New Keynesian Economics with Household and Firm Heterogeneity

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The New Keynesian model and heterogeneity

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  - Simple 3-equation version for intuition (C as single component of agg. demand)
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  - Quantitative versions for policy analysis (C and I; other "bells and whistles")
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- Yet, micro data on households and firms show vast amounts of heterogeneity!
  - in income, wealth, consumption; productivity, size, leverage…
- How does this matter for the aggregate effects of monetary and fiscal policy?

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- This paper (in prep for JEL): **bring firm heterogeneity into HANK**
  - Firm heterogeneity really changes policy transmission — just like for households

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- Different from MPCs, we have no direct evidence on distribution of MPIs in data
  - More empirical work needed to discipline these new mechanisms

Plan

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1. Policy transmission in representative household + representative firm NK model
2. HANK review: transmission mechanisms for C with household heterogeneity
3. New transmission mechanisms for I with firm heterogeneity
4. Complementarities from combining heterogeneous households and firms

Representative household + firm model

Representative agent model

$C_t \equiv$ consumption, $N_t \equiv$ hours, $A_t \equiv$ assets, $Y_t \equiv$ output, $K_t \equiv$ capital, $I_t = K_t - (1-\delta)K_{t-1} \equiv$ gross investment
$w_t \equiv$ real wage per hour, $r_t \equiv$ ex-ante real rate, $T_t^h \equiv$ household transfer, $T_t^f \equiv$ firm transfer, $D_t \equiv$ dividends

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- Representative firm produces $Y_t = K_{t-1}^{\alpha} N_t^{\nu}$, faces capital adjustment costs, solves

$$\max_{K_t, N_t} \sum_{t\geq 0} \prod_{s\leq t} \frac{1}{1 + r_s} D_t \qquad D_t \equiv Y_t - w_t N_t - I_t - \varphi\left(\frac{I_t}{K_{t-1}} - \delta\right) K_{t-1} + T_t^f$$

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- Flexible prices and perfect competition: $w_t = MPN_t = \nu Y_t / N_t$

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Nominal wage rigidities, monetary and fiscal policy

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- Sticky nominal wages, reset à la Calvo [eg Erceg-Henderson-Levin]

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with CPI inflation $1 + \pi_t = (1 + \pi_t^w) w_{t-1}/w_t$. Implies ex-ante real rate $r_t = r_t^*$

[+ select among equilibria the one that brings aggregates back to s.s. in the long run]

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- **Equilibrium** given m.p. $\{r_t^*\}$ and f.p. $\{T_t^h, T_t^f\}$ is seq. of prices $\{w_t, \pi_t, \pi_t^w\}$ and aggregates $\{C_t, I_t, Y_t, D_t, K_t, N_t\}$ such that the goods market clears at all dates, $C_t + I_t + \varphi_t = Y_t$

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- Set $\alpha, \nu, \delta, \psi$ exogenously (here $\alpha + \nu < 1$), β to hit $r = 1\,\%$ quarterly

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0.32	0.6	2.5%	1	0.99

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- Set $\alpha, \nu, \delta, \psi$ exogenously (here $\alpha + \nu < 1$), β to hit $r = 1\%$ quarterly
- Here and throughout: pick remaining 2 parameters to hit the **peak** impulse response to an identified monetary policy shock [in spirit of Christiano-Eichenbaum-Evans]
  - Elasticity of intertemporal substitution $1/\sigma$ controls consumption response
  - Degree of capital adjustment costs ϕ controls investment response

α	ν	δ	ψ	β	σ	ϕ
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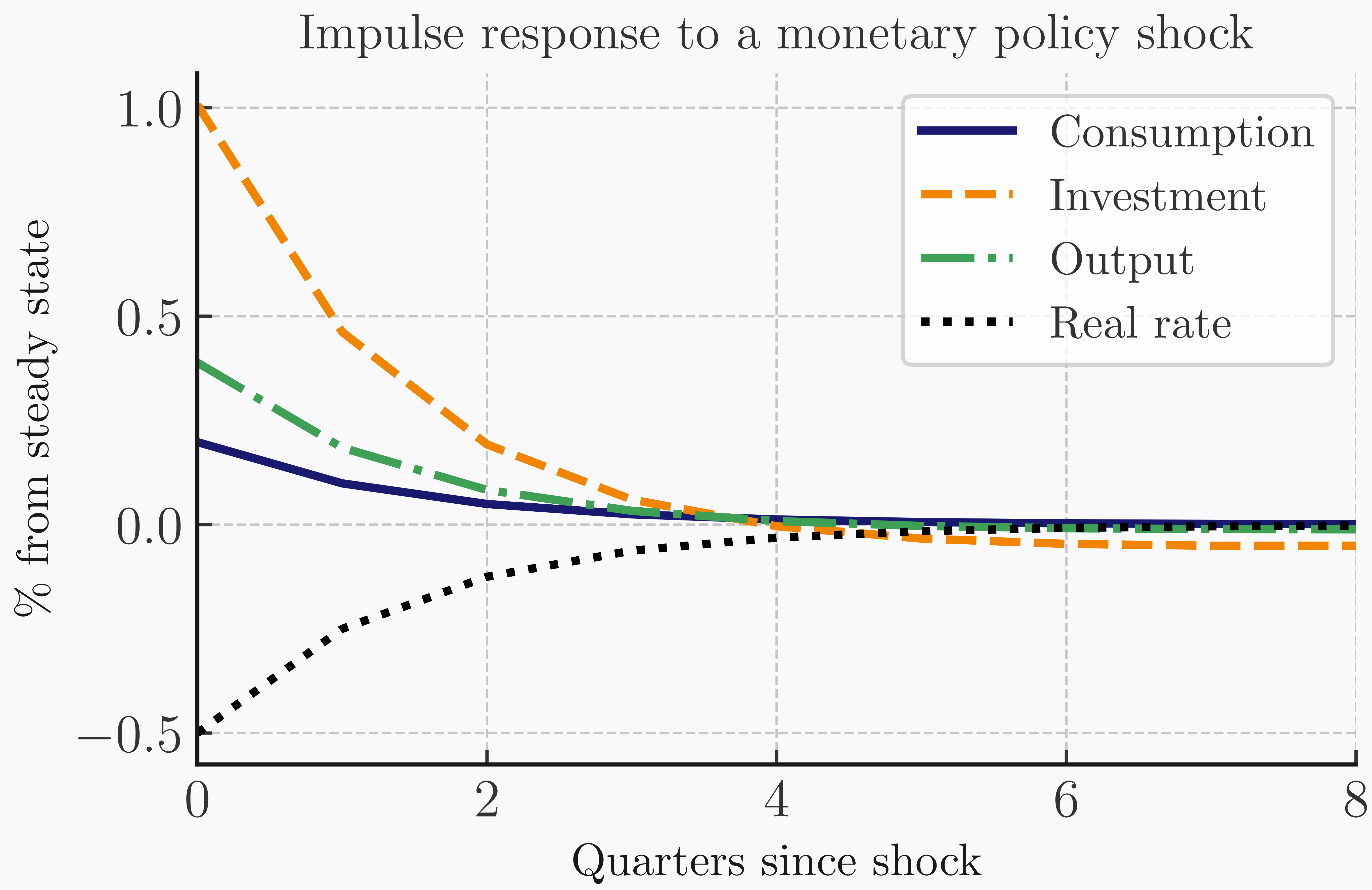
Impulse response to monetary policy shock



