A Theory of Debt Maturity:
The Long and Short of Debt Overhang

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Debt Overhang

- Debt Overhang: Reduced investment incentives when investment improves the value of existing debt ($\Longrightarrow$ externality).
- Myers (1977): risky debt maturing in the future leads to underinvestment.
  - A comment in Myers: debt maturing before an investment decision cannot cause overhang.
  - Generalization: If short-term debt is always default risk free, it cannot cause overhang.
- But, ex-post, shorter-term debt leads to earlier default (Diamond (1991), Gertner-Scharfstein (1991)). Not about investment incentives, but this should be related.

Can shorter-term debt lead to greater debt overhang?

- Yes, via several channels.
- Investment takes place over time:
- Firms make investment decisions now and in the future given existing debt.
  - Debt maturity influences the distribution of future overhang.
- There is some debt in place when rolling over existing debt and default is a decision.
- Differing resolution of uncertainty (conditional volatility) in good and bad times can be important.

Debt Overhang framework

- Investment decisions are made by equity owner to maximize the value of equity.
- No renegotiation of debt contracts.
- Debt holders cannot do real investment themselves (Investments lost if not done by owners). No other distress costs.
- Question: does the firm want to invest?
  - The firm will forgo investment projects with NPV below the wealth transfer to debt holders plus any loss from inefficient decisions implied by the debt structure.

Probable Basis for the Idea for less shorter-term overhang--beyond Myers

- Black Scholes Merton log normal diffusion asset with one zero coupon bond issue maturing on date T with face value F_T.
- A small scale expansion single investment just after bond issue at date 0, before any resolution of uncertainty.
- Vary T, *hold date 0 market value of debt constant*.
- Proposition 1: Overhang is increasing in T. Investment/early recap incentives are best with shorter-term debt.

BSM immediate investment setting

- Black-Scholes-Merton log normal diffusion asset

$$V_t = V_0 \exp\left(-\frac{\sigma^2}{2} t + \sigma Z_t \right)$$

- One zero coupon bond with maturity m with face value F_m.
- A scale expansion single investment just after bond issue at date 0, before any resolution of uncertainty.
- Overhang: $\partial D(V;F_m,m)/\partial V = D_V(V;F_m,m)$, debt value increment due to investment.
- $m_2 > m_1$. And, adjusting F_m so that $D(V;F_1,m_1)=D(V;F_2,m_2)$, i.e. the same date 0 leverage.
- *Proposition 1: $D_V(V;F_2,m_2) > D_V(V;F_1,m_1)$.* ***Overhang is increasing in maturity always.***

Short-term debt shares less risk

- Most interpret this as short-term debt minimizes or eliminates overhang.
  - Empirical implication: firms with future investments (growth firms) should use shorter-term debt.
  - Mixed evidence: Barclay & Smith (1995), Guedes and Opler (1996), Stohs and Mauer (1996), Johnson (2003)

Outline

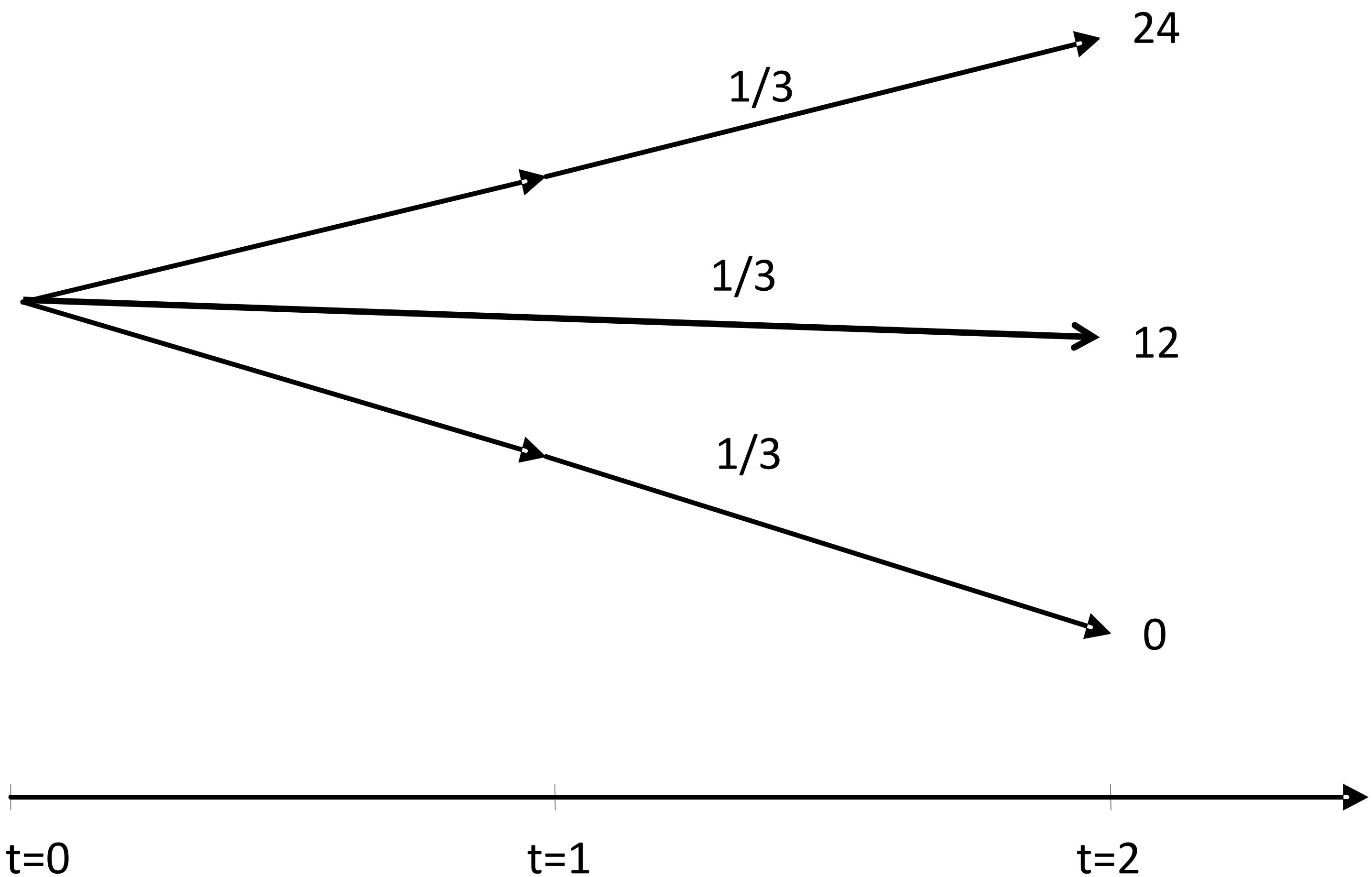
- A series of examples to illustrate why this result occurs and its implications
  - When does short-term debt lead to less overhang?
  - What if we have future investment?
- We then integrate these results in a generalized

  Leland model with dynamic investment and endogenous default
- We also show what happens if the asset-in-place has higher volatility following bad shocks to value.

