Key Workers and Funding Horizons: Interest Rates and Growth

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Current Advances in Macro and Financial Markets
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Reporting on two papers, both with Nobuhiro Kiyotaki (Princeton) and Shengxing Zhang (LSE):

- "Key Workers and Funding Horizons"

- "Funding Horizons, Interest Rates, and Growth"

- To finance investment, entrepreneurs raise external funds against the value of the firm

- Value of the firm, debt + equity, appears to have short horizons:
  - cash-flow based debt is limited by 3 to 4.5 years' worth of recent EBITDA (Lian and Ma, QJE 2021)
  - under equity financing, stock analysts typically provide 5-year earning forecast (De la O and Myers, JF 2021)

- Why are external financiers' horizons short, even when the firm's duration is long?
- How do short funding horizons interact with growth and business cycles?

- Approach:
  - Key workers' human capital is essential for constructing and maintaining production facilities
  - Their human capital is inalienable (Hart and Moore, QJE 1994)

Discrete time, infinite horizon, $t = 0,1,2,\ldots$

At date 0, construction requires a group of $n \geq 1$ engineers (key workers): per unit,

$$\left.\begin{array}{c} x \text{ goods} \\ 1 \text{ building} \end{array}\right\} \rightarrow \text{1 plant with initial productivity } z_1 = 1$$

Let $q = \dfrac{f}{R-1}$ be price of a building (f is rental price), where $R > 1$ is gross interest rate

$$\text{investment scale} = \frac{n \times \text{net worth of an engineer}}{x + q - b}$$

where $b =$ external funding capacity per unit

To finance as big an investment as possible, engineers sell the plant ownership to a saver

- At date $t \geq 1$, a plant with productivity $z_t = z$, say, where $z \leq 1$, generates az goods

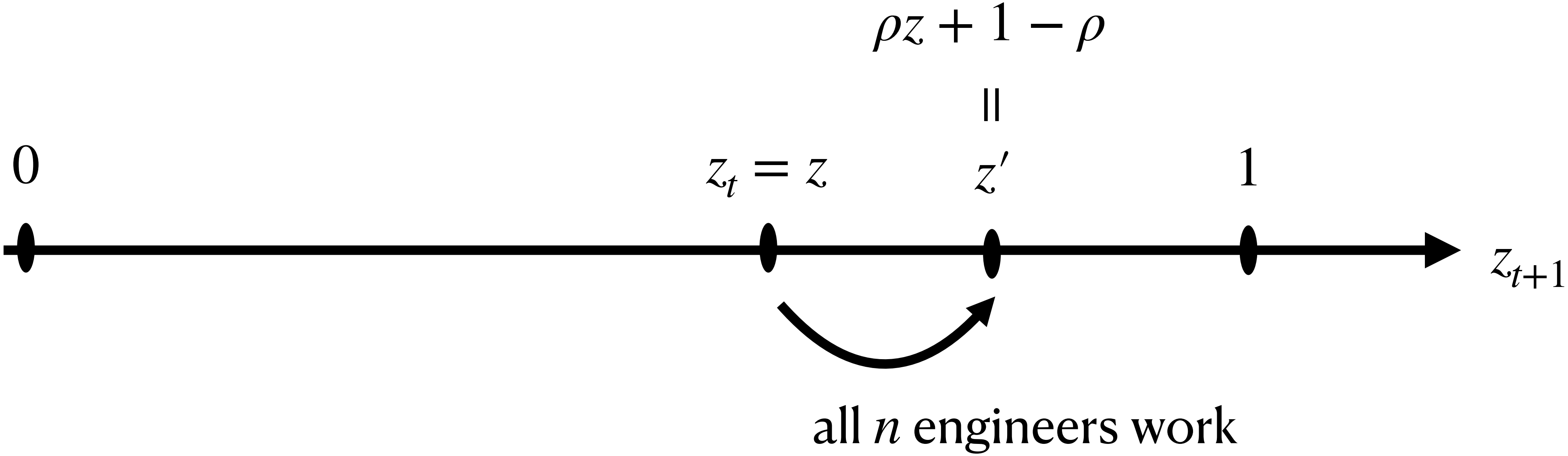
- Owner automatically receives these az goods (no need for engineers)

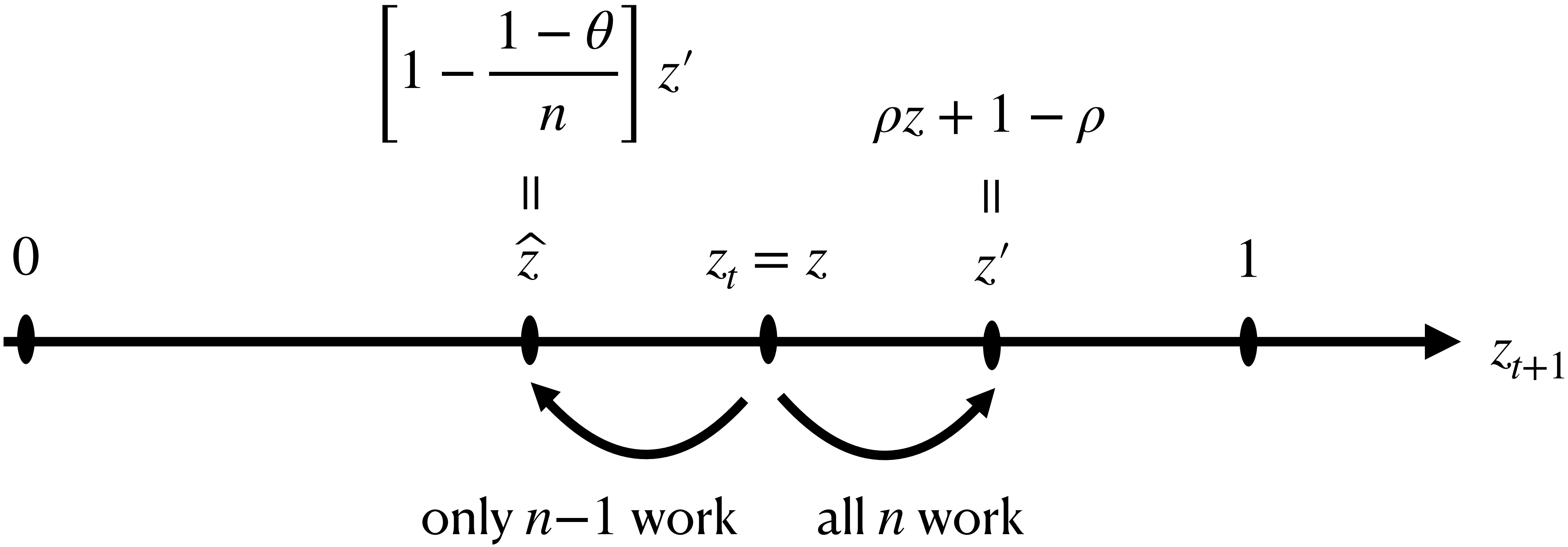
- Engineers' skills are needed to maintain the productivity next period z_{t+1}:

all n engineers work	$\rightarrow$	$z_{t+1} = z' = \rho z + 1 - \rho$
only $n - 1$ work	$\rightarrow$	$z_{t+1} = \hat{z} = \left[1 - \dfrac{1-\theta}{n}\right] z'$
fewer work	$\rightarrow$	complete and permanent plant failure

here, notice the production "roundaboutness" — cf Böhm-Bawerk 1889 & Austrian School