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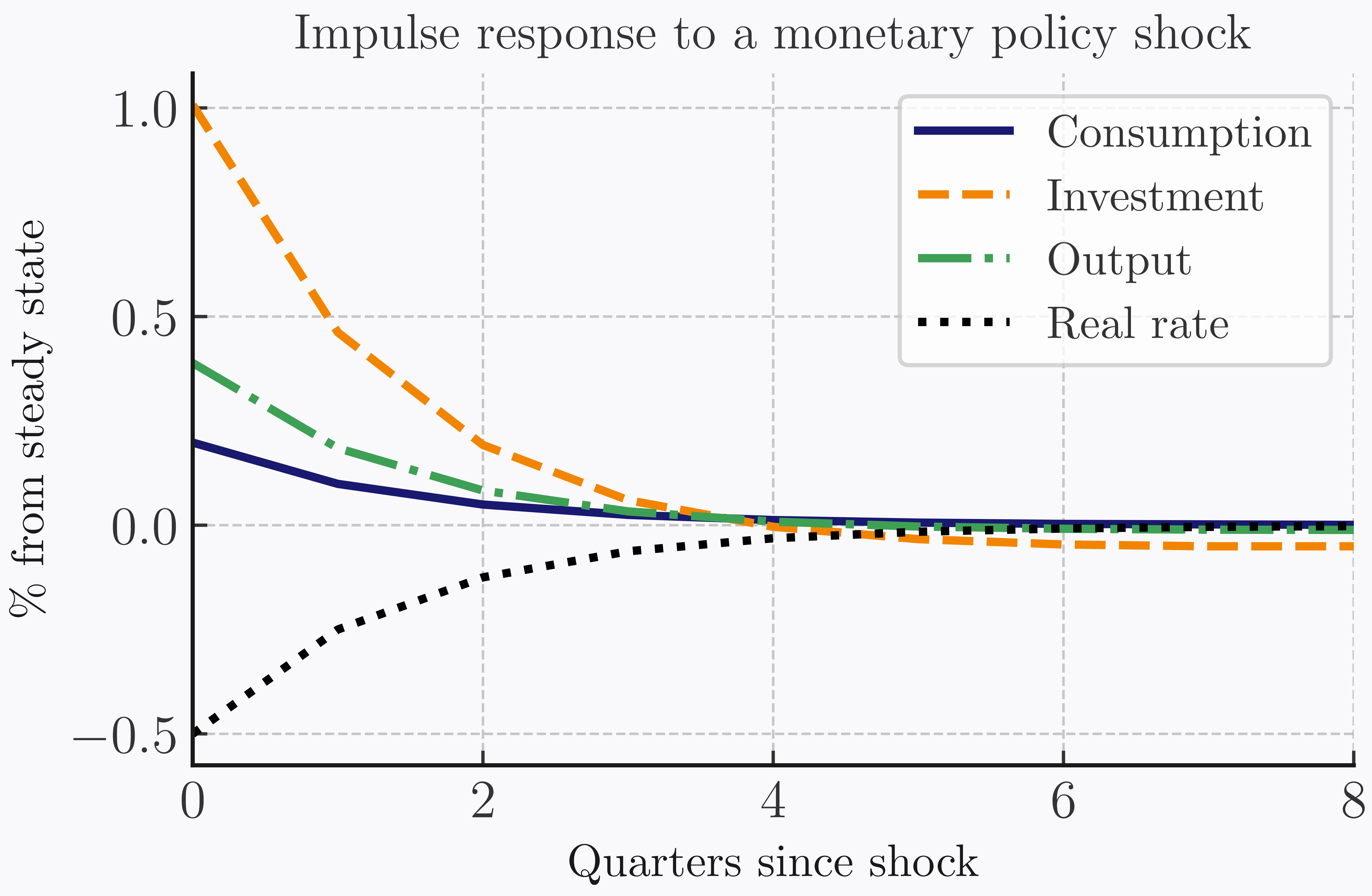