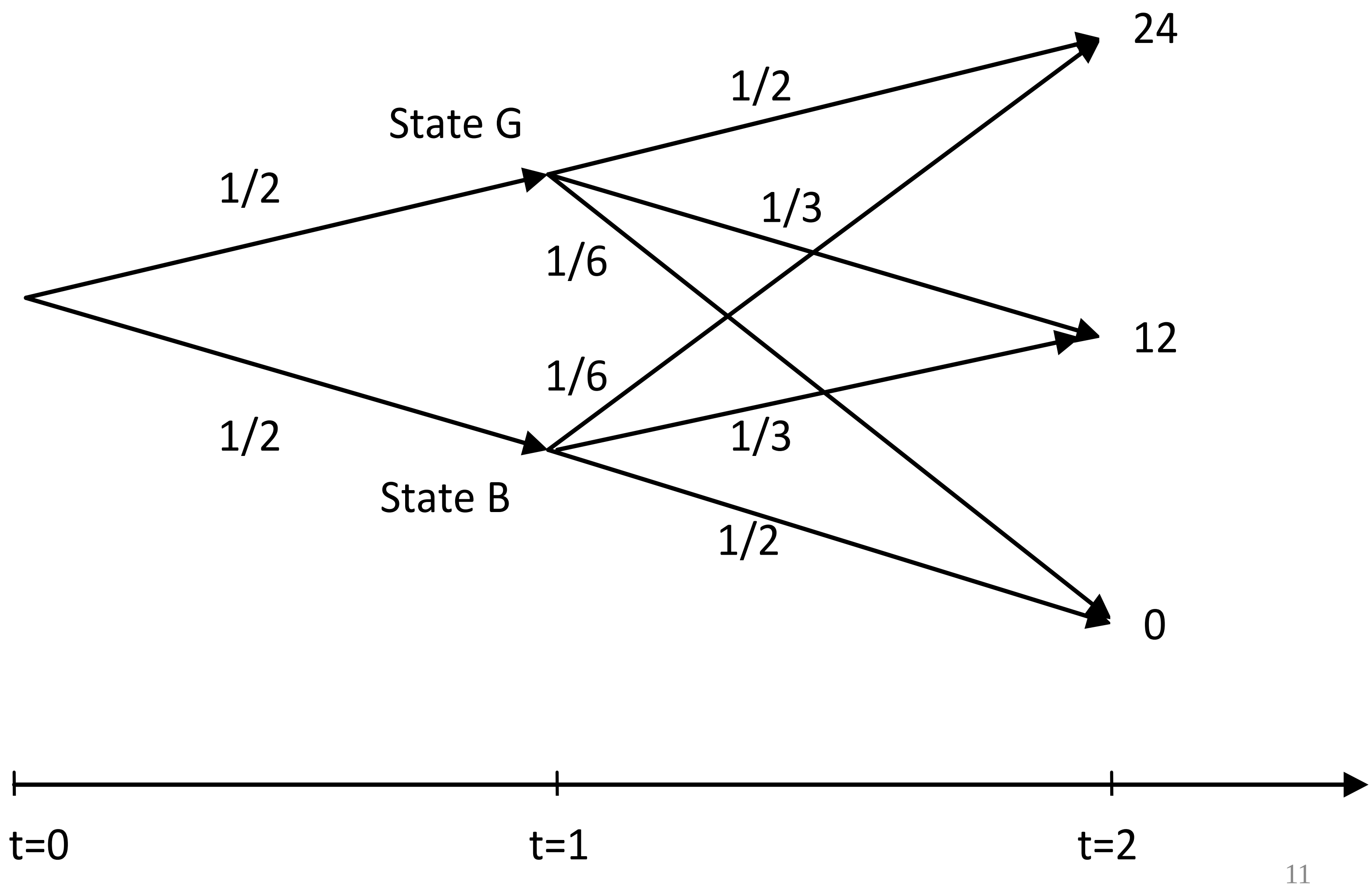
An asset in place before investment

- The firm has an asset-in-place which brings final cash flows only at date 2.
- There are three potential outcomes {24, 12, 0} each occurring with probability 1/3 from the perspective of date 0.
- At date 1 some public information arrives.
  - With half prob., good news arrives at state G
  - Symmetrically, bad news arrives at state B.

Asset in place



Asset in place (symmetric)



Two timings for investment

- Investment technology: marginal investment which adds a small amount to each state's payoff at date 2
- Example number:

1. Invest only at date 0, after debt issue, before uncertainty is resolved (BSM-like example)
2. Invest just before date 1, after state is known (future investment)

BSM-like Example 1: Short vs. Long, same date 0 market value

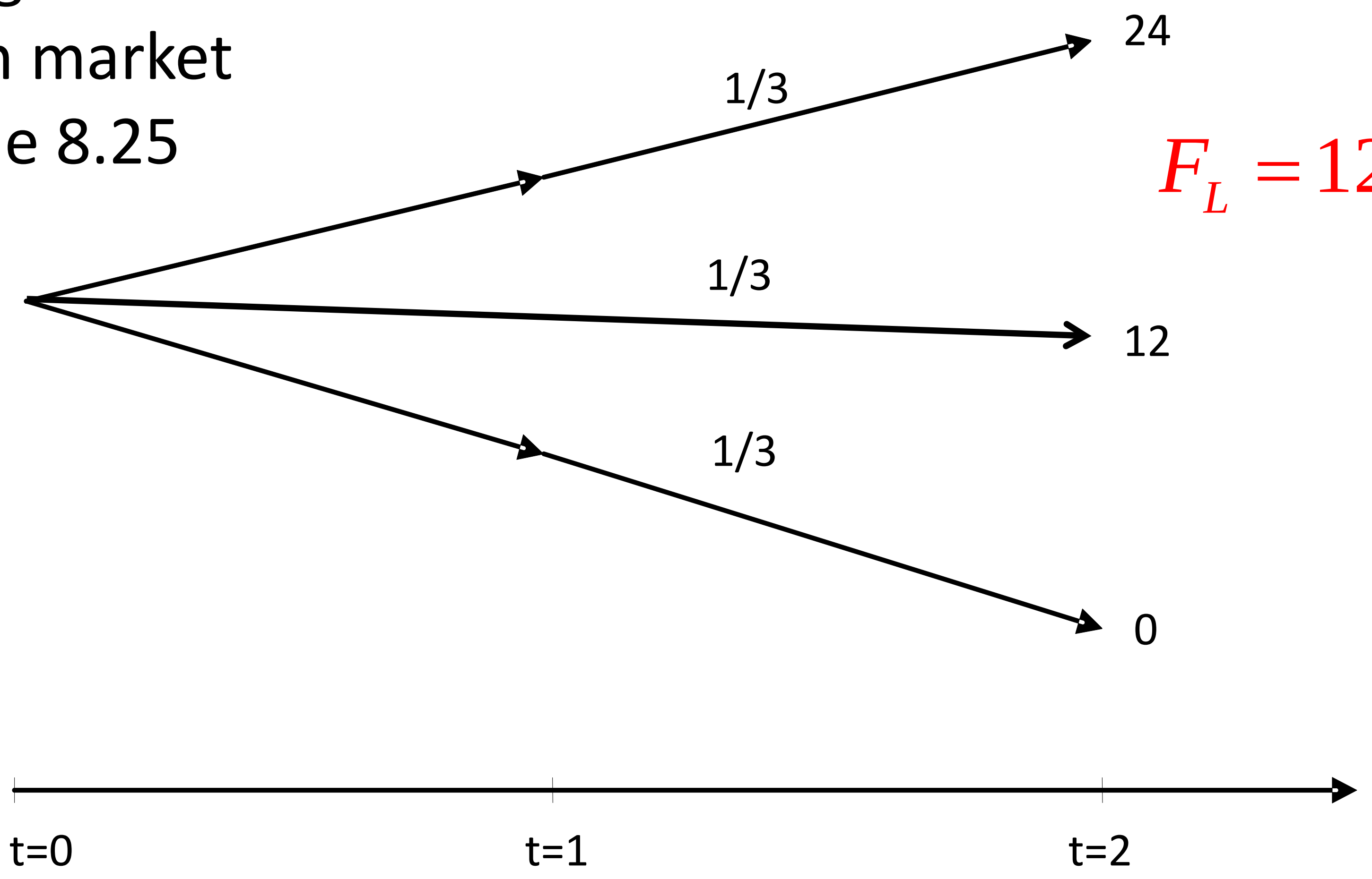
- All long (zero coupon, due on date 2)
- All short due on date 1 (refinanced).
- To look at the effect of maturity on immediate investment overhang, we must hold leverage constant.
- Both maturities have market value 8.25 on date 0.

A single investment, just after debt issue (date 0)

- No resolution of uncertainty before the investment, but investment is discretionary.
- An investment which adds a small amount, ε, to payoff in each state at date 2.
- Look at Present value of increment to equity value (compare to investment cost: bigger PV of increment to equity, larger investment incentives).
- Risk neutral valuation, for simplicity.