- Engineers negotiate wage payment with plant owner every period


$\rho z + 1 - \rho$
$\parallel$
0
$z_t = z$
z'
1
z_{t+1}
all n engineers work



$\left[1 - \frac{1-\theta}{n}\right] z'$
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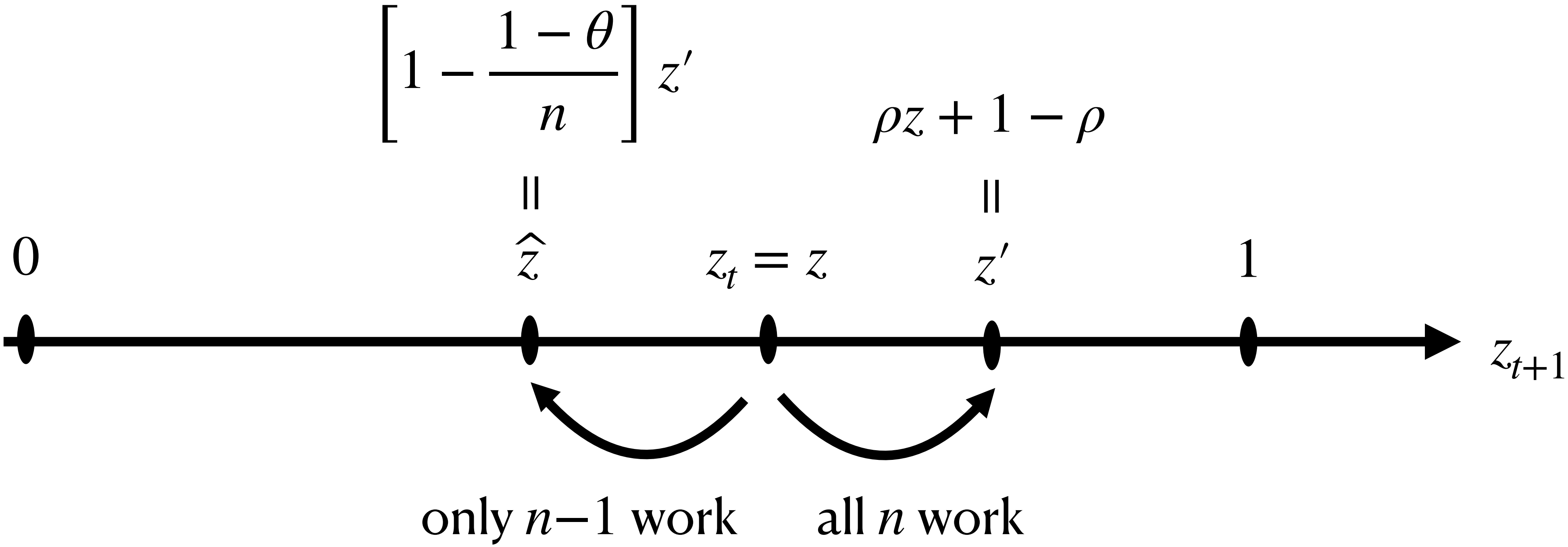
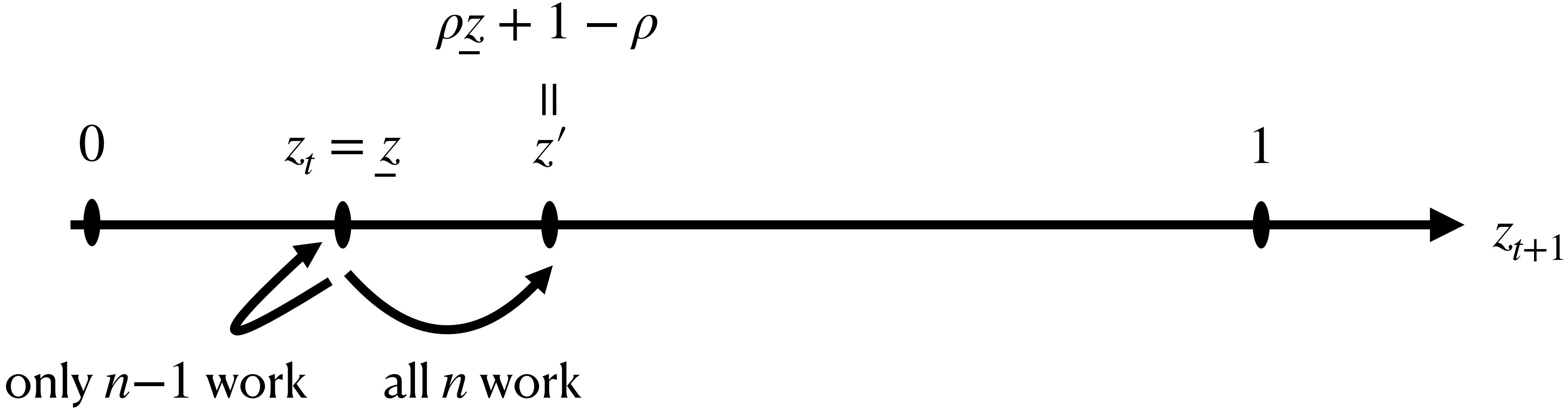
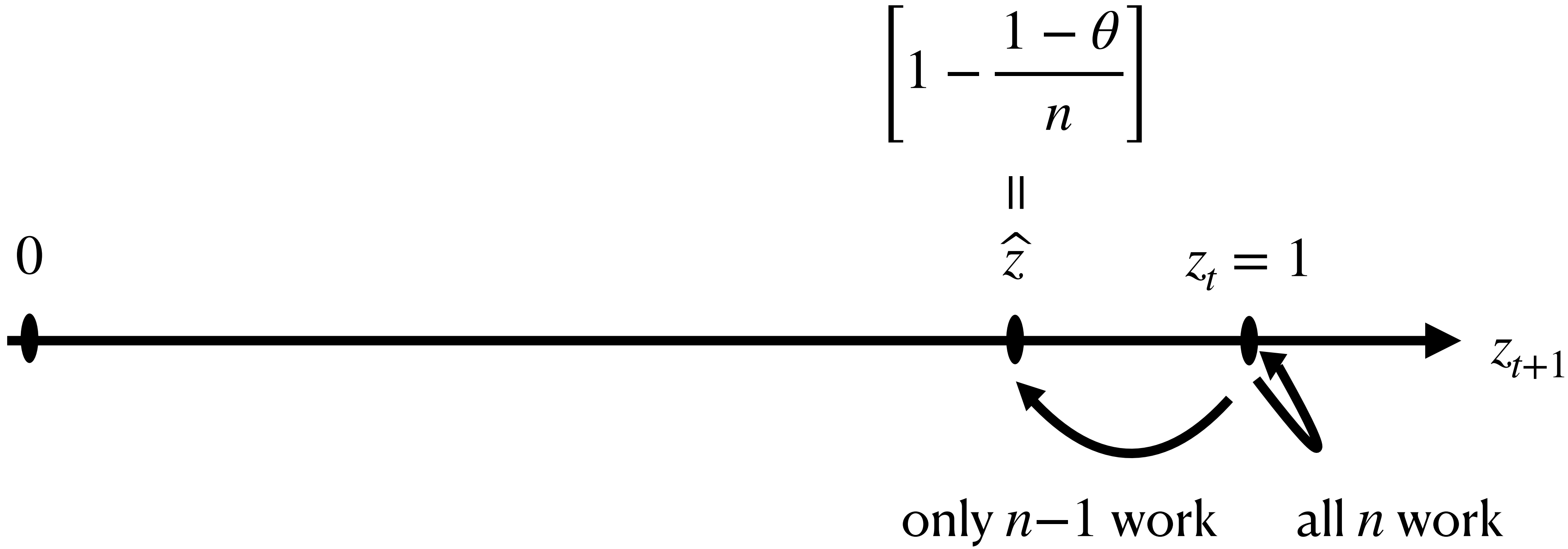