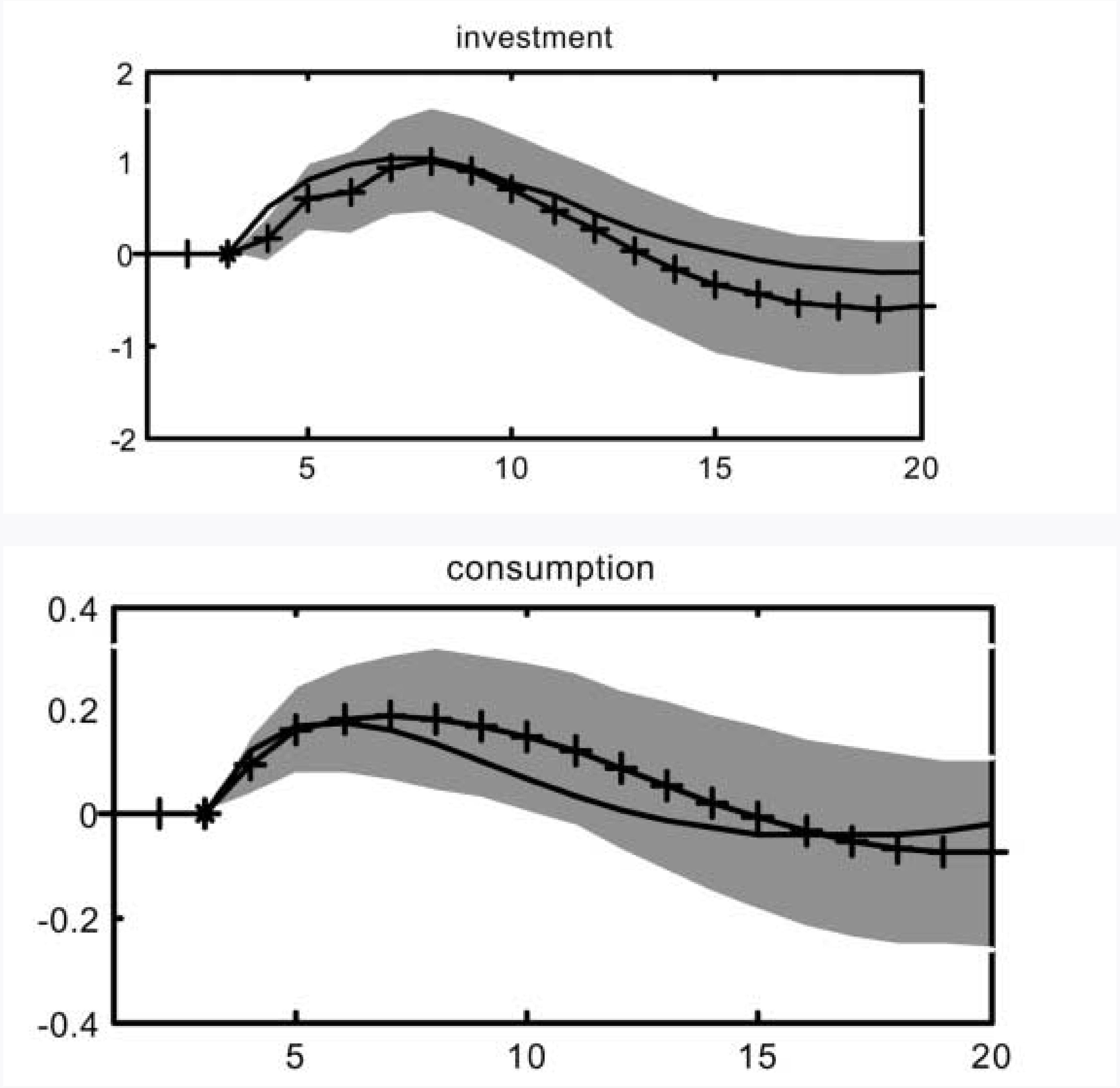

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source: Christiano, Eichenbaum, Evans 2005

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[Kaplan-Moll-Violante]

$$d \log C_t = -\frac{1}{\sigma} \cdot \sum_{s \geq t} \frac{dr_s^*}{1+r} + (1-\beta)\left(\frac{1}{\sigma}\sum_{k=0}^{\infty}\beta^k \sum_{s \geq k} \frac{dr_s^*}{1+r} + \sum_{s=0} \beta^t d\left(\frac{w_t N_t + D_t}{C}\right)\right)$$

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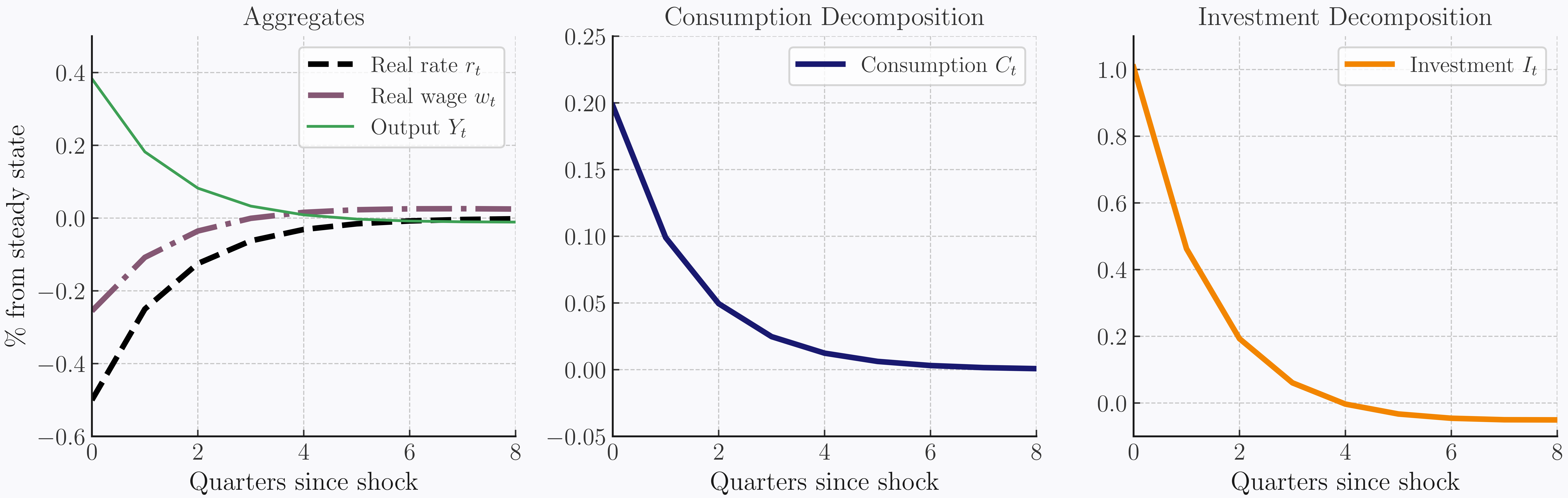
- **Equilibrium in sequence space** given $\{r_t^*, T_t^h, T_t^f\}$: sequence of real wages $\{w_t\}$ such that

$$C_t(\{r_s^*\}) + I_t(\{r_s^*, w_s\}) + \varphi_t(\{r_s^*, w_s\}) = Y_t(\{r_s^*, w_s\}) \quad \forall t$$

Decomposing the transmission mechanism of m.p.