Asset in place (and Long term debt)

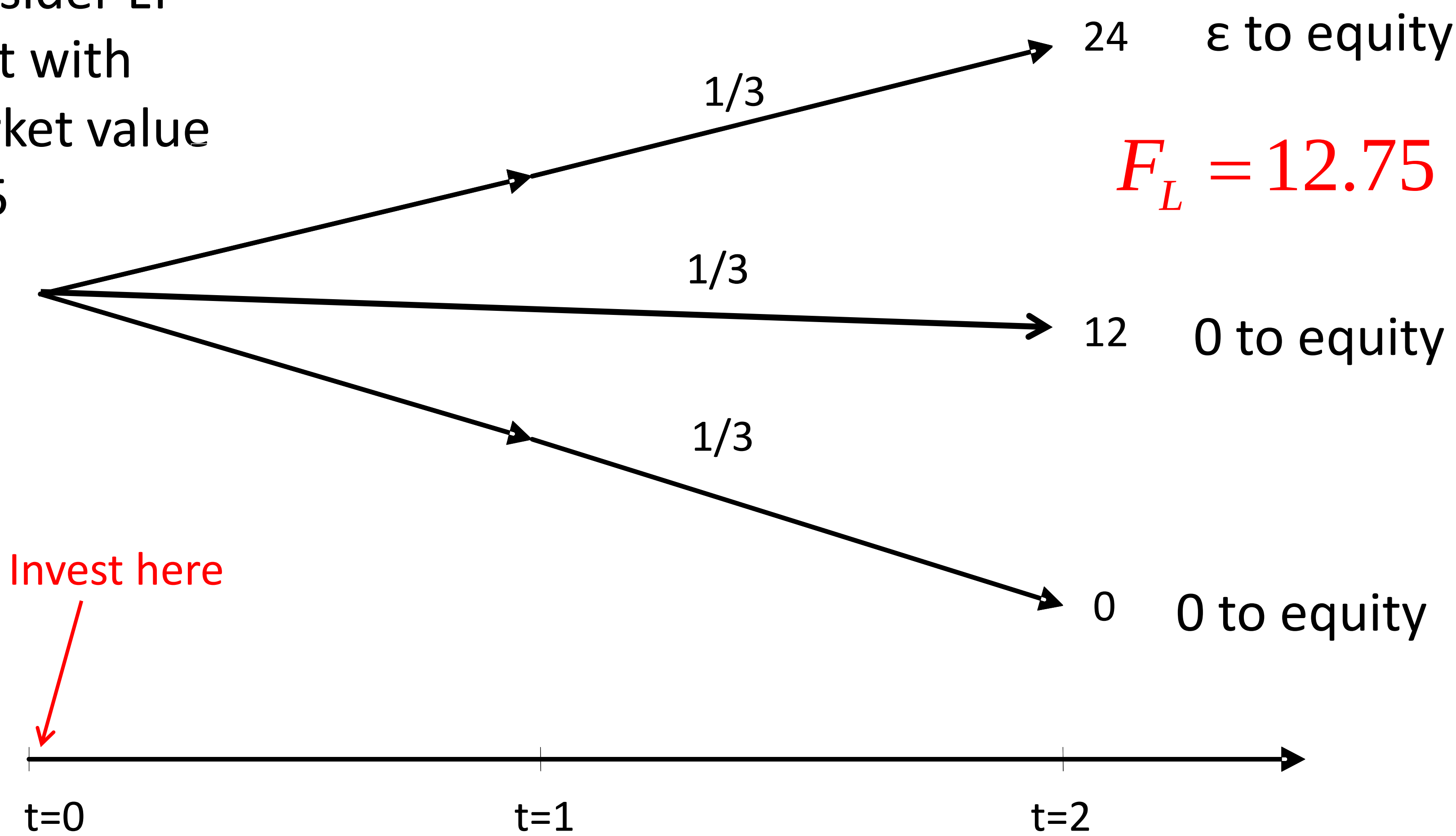
Long-term debt with market value 8.25



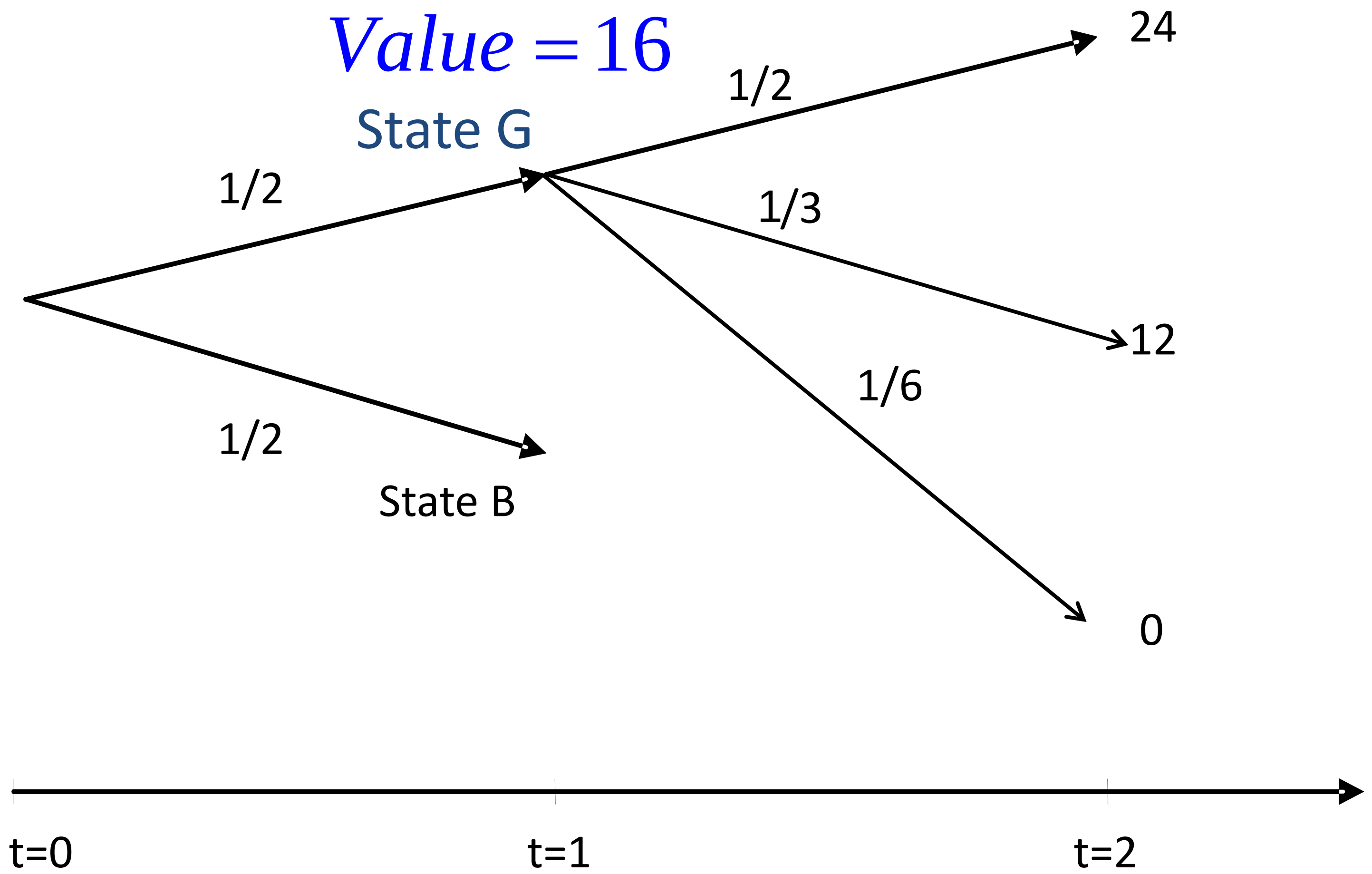
$F_L = 12.75$

Add ε to all realizations of the asset in place (1/3 ε to equity with LT)