$$\text{gap} \quad z' - \widehat{z} = \frac{1-\theta}{n} z' = \frac{1-\theta}{n}(\rho z + 1 - \rho)$$

= an engineer's marginal contribution to maintenance lowest feasible productivity value $\underline{z} = \dfrac{(1-\rho)\left[1-\frac{1-\theta}{n}\right]}{1-\rho\left[1-\frac{1-\theta}{n}\right]} \in (0,1)$



along equilibrium path, productivity z stays at maximum value 1:



- External funding capacity per unit equals plant value to an owner: $b = \frac{1}{R}V(1)$,

$$V(z) = az + \max\left\{ q, -nw(z) + \frac{1}{R}V(z') \right\}$$

where $w(z)$ is wage payment per unit to each engineer

- Each engineer makes a take-it-or-leave-it offer to owner,
  taking other engineers' offers as given

In Nash equilibrium, away from liquidation, $V(z) = az - nw(z) + \frac{1}{R}V(z')$ and

$$w(z) = \frac{1}{R}[V(z') - V(\hat{z})]$$

Proposition: Away from liquidation, within the class of polynomials, $V(z)$ is unique and affine: $V(z) = c + vz$.

So
$$w(z) = \frac{1}{R}[V(z') - V(\hat{z})] = \frac{v}{R}(z' - \hat{z}) = \frac{v}{R}\frac{1-\theta}{n}z'$$

and
$$\begin{aligned} V(z) &= az - nw(z) + \frac{1}{R}V(z') \\ &= az - n\left[\frac{v}{R}\frac{1-\theta}{n}z'\right] + \frac{1}{R}[c + vz'] \\ &= az + \frac{1}{R}[c + v\theta z'] \end{aligned}$$

Substituting $V(z) = c + vz$ into LHS, and $z' = \rho z + 1 - \rho$ into RHS, we get:

$$c + vz \;=\; az + \frac{1}{R}\left[c + v\theta(\rho z + 1 - \rho)\right] \qquad \text{for all } z \text{ in } [\underline{z},1]$$

To solve for the unknowns c and v, we equate coefficients in this identity:

Coefficient of z:

$$v = a + \frac{1}{R}v\theta\rho$$

Solving for v:

$$v = \frac{Ra}{R - \theta\rho}$$

$$= \; a + \frac{\theta\rho}{R}a + \left(\frac{\theta\rho}{R}\right)^2 a + \left(\frac{\theta\rho}{R}\right)^3 a + \ldots$$

Short-termism

(we could also obtain this expression for v by iterating forward the coefficient of z)

Along equilibrium path, $z = z' = 1$ and $w(1) = w$, say, and wage bill equals

$$nw = n\left[\frac{v}{R}\frac{1-\theta}{n}\right] = \frac{1-\theta}{R}v = \frac{1-\theta}{R}\left[a + \frac{\theta\rho}{R}a + \left(\frac{\theta\rho}{R}\right)^2 a + \ldots\right]$$

External funding capacity equals

$$b = \frac{1}{R}V(1) = \frac{1}{R}(a - nw) + \frac{1}{R^2}(a - nw) + \frac{1}{R^3}(a - nw) + \ldots$$

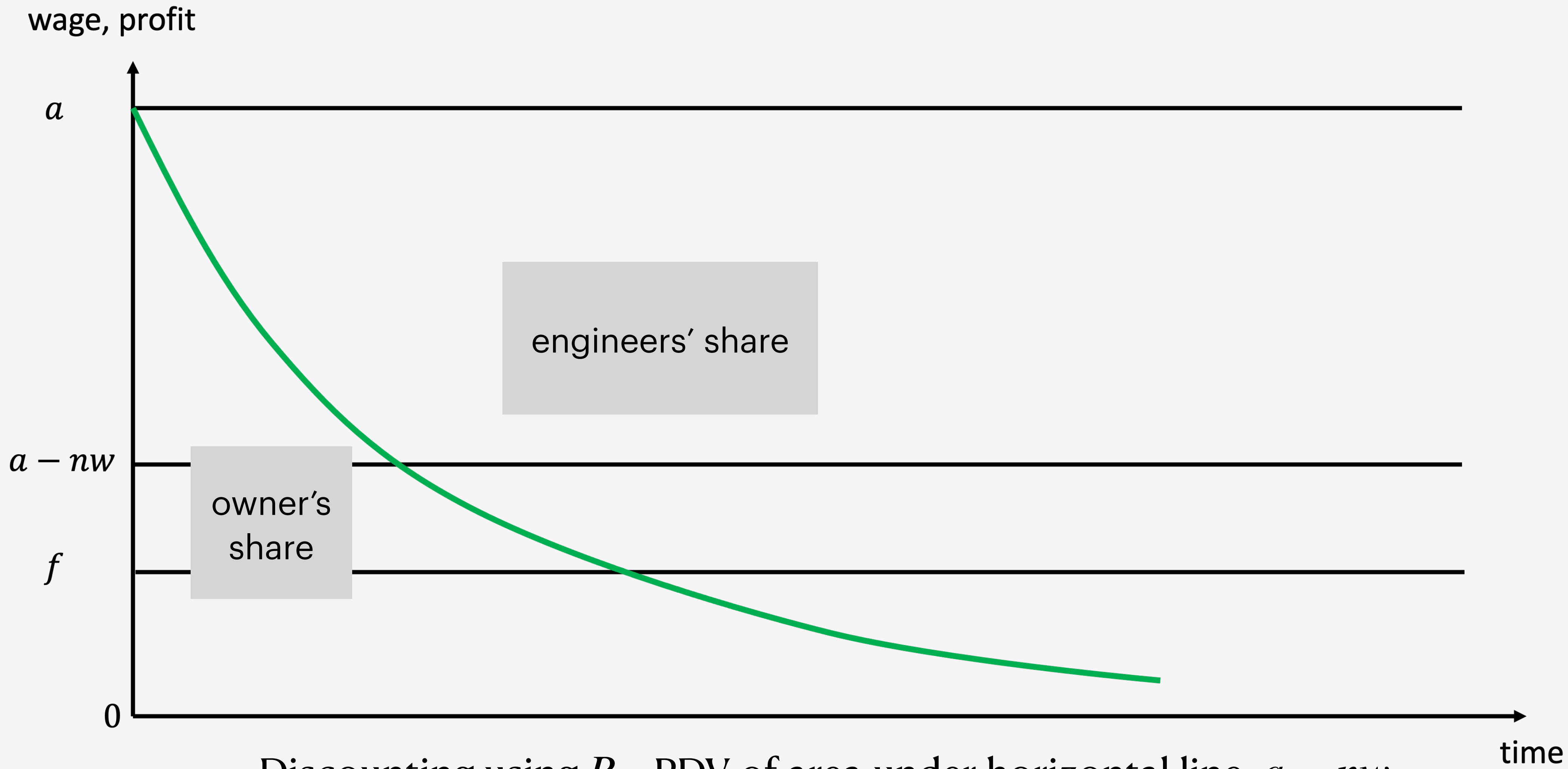
horizontal line $a - nw$ on next page ...