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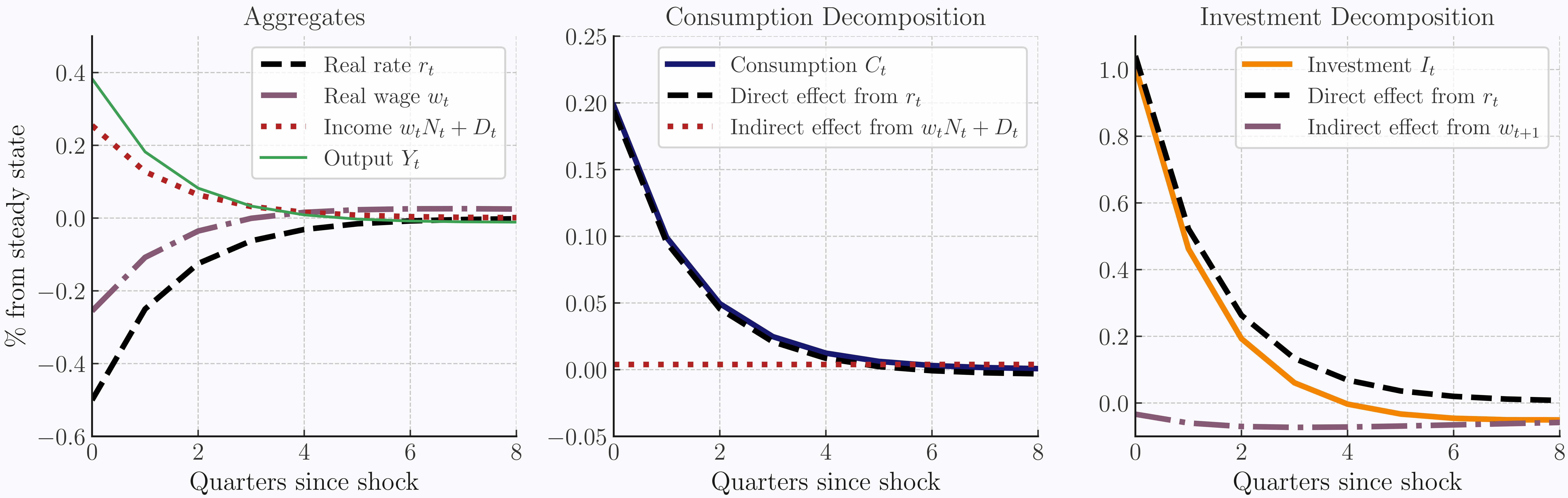

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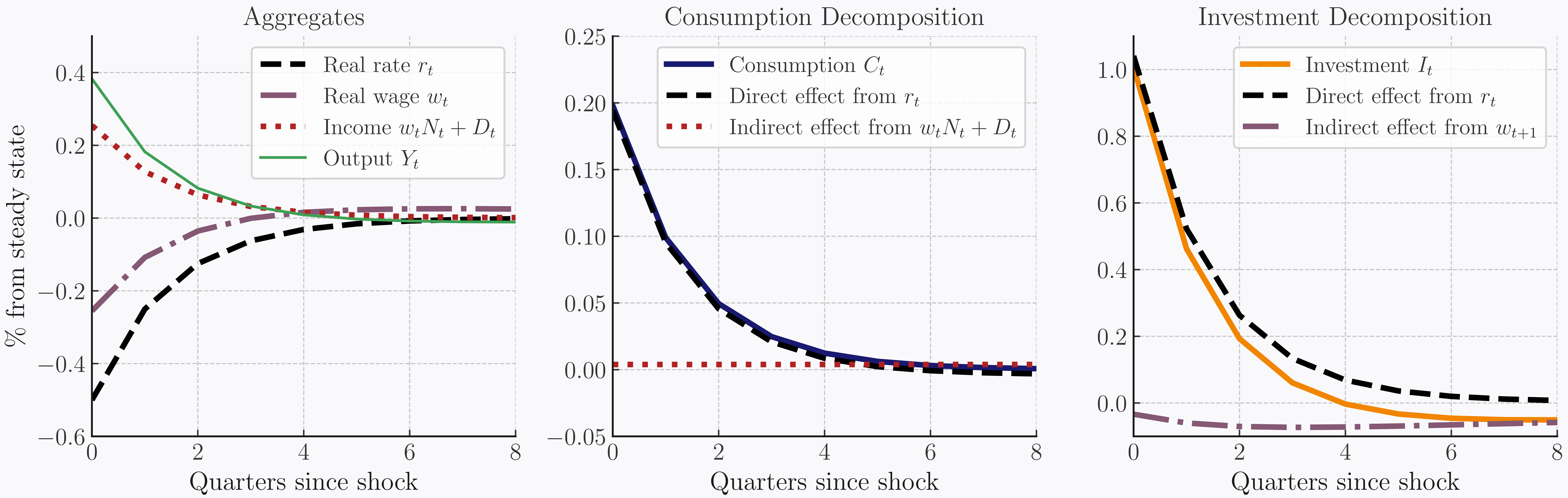

- Income has very small effect on *C*, current wages have no effect on *I*
- vs micro evidence: high *MPCs* out of incomes, non-zero *MPIs* out of cash flows!