Consider LT debt with market value 8.25

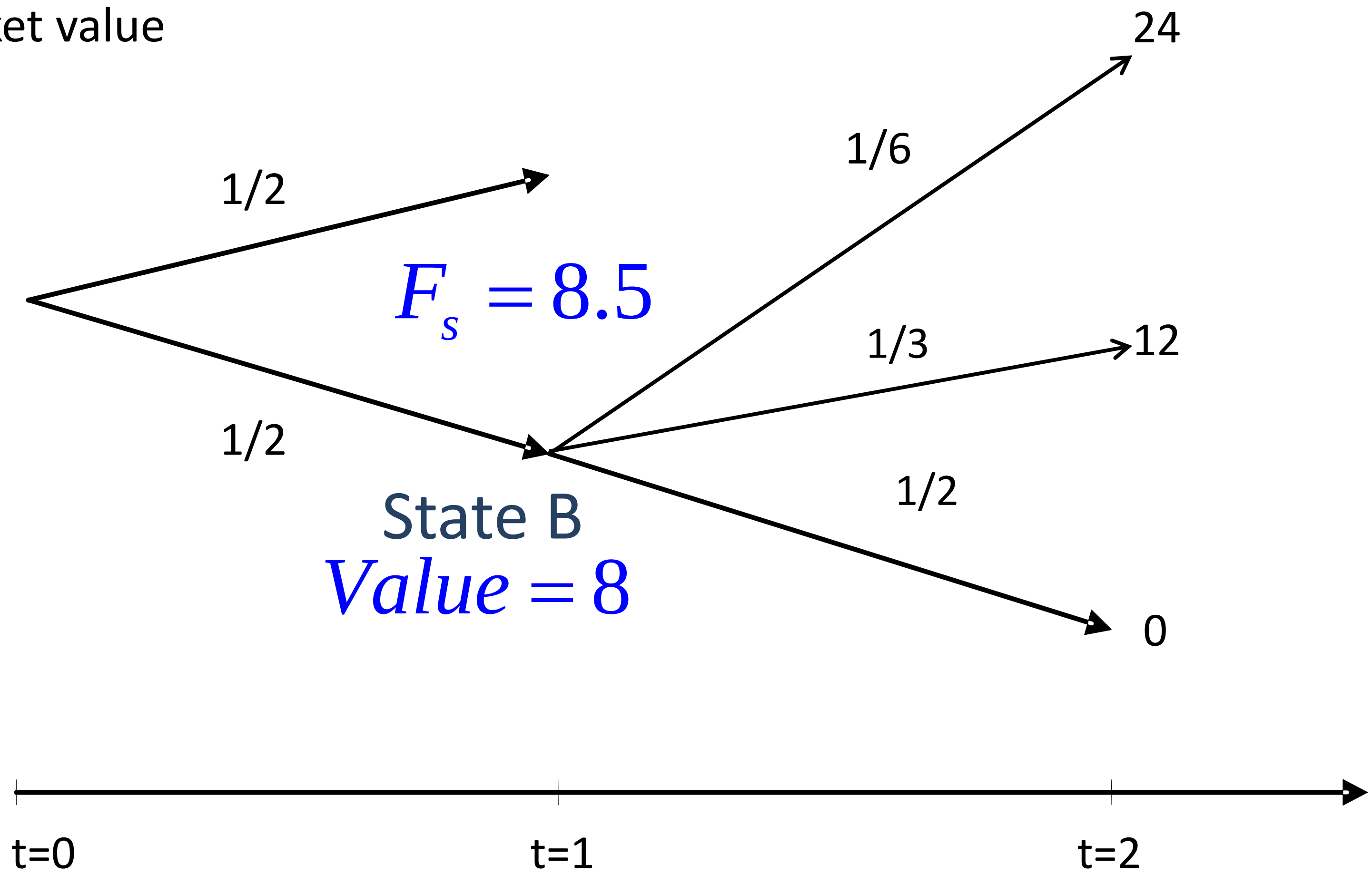


Good news about date 2 pay offs arrives on date 1



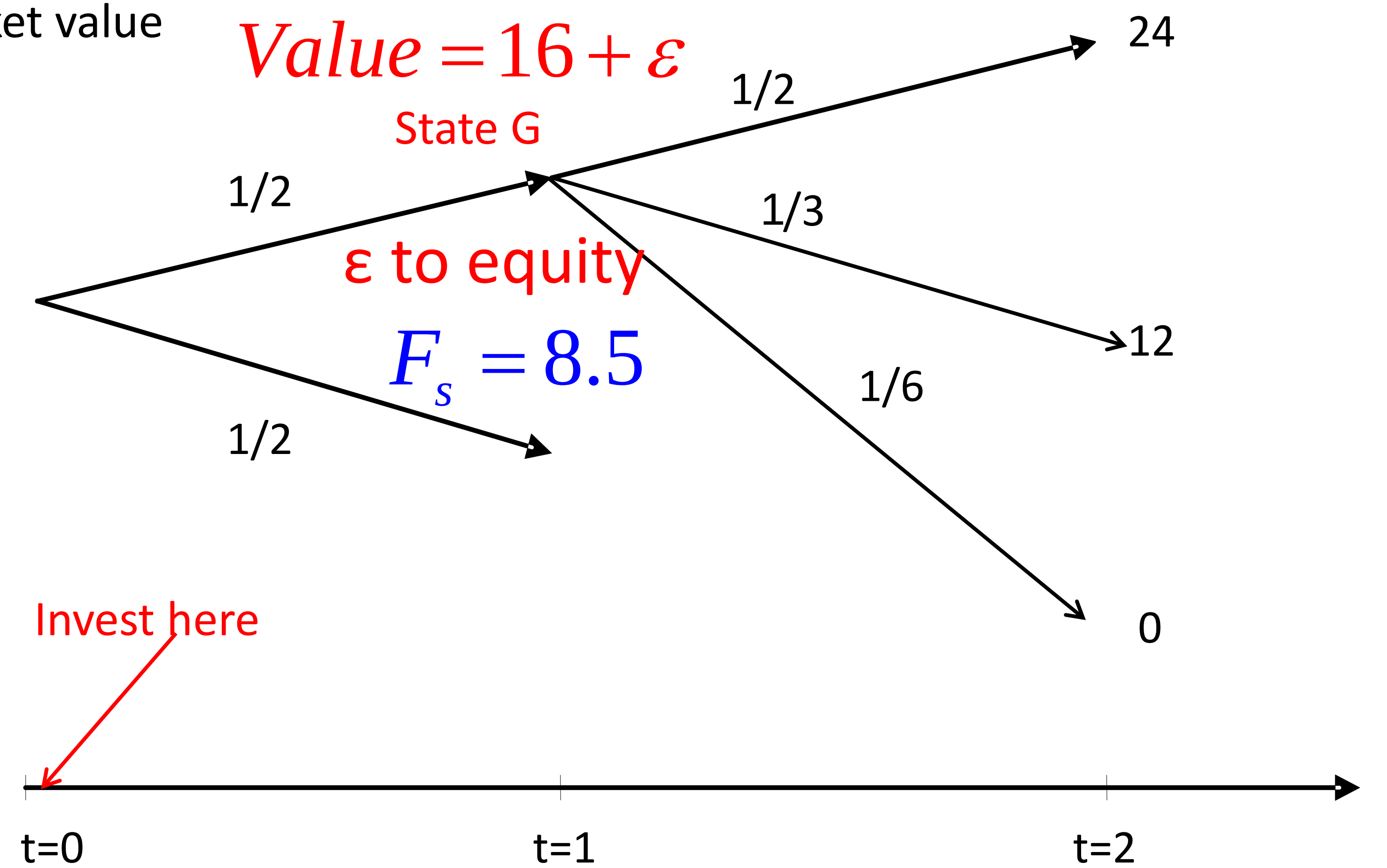
Symmetric Bad News about date 2 pay offs arrives on date 1