$$= \frac{1}{R}a + \frac{1}{R^2}a\left[1 - (1-\theta)\right] + \frac{1}{R^3}a\left[1 - (1-\theta) - (1-\theta)\theta\rho\right]$$

$$+ \frac{1}{R^4}a\left[1 - (1-\theta) - (1-\theta)\theta\rho - (1-\theta)\theta^2\rho^2\right] + \ldots$$

downward-sloping green line on next page ...

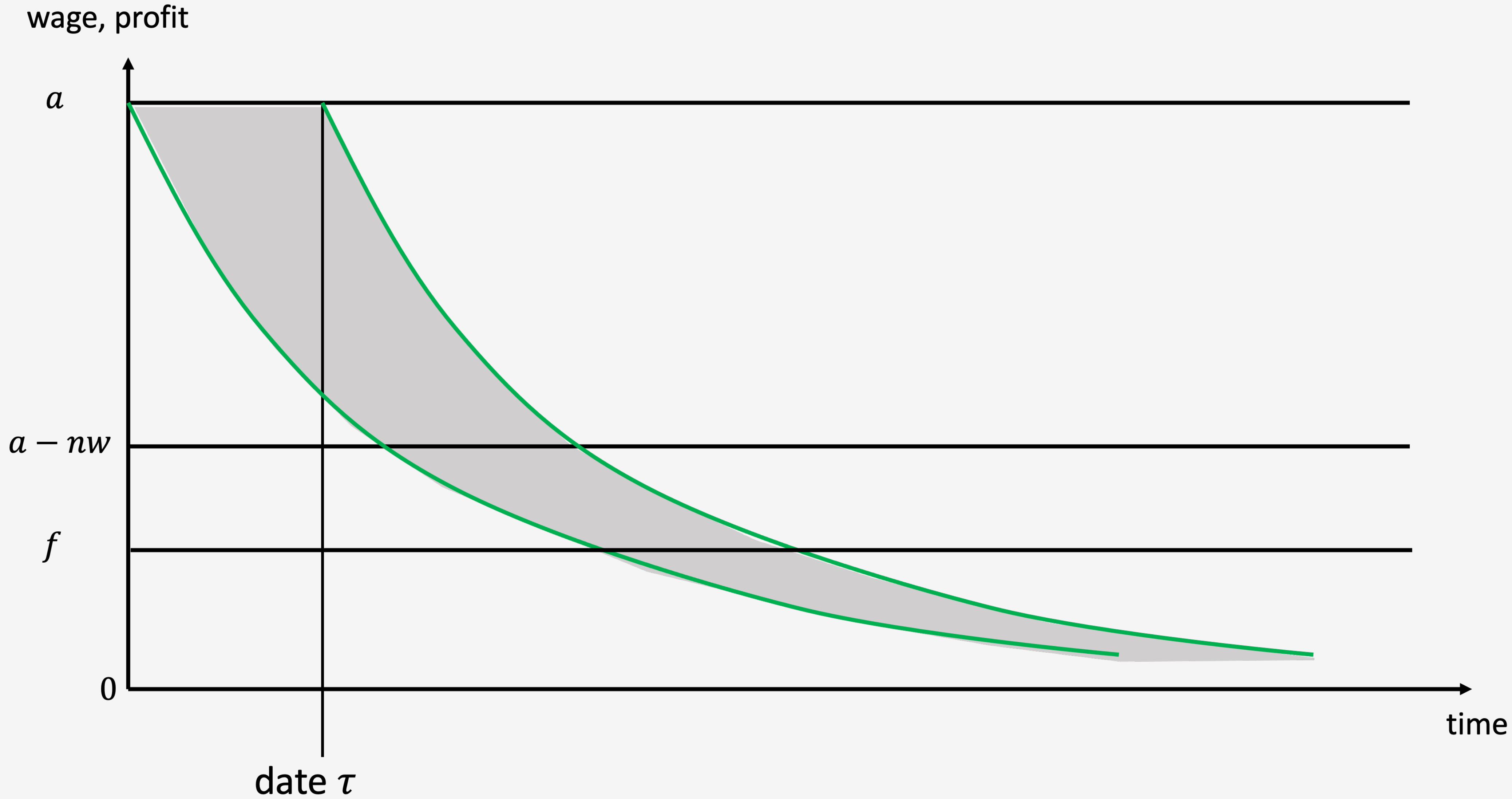
Earnings Share of Owner and Engineers