[Parker-Johnson-Souleles, Jappelli-Pistaferri, Fagereng-Holm-Natvik…; Fazzari-Hubbard-Petersen…]

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- **Next**: reevaluate effects of monetary and fiscal policy in light of these models

Heterogenous households (HANK)

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- To get higher *MPC*s, build on long tradition of models with idiosyncratic income risk + prec. savings + borrowing constraints [Zeldes-Deaton-Carroll; Imrohoroglu-Bewley-Huggett-Aiyagari;…]

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- Household in idiosyncratic income state e with incoming assets a solves

$$v_t(a, e, \beta) = \max_{c,a'} u(c) + \beta \mathbb{E}[v_{t+1}(a', e', \beta') \,|\, e, \beta]$$

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- Calibrate income process e to micro data, set β process to hit aggregate A and $MPC = 0.25$
    - Single-β model faces tradeoff between hitting one and the other, other resolutions possible

[Kaplan-Violante 2022; Auclert-Rognlie-Straub 2025]

Steady state policies, MPCs, and distribution

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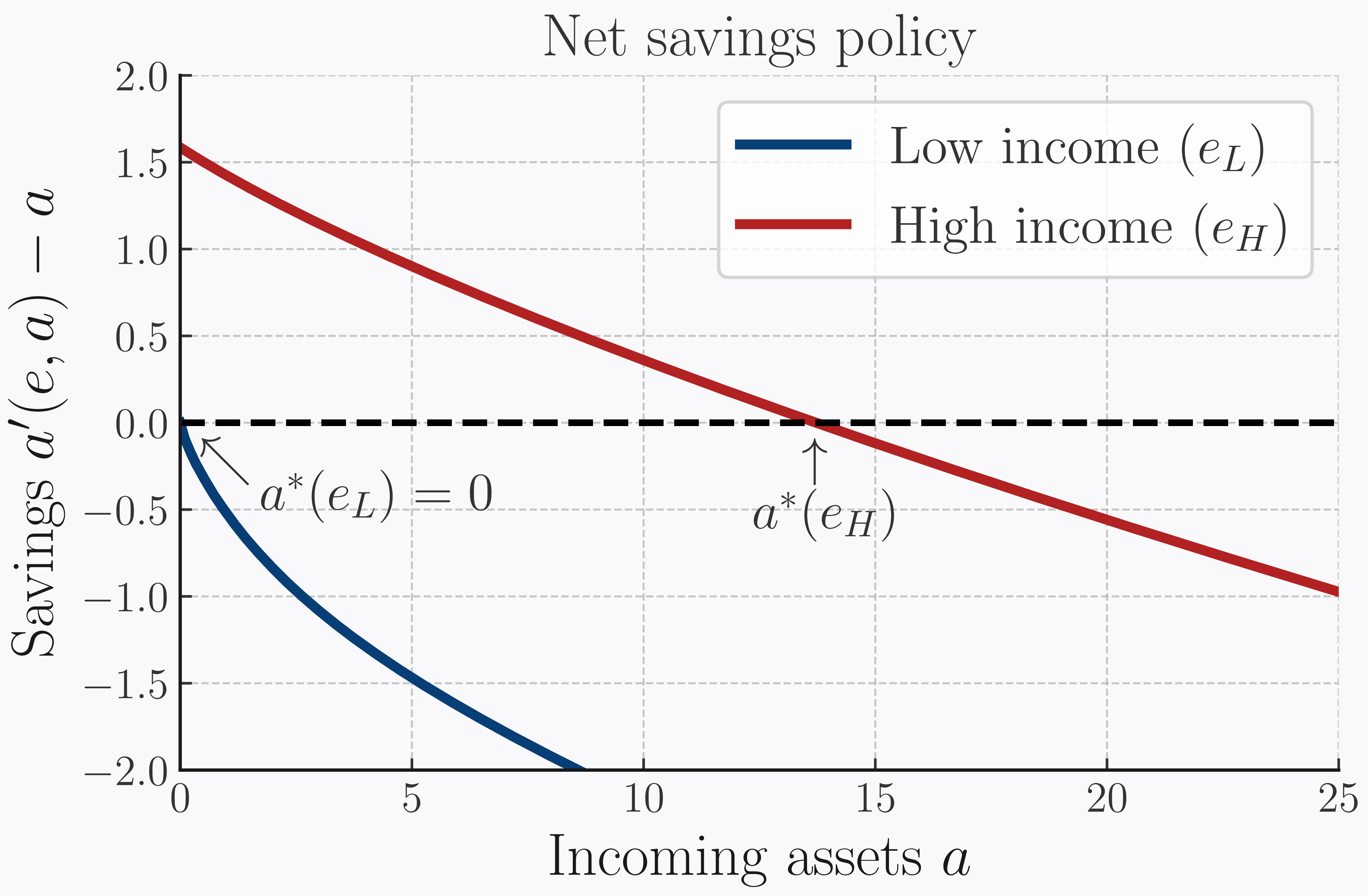
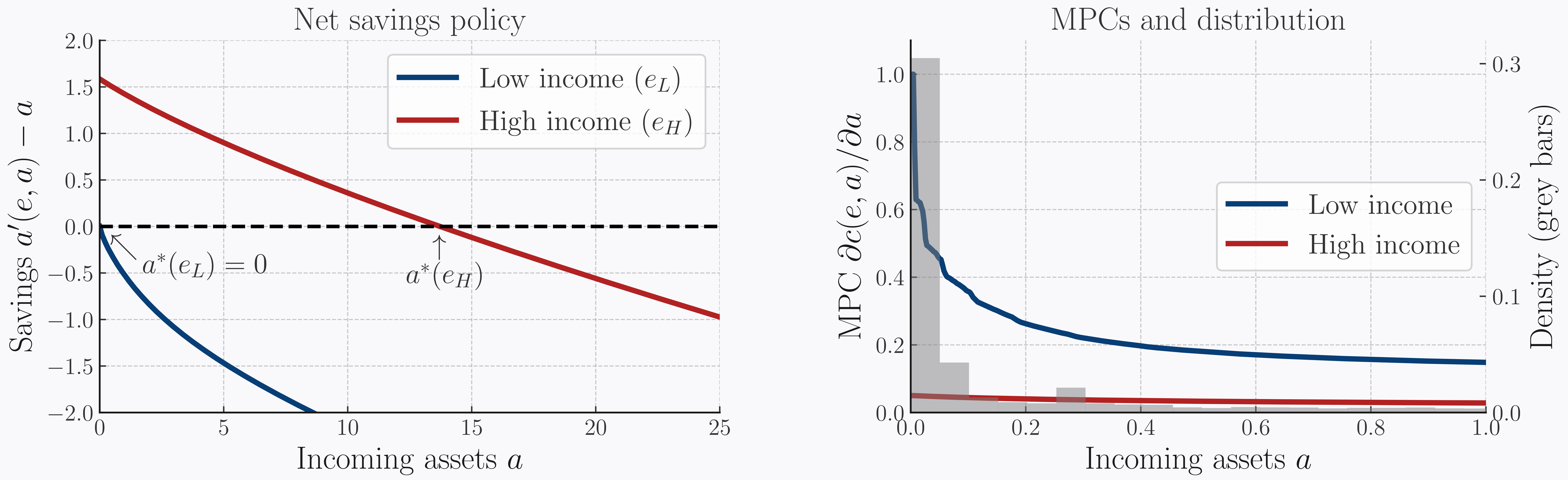