ST debt with market value 8.25



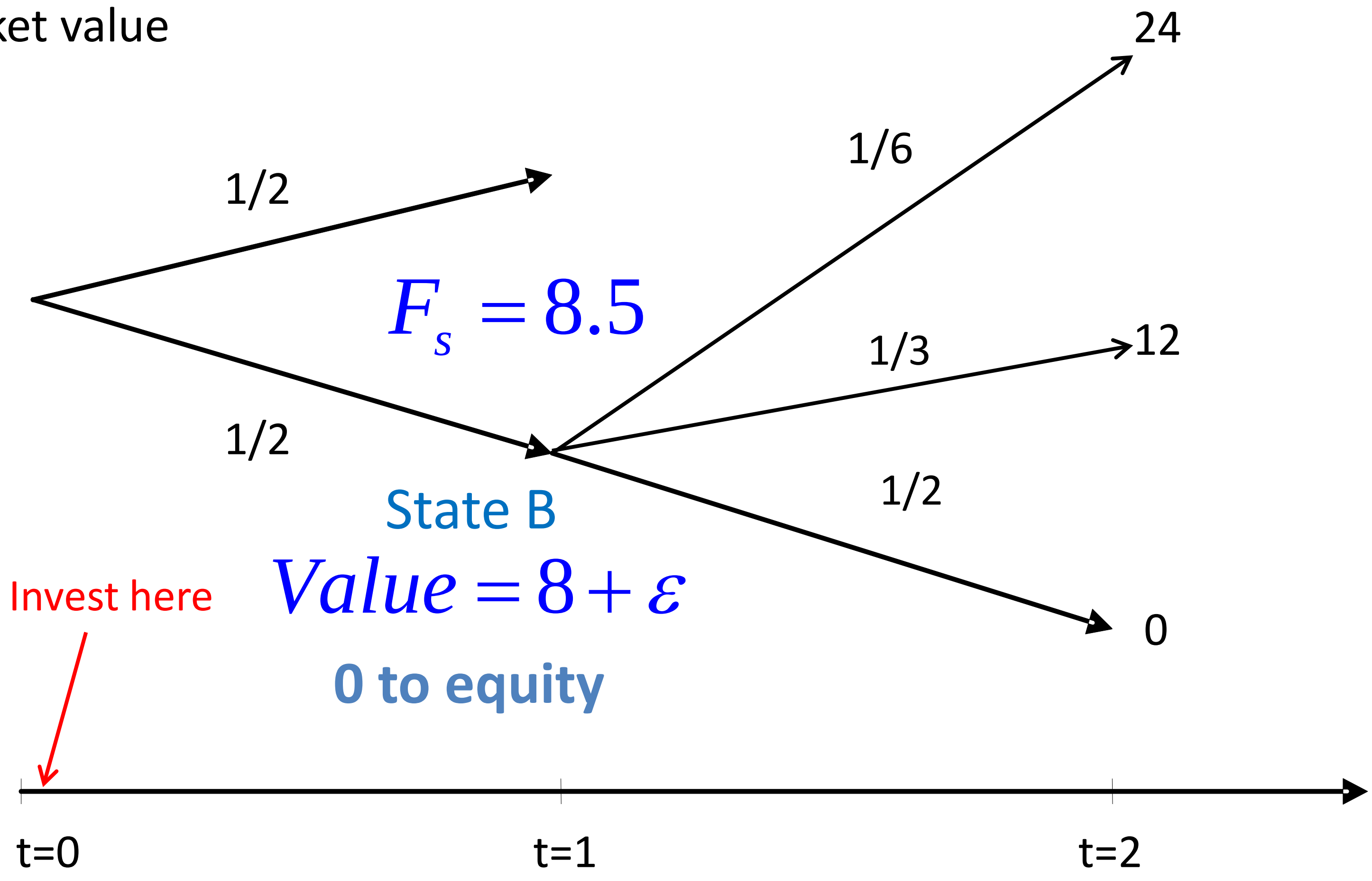
Add ε to all realizations of the asset in place (payoff when good news)

ST debt with market value 8.25

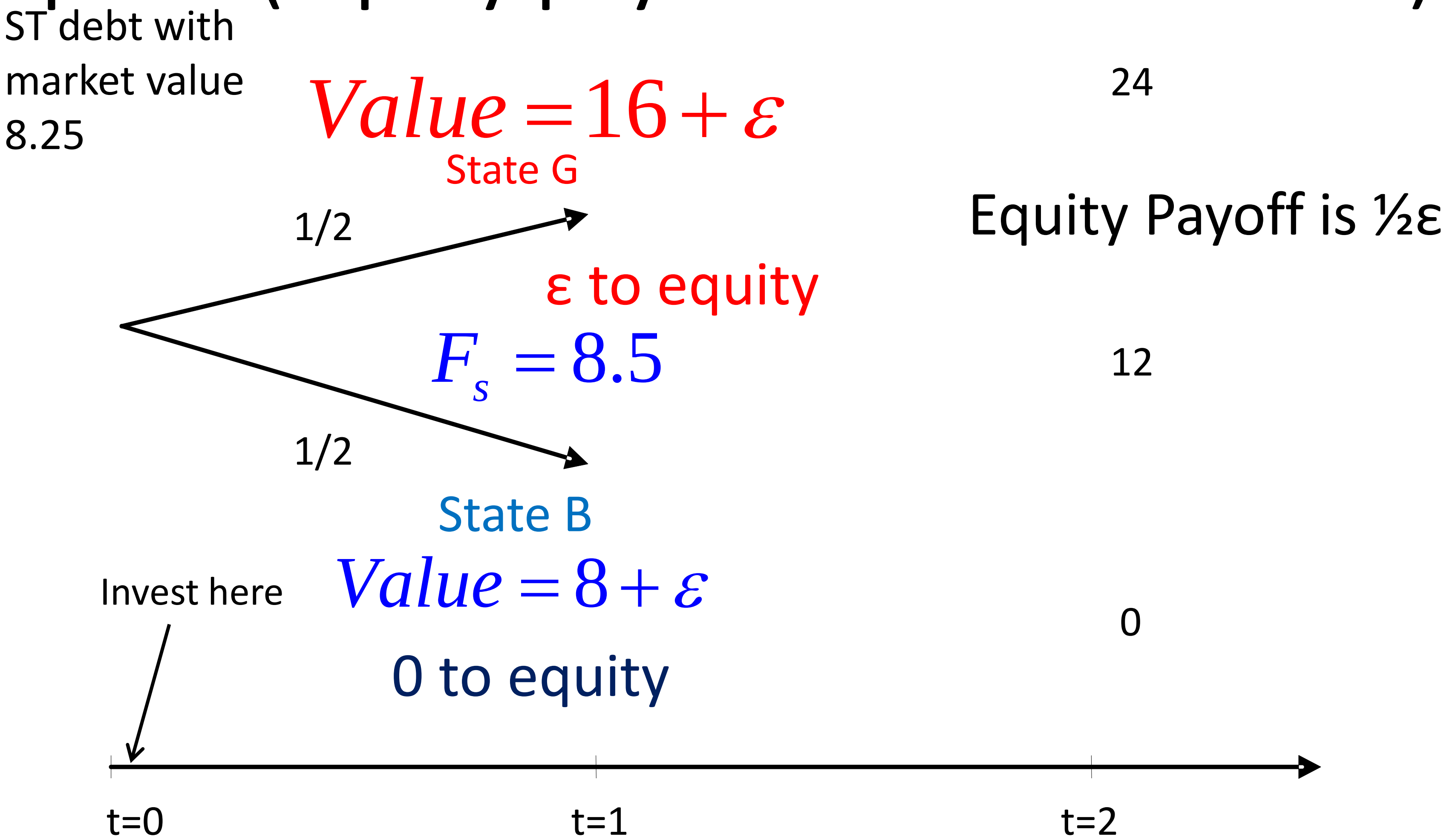


Add ε to all realizations of the asset in place (payoff when bad news)

Both debts with
market value
8.25



Add ε to all realizations of the asset in place (Equity payoffs with short-term)