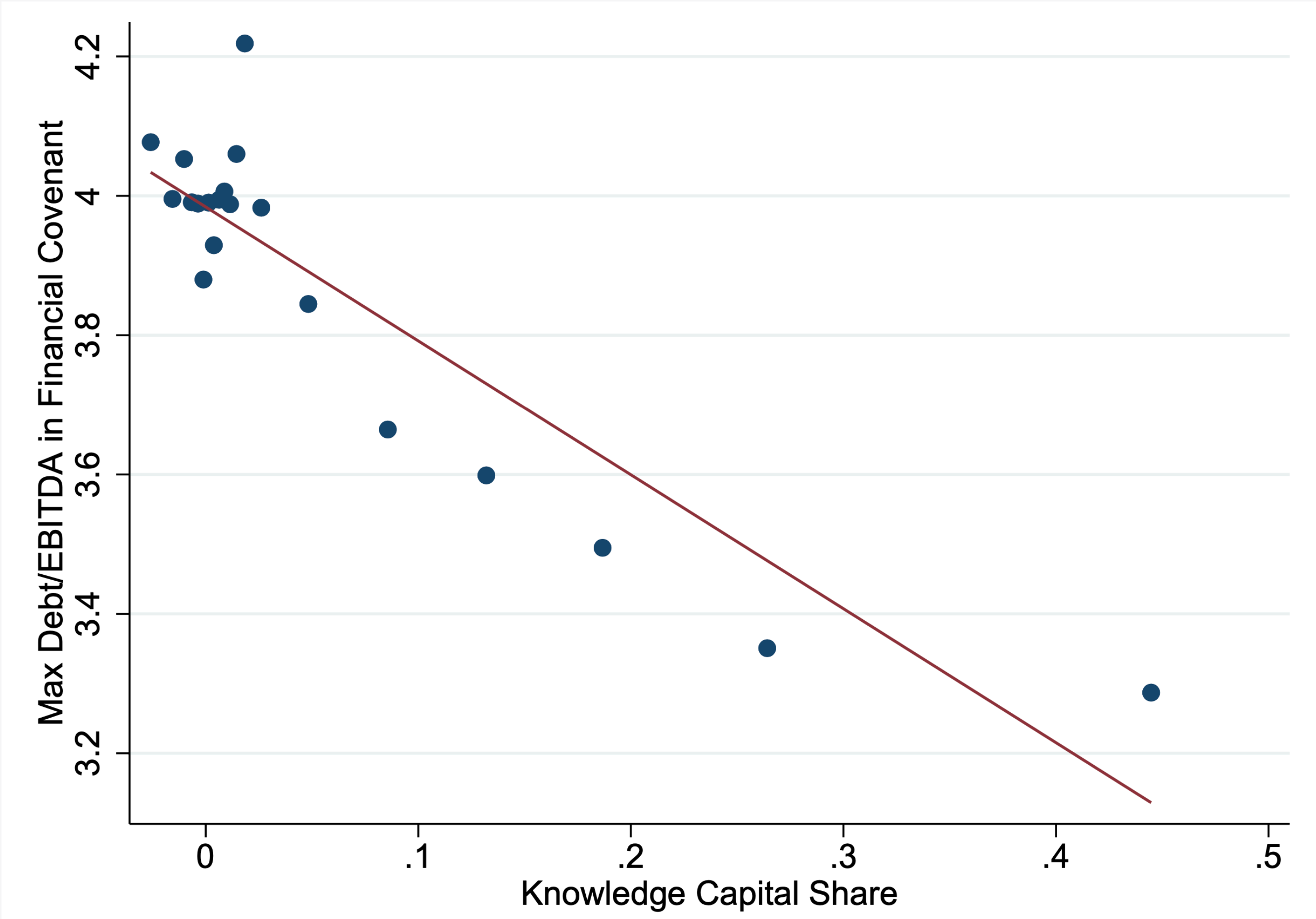
Discounting using R, PDV of area under horizontal line $a - nw$

$= \text{PDV of area under downward-sloping green line}$

Why doesn't the plant owner eventually liquidate?



Human capital and credit horizons



from Yueran Ma's ongoing research

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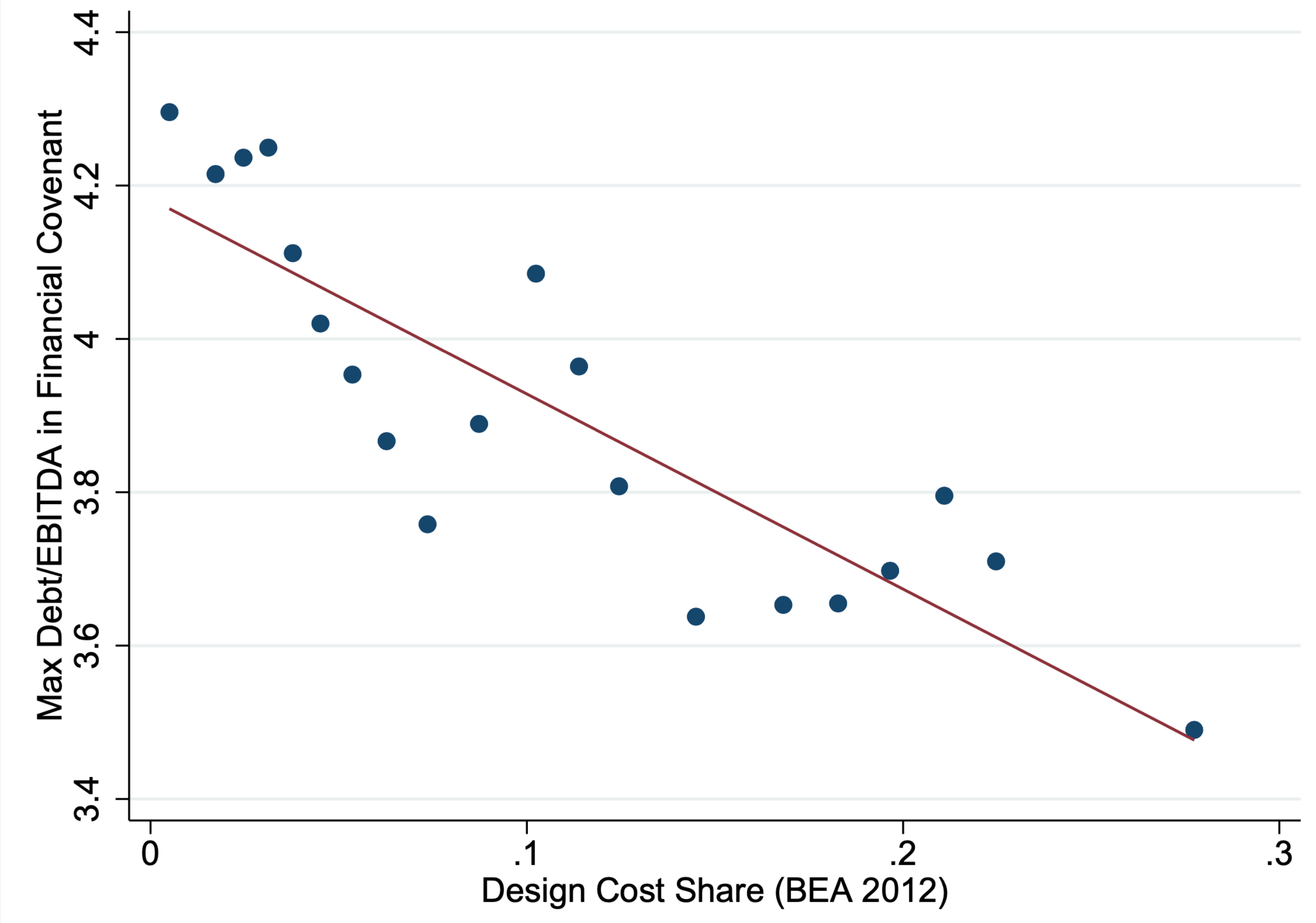

