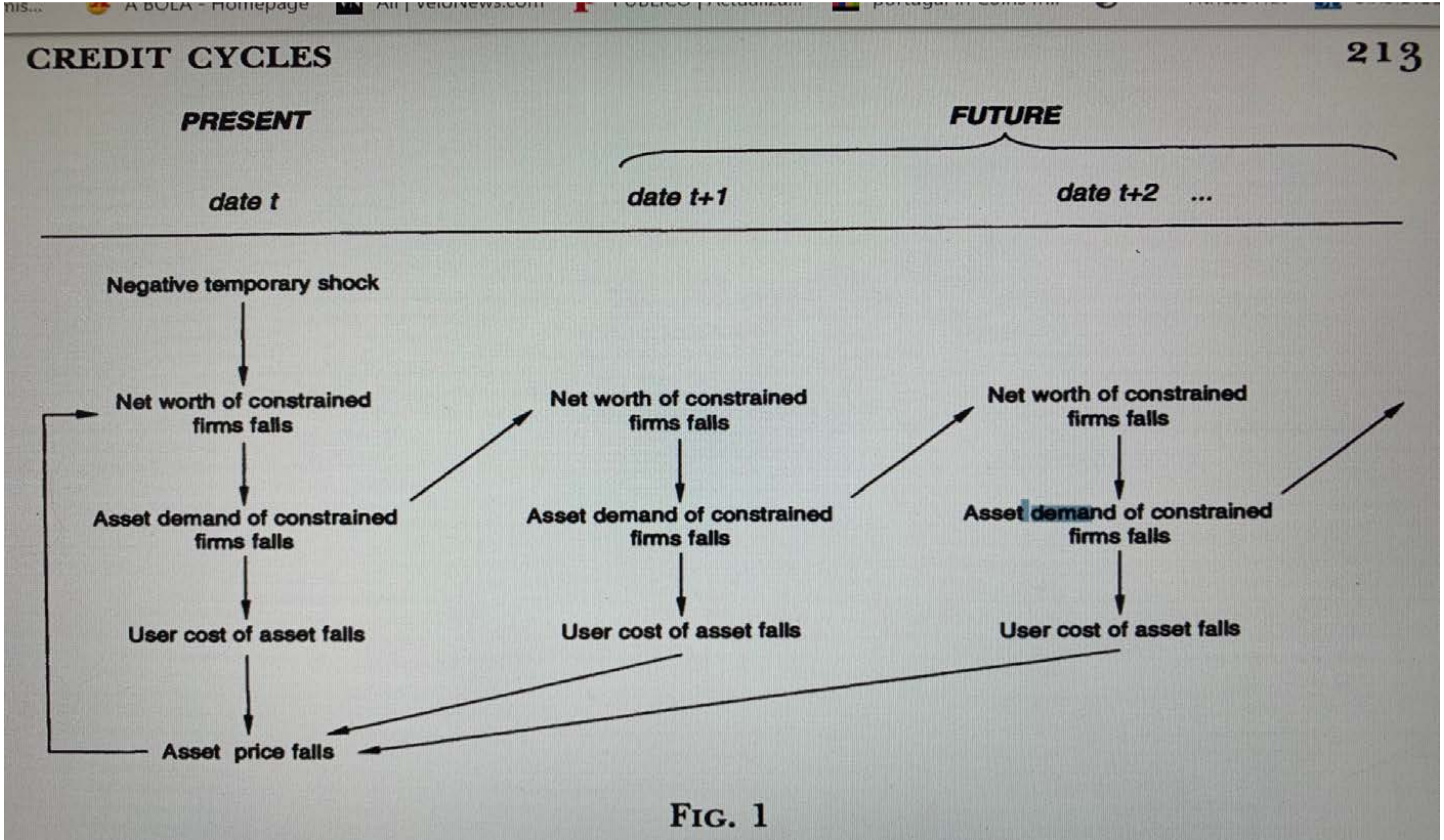
- Recall that would not have any effects in the frictionless benchmark

Asset feedback amplifies the net worth channel



Channel I: Balance sheet channel
Channel II: Asset market feedback

From KM: Future reductions in demand are important for the strength of the feedback