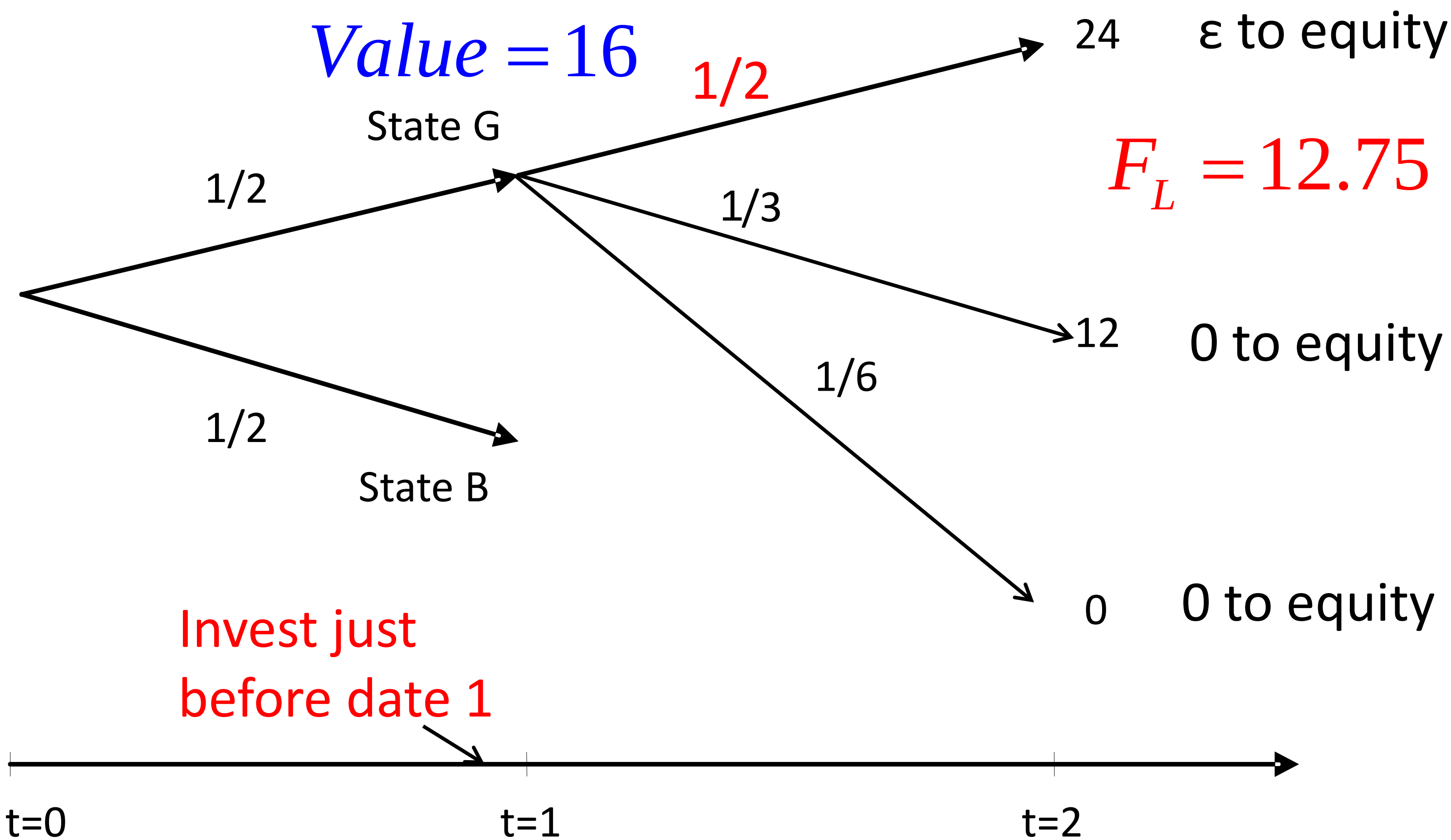
Short term shares less risk, has less overhang

- Constant Volatility, immediate investment
- Long Term, equity gets 1/3 ε (remainder to debt).
- Short Term, equity gets 1/2 ε (remainder to debt).

Example 2: Invest after news about state

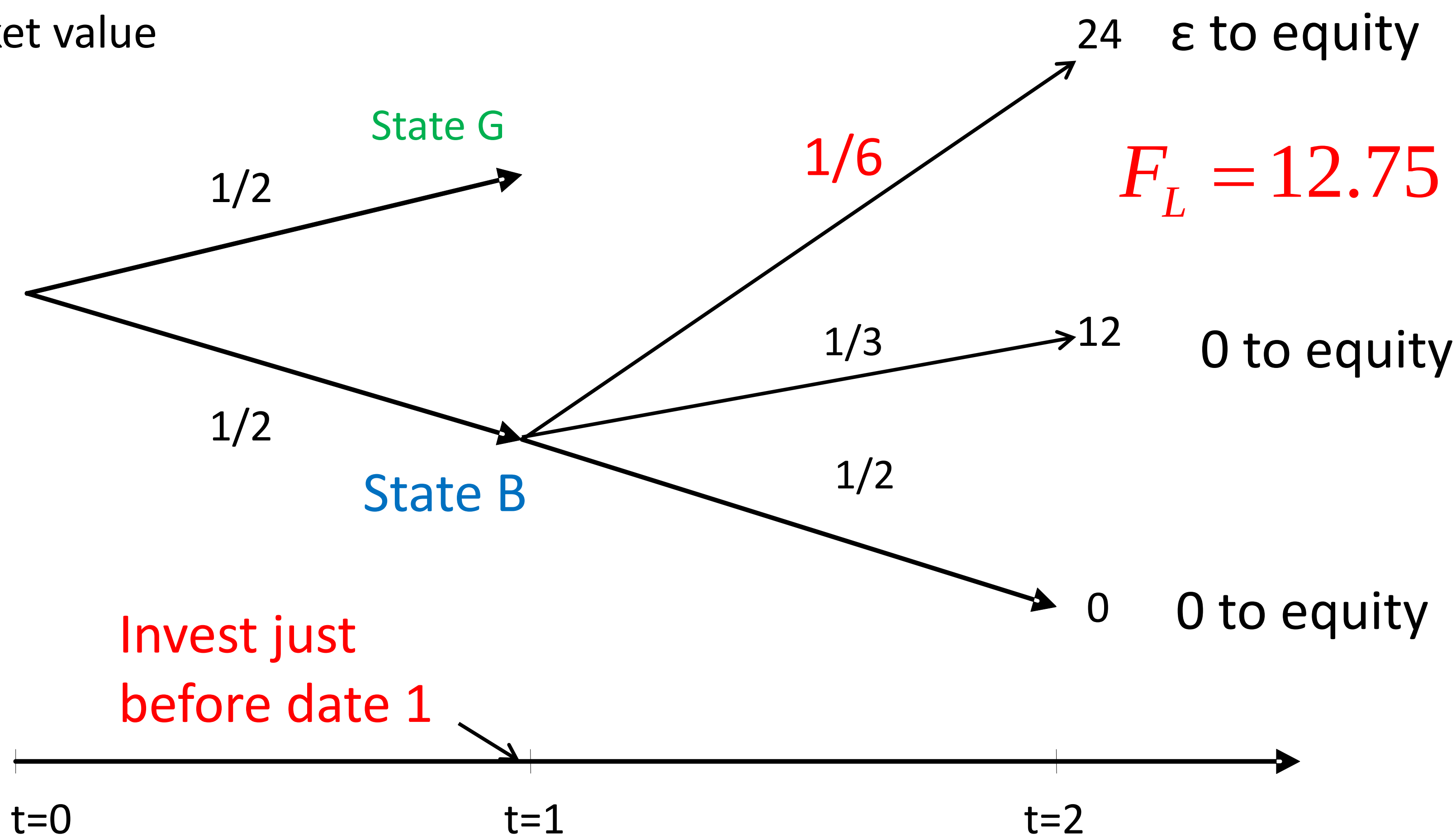
- Effect of overhang on Future Investment.
- Just before date 1, State G or B known, debt has not yet matured (even short-term).
- Now short-term debt generates more volatile equity value before investment and thus more volatile overhang.