- Buffer-stock behavior generates stationary distribution over assets

Steady state policies, MPCs, and distribution



- Buffer-stock behavior generates stationary distribution over assets
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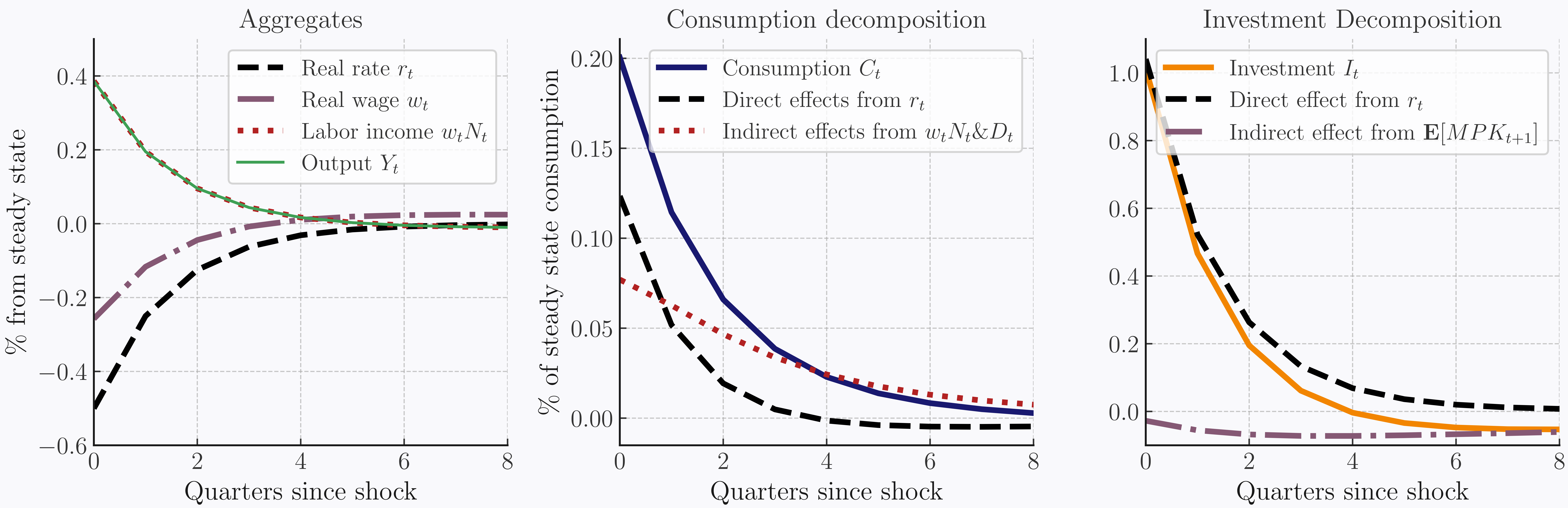
Impulse response to monetary shock



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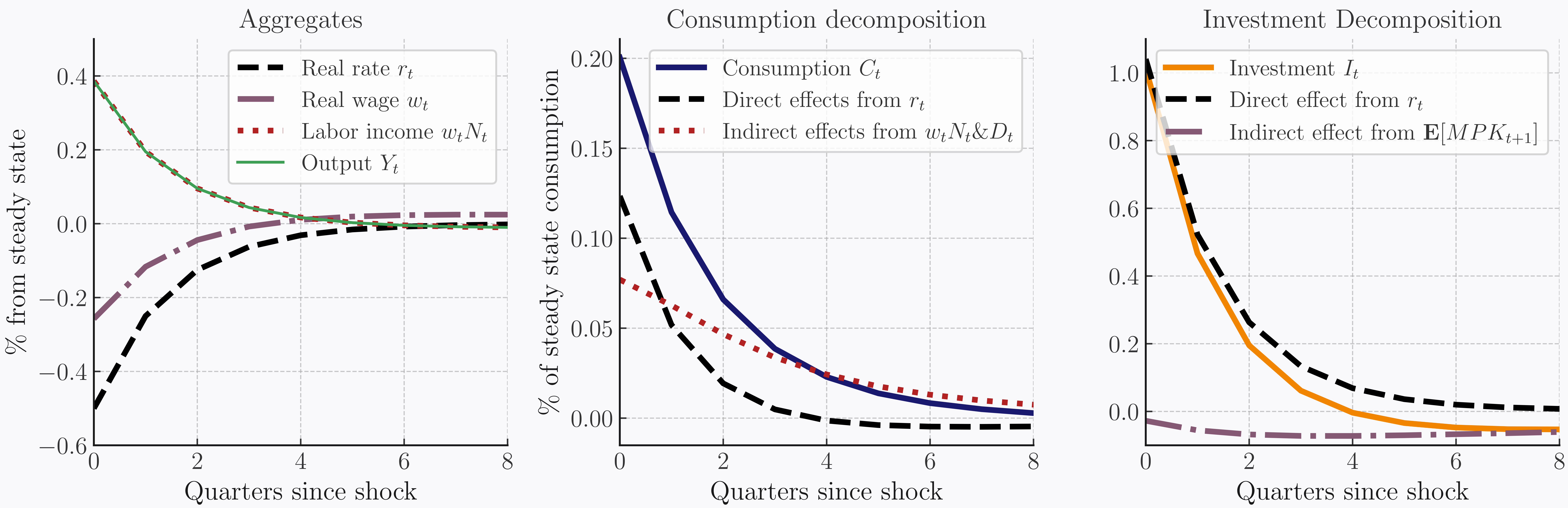