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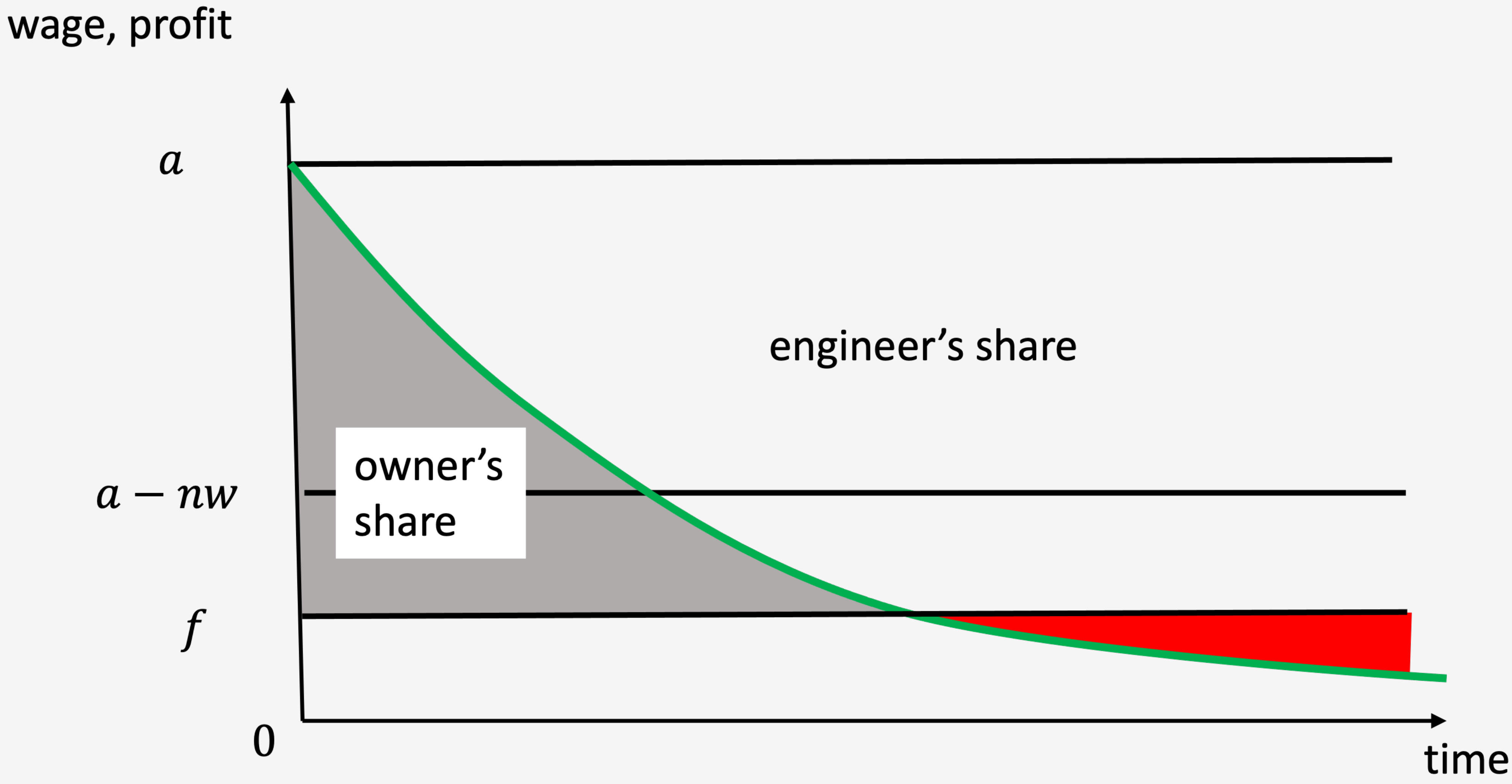
Long-Run implications of short funding horizons

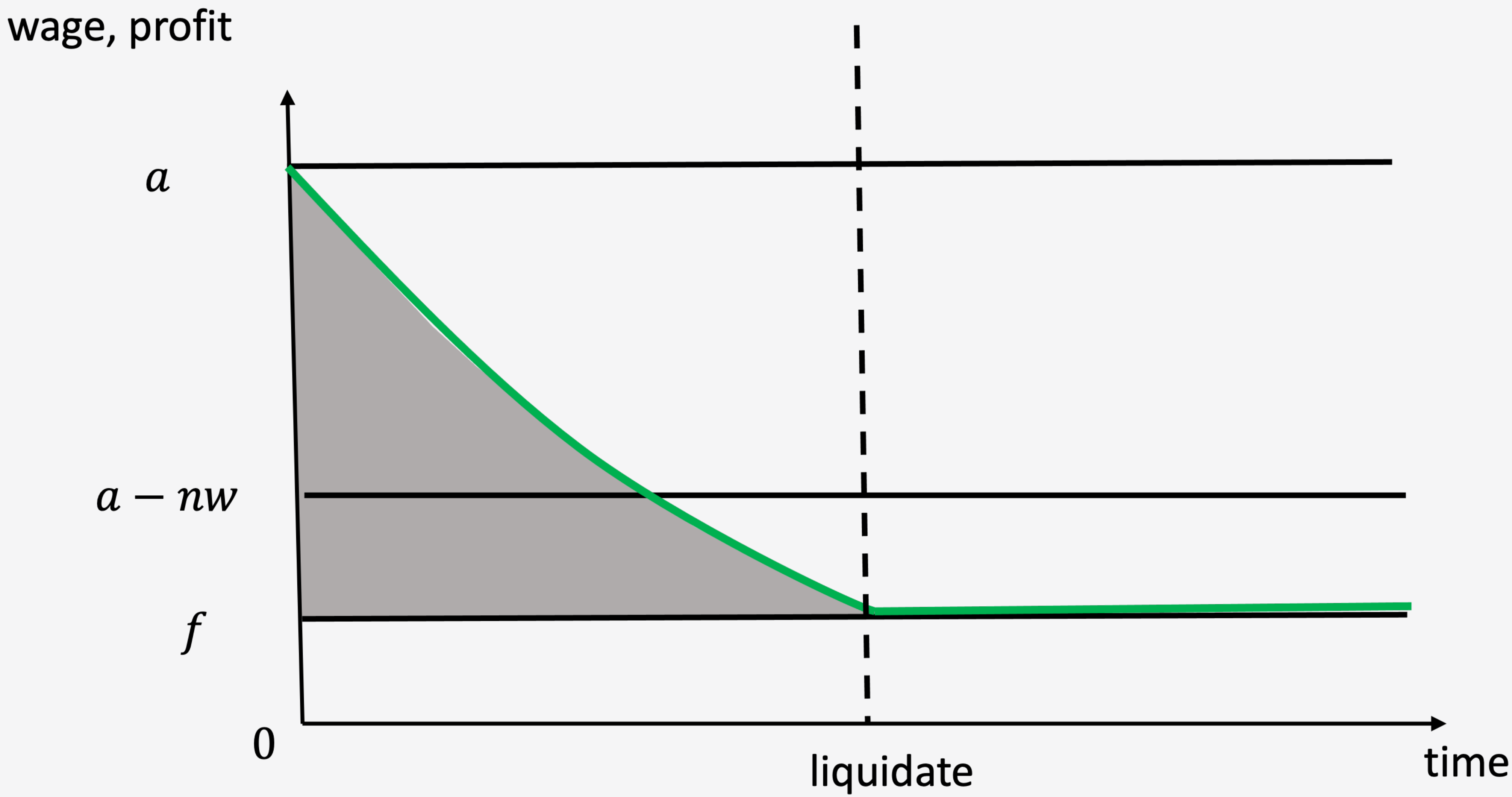
$$\text{gross investment} = \frac{\text{net worth of engineers after consumption}}{\text{investment cost } (x+q) - \text{ external funding capacity } b}$$