Long term overhang after Good news about date 2 payoffs (Equity gets ½ε)

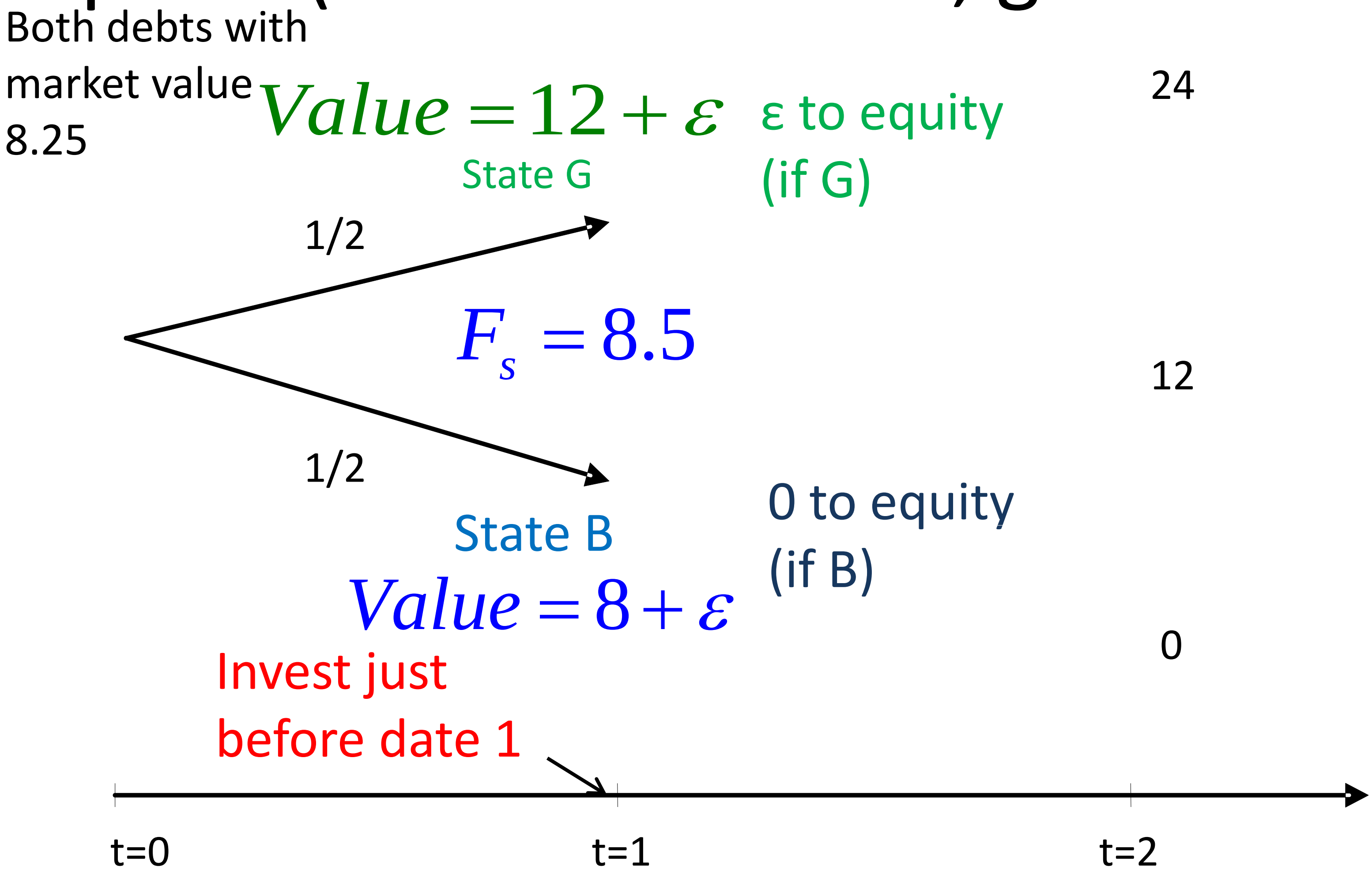


Long term overhang after bad news
Equity gets 1/6 ε

Both debts with market value 8.25



Add ε to all realizations of the asset in place (Short-term debt, given news)



Short-term debt has more volatile overhang

- Implies more volatile future investment than long-term: equity gets (G,B)=(0,1ε) with short, vs. (G,B)=(1/6 ε, 1/2 ε) for long.
- Investment incentives which are more volatile.
- Good for firms whose investment opportunities more correlated with value of assets in place.
- (Shown more generally in Leland type model)

Combine the examples: Investment now and in the future

- Leland (1994, 1998) extended to continuous investment choice.
- Firm asset generates cash flows at a rate of X_t . These assets-in-place evolve as follows:

$$\frac{dX_t}{X_t} = \tilde{i}_t dt + \sigma dZ_t$$

- Here, σ is the constant volatility, and $\{Z_t : 0 \le t < \infty\}$ is the standard Brownian motion.

Dynamic Investment Setting

- Generalize Leland (1994,1998) to dynamic (continuous) investment opportunities.
- A stationary debt structure, refinancing at a constant rate 1/m (so debt has average maturity m)
  - Constant amount promised to debt holders, varying roll-over losses to equity holders who decide when to stop absorbing the loss (and thus default).
- Choose whether to invest (constant NPV) at each instant and whether to repay, injecting equity if needed, or default.
- No liquidity problems for equity only default option.

Model Setting

- Asset in place X_t follows $\frac{dX_t}{X_t} = \tilde{i}_t dt + \sigma dZ_t$
- Investment cost $\lambda X_t \tilde{i}_t$ vs investment benefit $XE'(X)$
- Endogenous investment threshold X_i

$$i(X) = \begin{cases} i & X \geq X_i \\ 0 & X < X_i \end{cases}$$

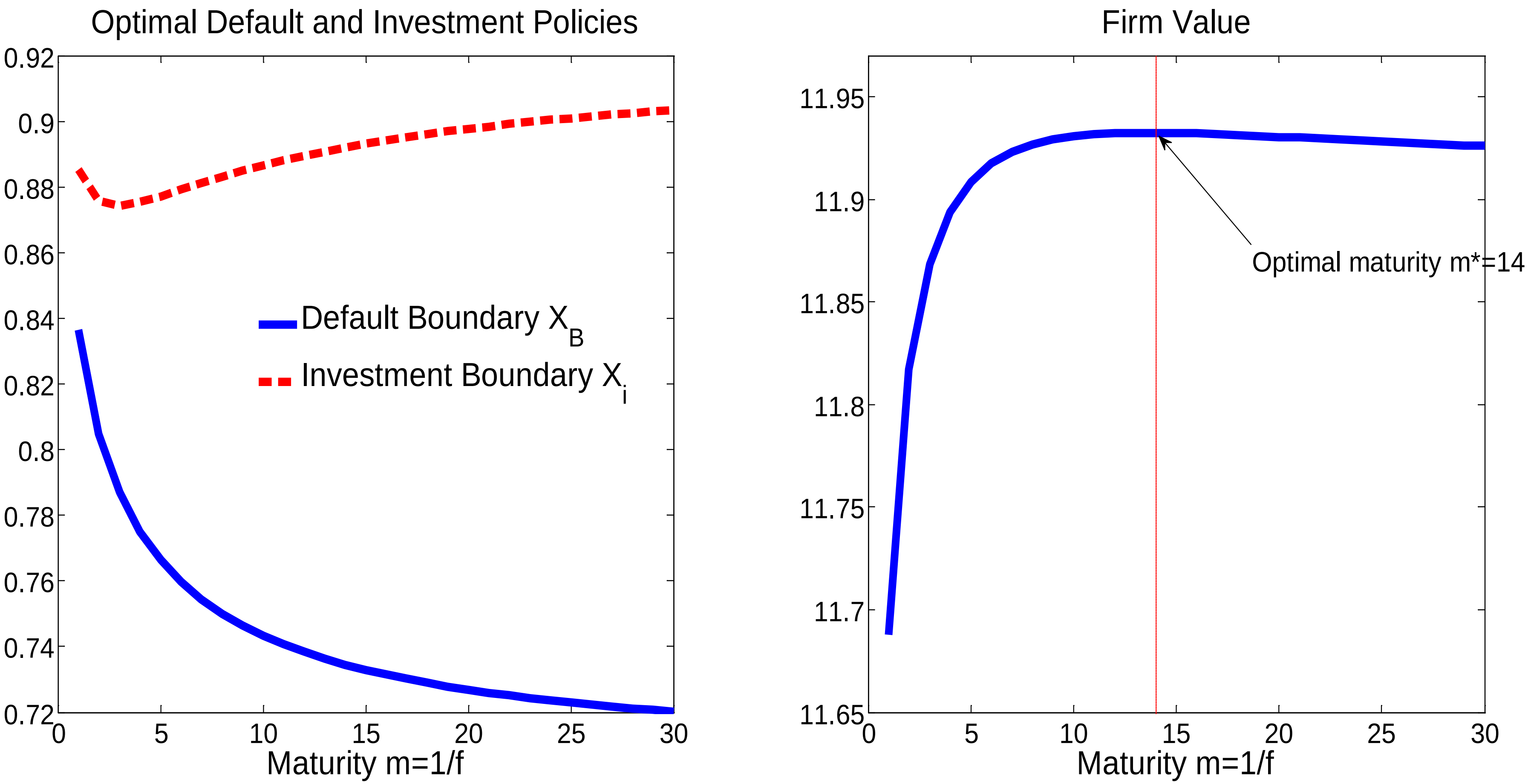
- Zero-coupon debt with principal P. Equity holders refinance 1/m fraction so pay:

  (D(X)-P)/m every period.
- Equity's cash flow: $X_t dt - \lambda X_t \tilde{i}_t dt + \frac{1}{m}\left[D(X_t) - P\right]dt.$
- Equity defaults when X_t hits X_B

Results

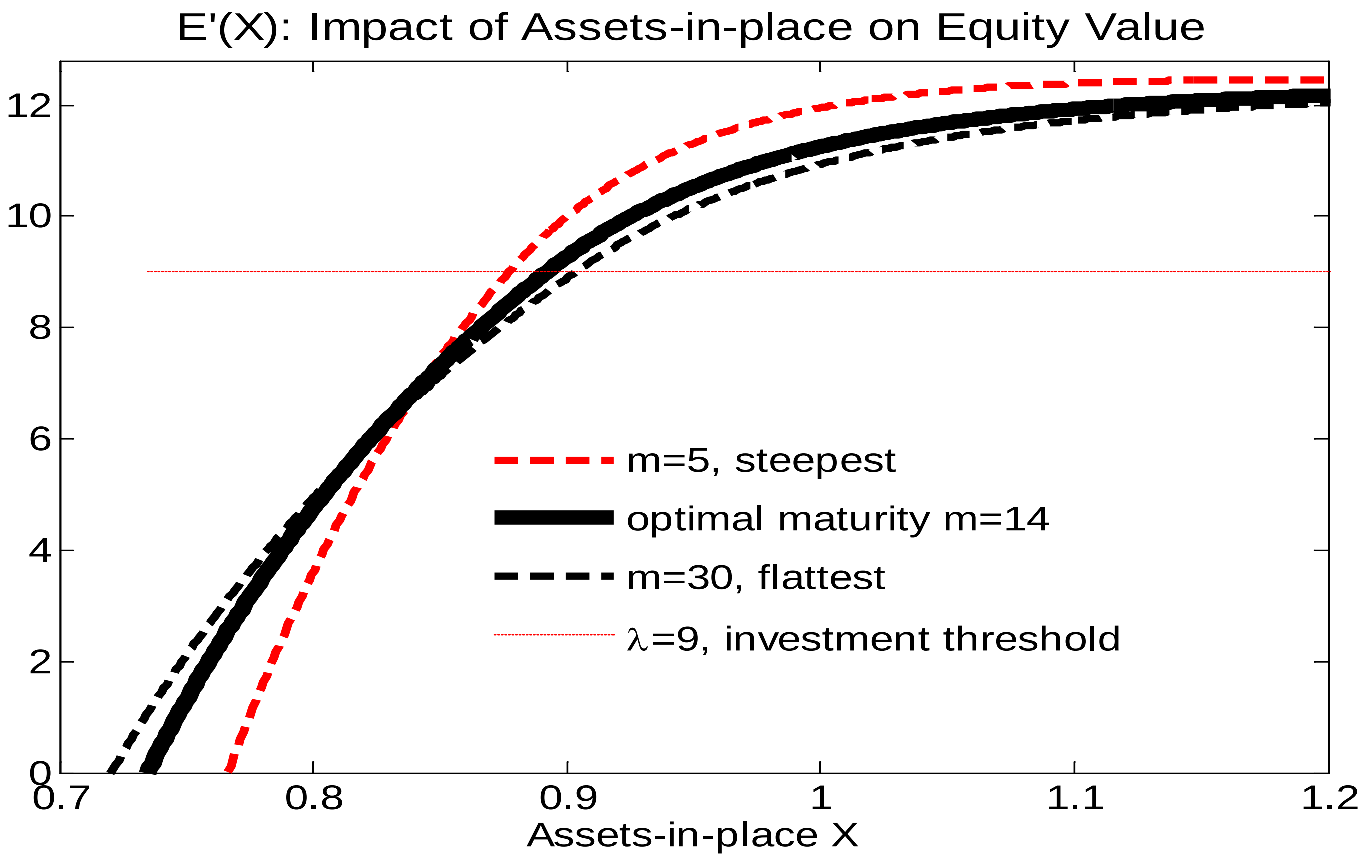
- Shorter maturity debt increases the "static" sensitivity of equity value to asset-in-place (as it shares less risk), good for investment
- But this leads to more volatile overhang and more dependence of equity sensitivity on firm value.
- Very volatile overhang due to shorter maturity debt induces earlier default, extinguishing investment opportunities sooner.
- Investment incentives and value maximized with interior maturity (not too short or long)

Optimal maturity



Optimal investment/default

- Invest if $E'(X) > \lambda$ and default when $E'(X_B) = 0$



Corner Cases for intuition

- If only one future investment which arrives in the future (so staying in business despite bad shocks is the goal), then optimal maturity is very long ($m \to \infty$)
- If only an immediate investment and not more then optimal maturity is very short ($m \to 0$)

Correlation between investment opportunity and asset in place

- Short-term debt can preserve investment incentives when asset-in-place is high, but dwarf incentives when asset-in-place is bad.
- Less positive correlation makes value maximizing maturity longer (investment incentives in bad times are important).
- Generalizes the example.

Short-term overhang and intertemporally linked investment

- Static model like Myers, no overhang for riskless debt. Things may be different in dynamic models.
- The more future growth, the more beneficial of today's investment (increase asset-in-place)
- ST debt makes firm default earlier, which truncates firm's future growth
- This reduces today's investment benefit!
- To the extreme, ultra short-term debt (like demandable deposit) is riskless, but equity defaults at X_B=rP, reducing investment incentives
  - Debt overhang occurs for riskless debt!

Summary and implications

- Short-term debt does not generally improve investment incentives once its dynamic effects of the increased volatility of overhang is understood.
- Future investment interacts with endogenous default.
- Incentive effects of very short-term debt structures have been misunderstood and little studied.

Financial Regulation: Implications/ Applications

- Requiring some long-term debt to “bail in” without failure need not increase overhang, reduce investment/lending or reduce private recapitalization incentives.
- Banks with bad incentives (to take systemic liquidity risk, for example) are problems of short-term finance and not just problems caused by a safety net or Too Big to Fail.
- Explicit quantitative analysis is needed to implement improved capital regulation.