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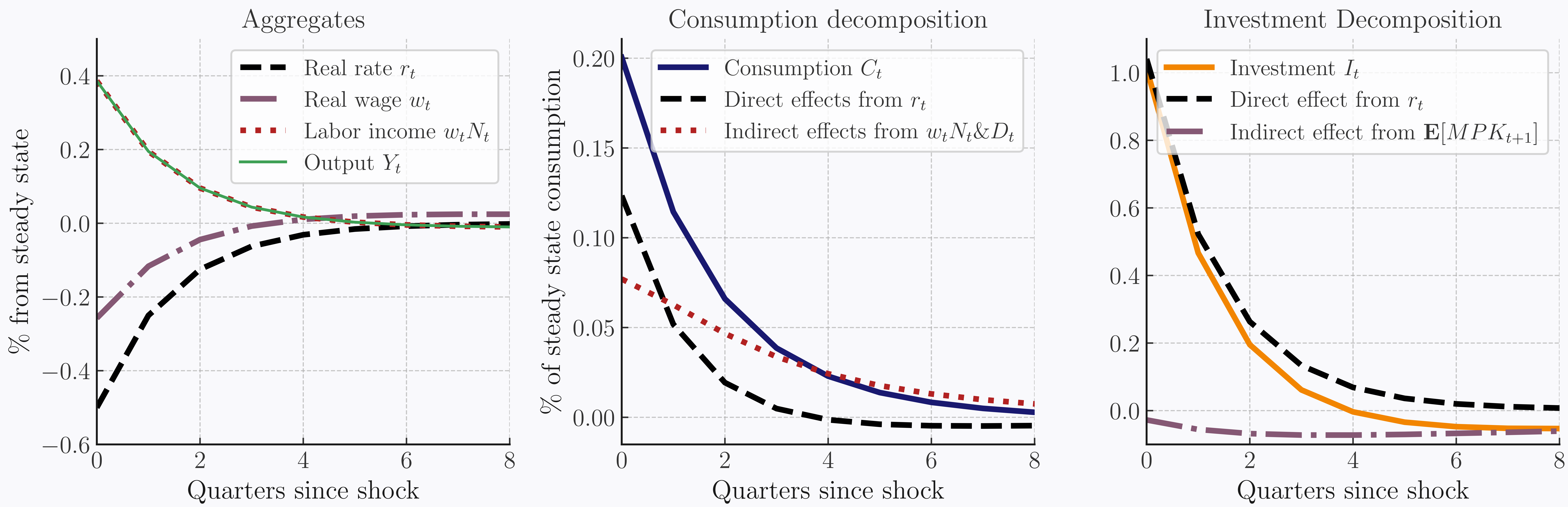