- External funding capacity b has a shorter horizon than building price q
- How does a persistent fall in interest rate affect *net* funding capacity, $b - q$?
- Our macro model: small open economy with exogenous world interest rate R

Cashflow behind net funding capacity $b - q$



Why this "funky" Austrian technology? Why not standard depreciation:



Proposition:

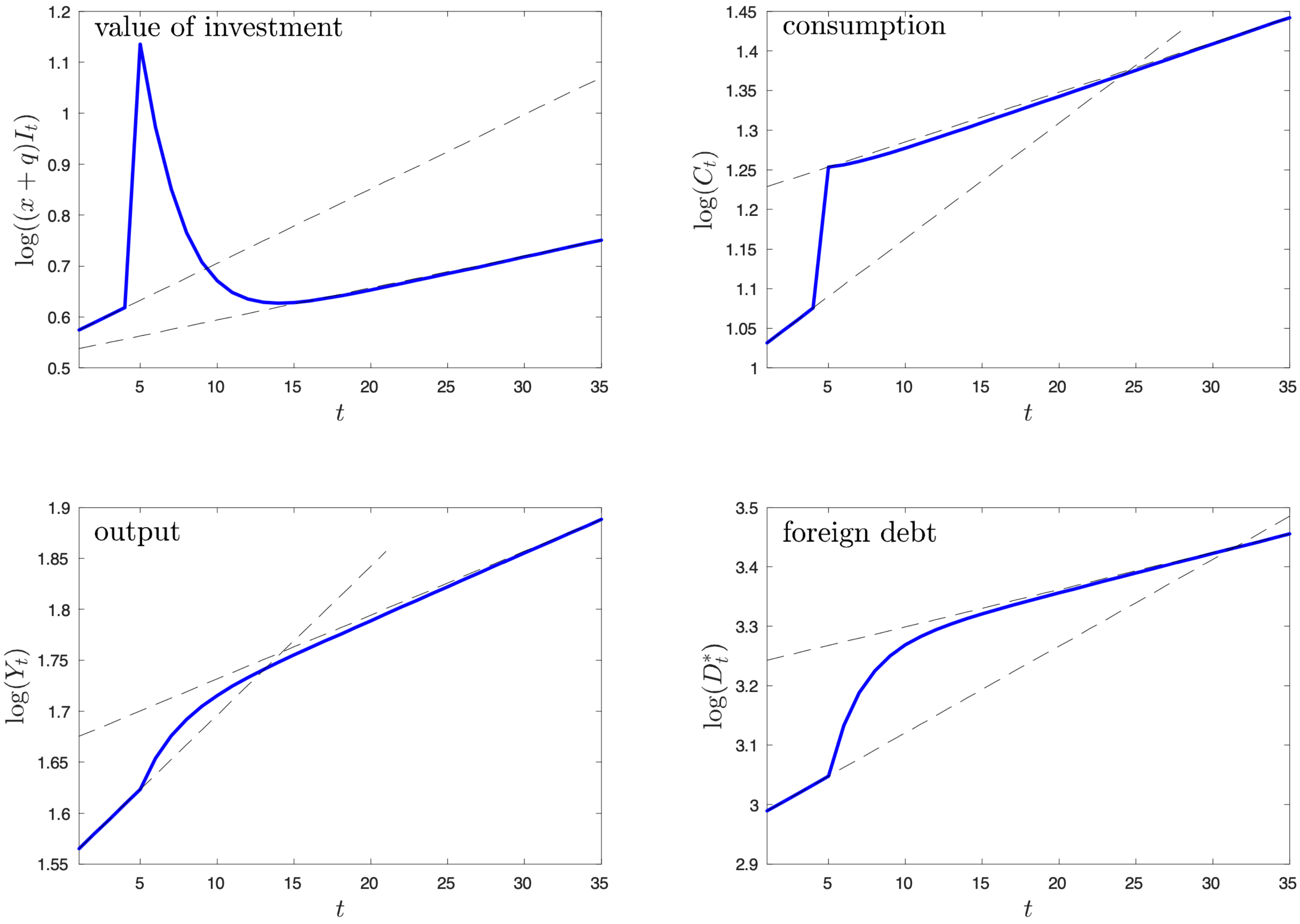
For $n \geq 2$, a persistent fall in R can cause q to rise more than b, so that net funding capacity $b - q$ *falls*

cf. housing market

In our macro model, this effect can be strong enough — overcoming rise in net worth — to stifle investment and growth:

$$\text{gross investment}\downarrow = \frac{\text{net worth of engineers after consumption}\uparrow}{\text{investment cost }(x+q)\uparrow\uparrow - \text{ borrowing capacity } b\uparrow}$$