Non-contingent debt is key for the result

- Suppose the shock is anticipated at date -1 and state-contingent contracts are allowed. Borrowing constraint becomes

$$b_0(s) \leq q_0(s) k_0$$

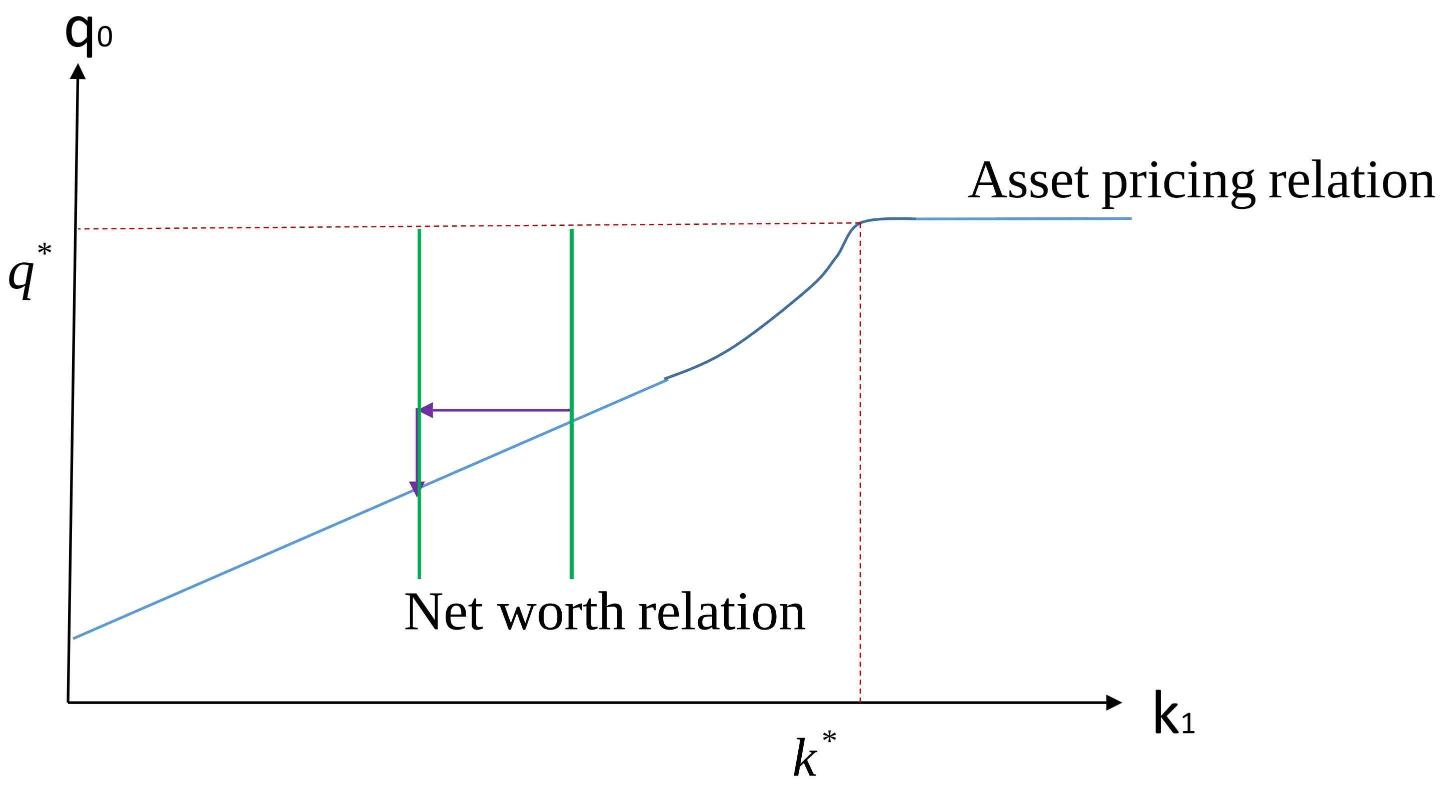
- Assuming that E has borrowed up to the limit, her net worth is:

$$n_0(s) = (a(s) + q_0(s)) k_0 - b_0(s) = a(s) k_0$$

- **Vertical net worth relation**: $k_1 = k^{next}(a(s) k_0)$ is independent of $q_0(s)$

- **Price feedback is gone:** A shock that lowers *a* to *a-Δa* lowers investment only through the net worth channel. No further amplification due to asset market feedback.

Non-contingent debt is key for the result



Open question: Lack of insurance

- Critique of KM: Nothing in the colateral constraint rules out contingent debt.

- **Important open question**: Why debt contracts (or liabilities) are not indexed to observable aggregate shocks?

- Equivalently: Why do potential investors/buyers remain **underinsured**?

Taking stock: Fire sales, asset market feedback, and deleveraging

- **Fire sales**: When assets are specialized, they are likely to be sold at a fire-sale discount during industry recessions.

- **Asset market feedback:** When financial shocks induce potential investors to sell specialized assets, the price will fall and increase financial distress

- **Deleveraging**: Sell assets to pay back debt

  - High leverage ratio generates large quantitative effects
  - Mechanisms seem to be relevant in practice
  - Crucially rely on non-contingent debt (i.e., lack of insurance)