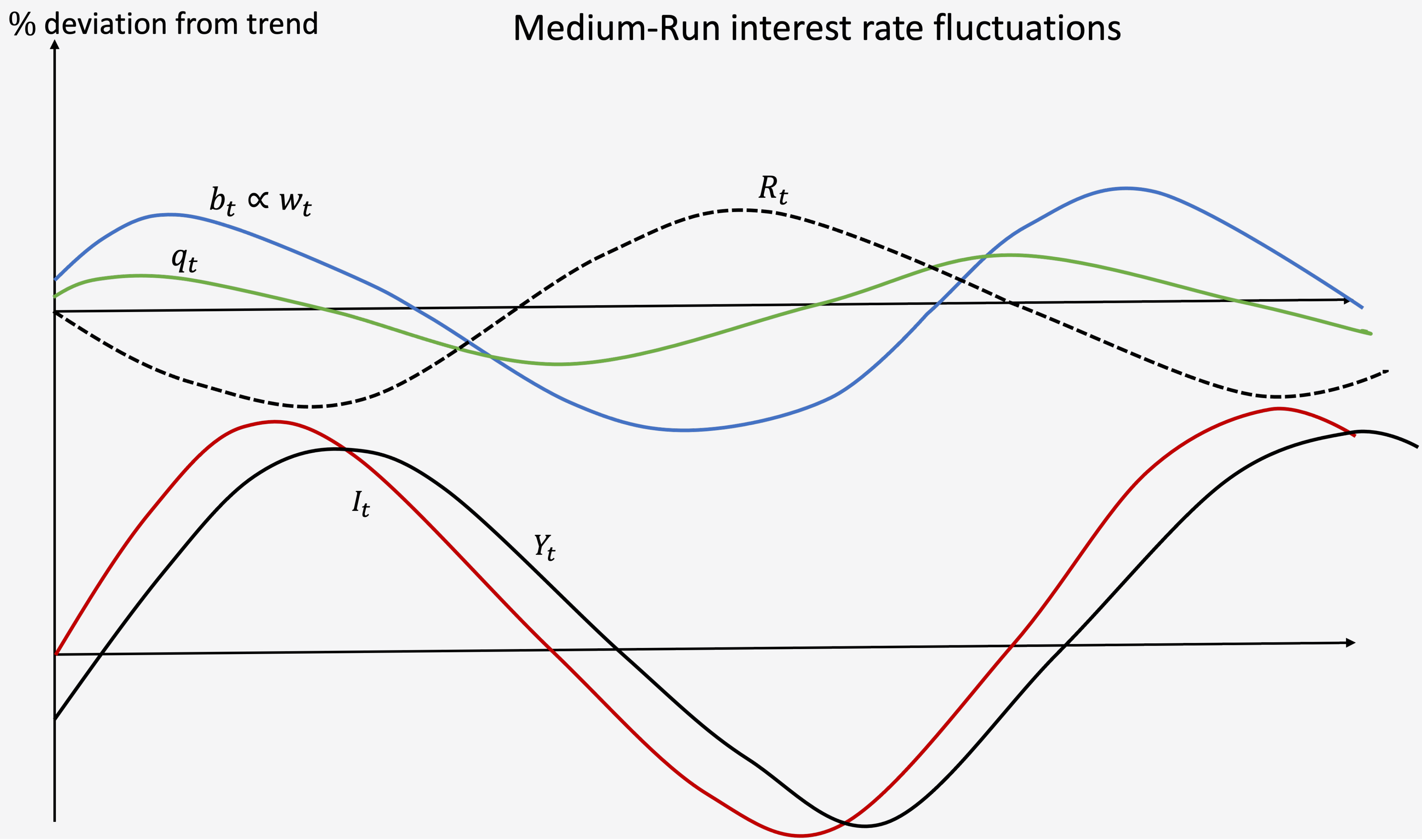
Unexpected fall of interest rate from 2.5% to 1.5% at date 5

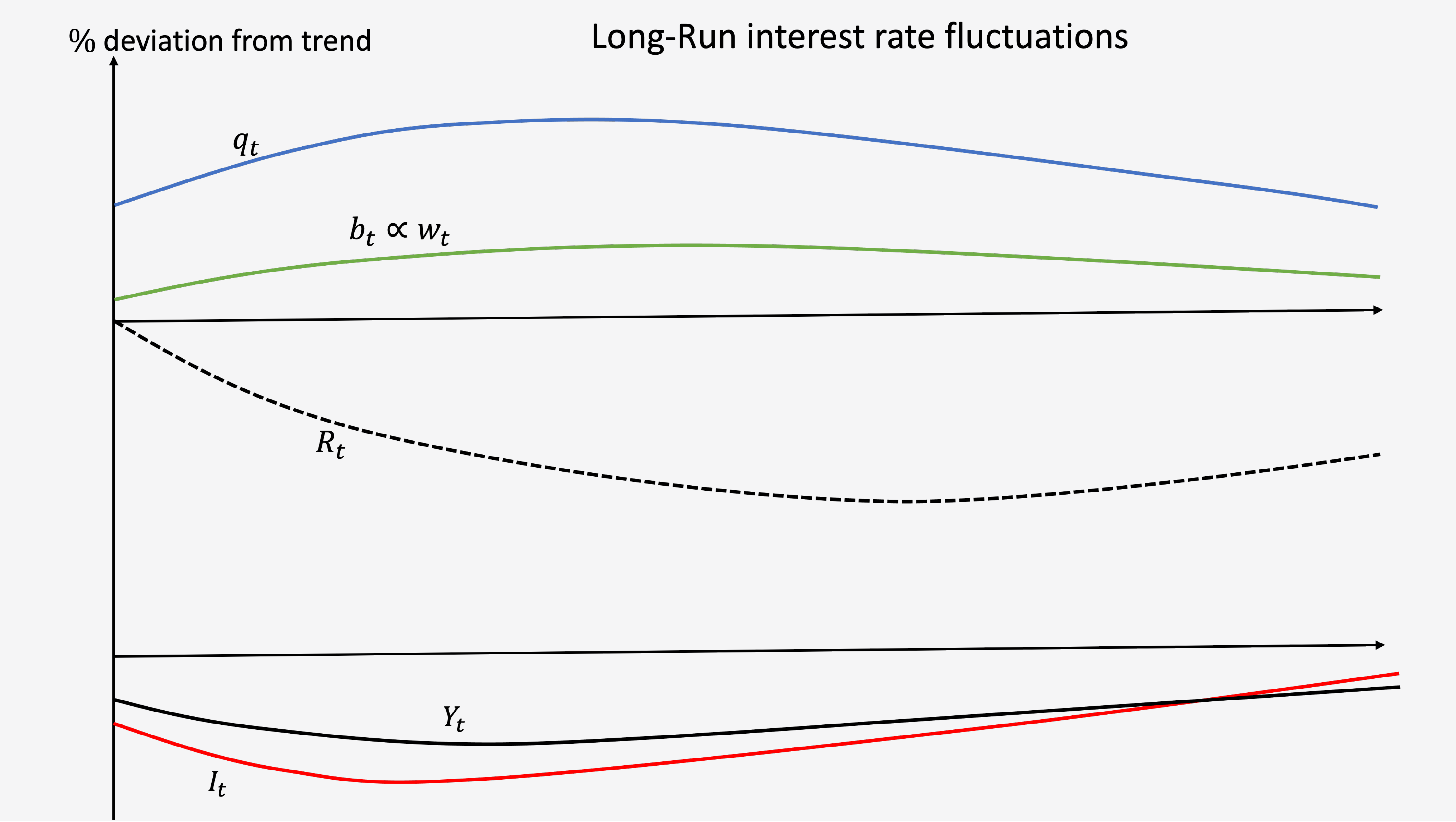


Medium-Run implications of short funding horizons

$$\text{gross investment} = \frac{\text{net worth of engineers after consumption}}{\text{investment cost } (x+q) \; - \; \text{external funding capacity } b}$$

If the fall in interest rate is only transitory, b rises more than q, so that $b - q$ *rises*


% deviation from trend
Medium-Run interest rate fluctuations
$b_t \propto w_t$
R_t
q_t
I_t
Y_t



Long-Run interest rate fluctuations
% deviation from trend
q_t
$b_t \propto w_t$
R_t
Y_t
I_t

Welfare: *all* domestic agents (engineers as well as savers) can suffer from drop in R

Policy?

- Inalienability of the engineers' human capital is the sole departure from Arrow-Debreu
- Suppose that the government could tax the plant owner's payroll at rate τ
- The government uses the revenue to subsidise investment with balanced budget
- Welfare can rise with τ:

  government is acting as a social creditor to engineers