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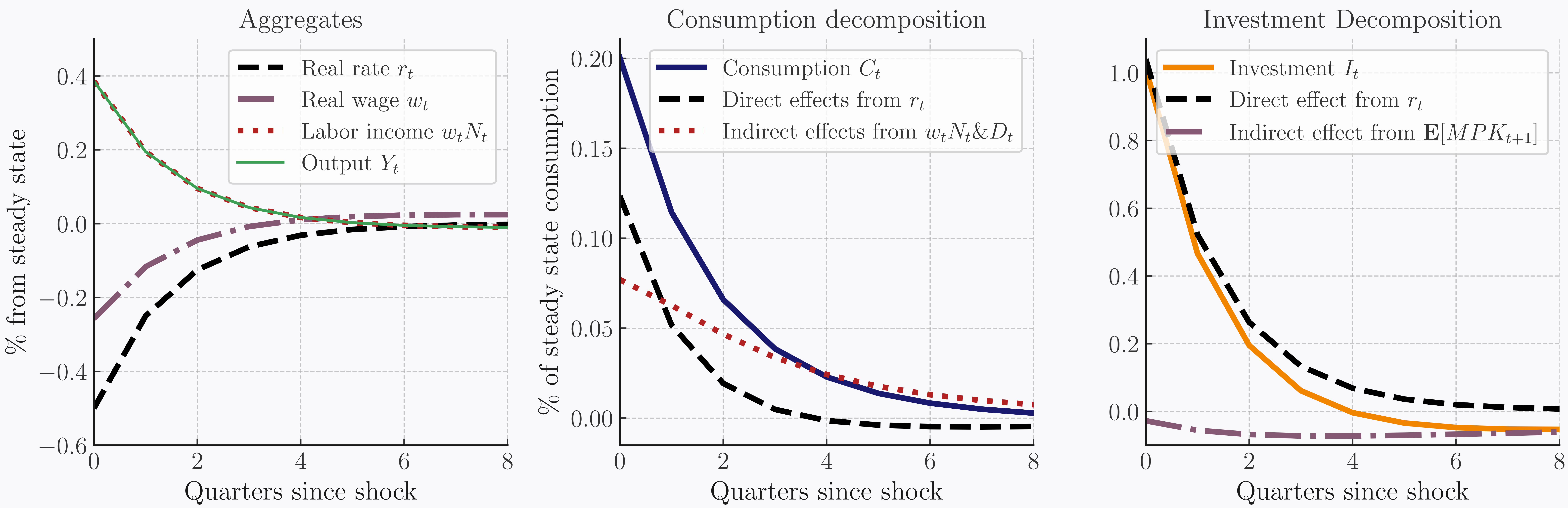
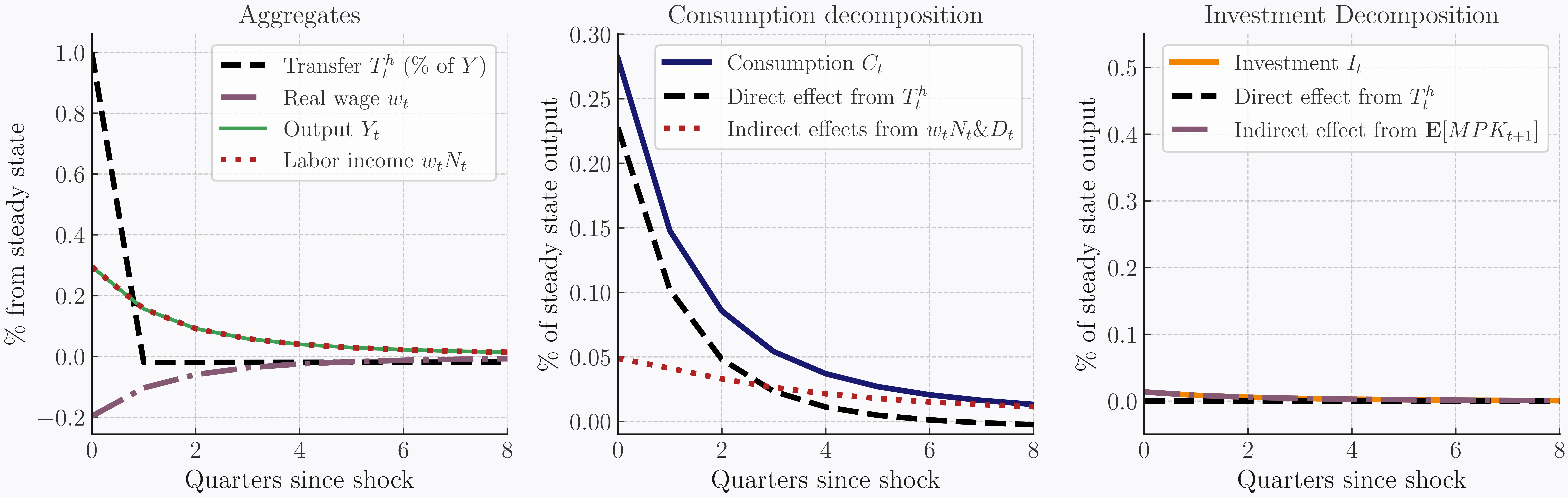


- Transmission of m.p. relies much more on indirect effects [Kaplan-Moll-Violante…]
- Magnitude of indirect effect on C controlled by income-weighted MPC (see $ew_t N_t$)
- Recalibrate to lower EIS ($\sigma = 1.6$) to counter $I \to Y \to C$ amplification [Auclert-Rognlie-Straub]

Impulse response to household transfer shock



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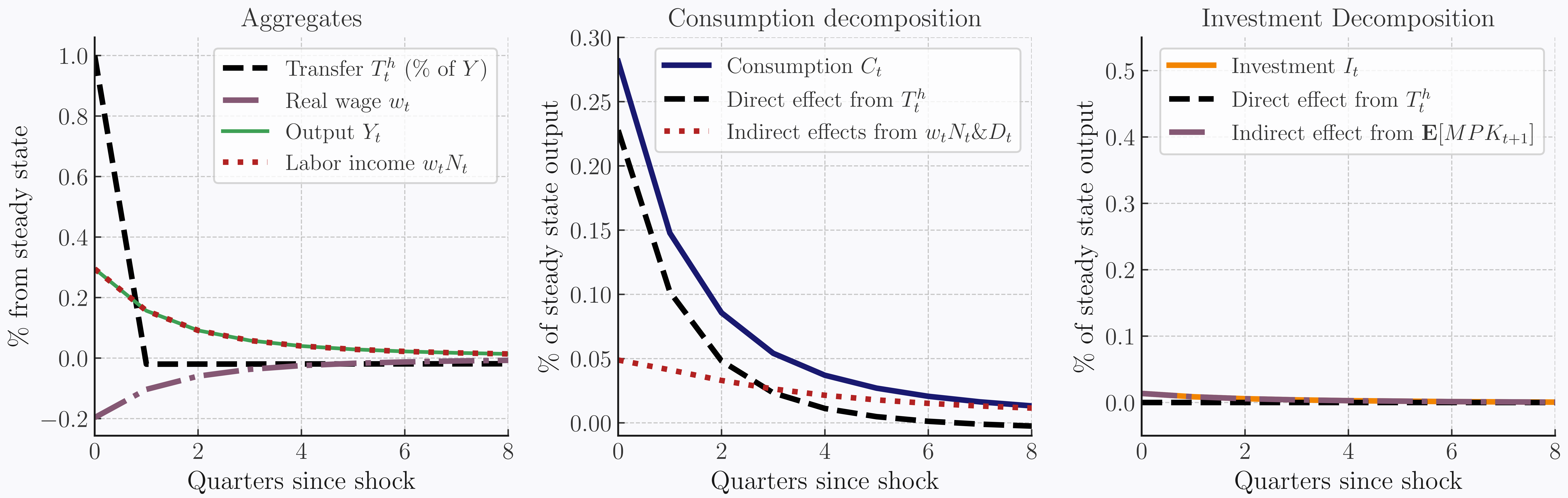

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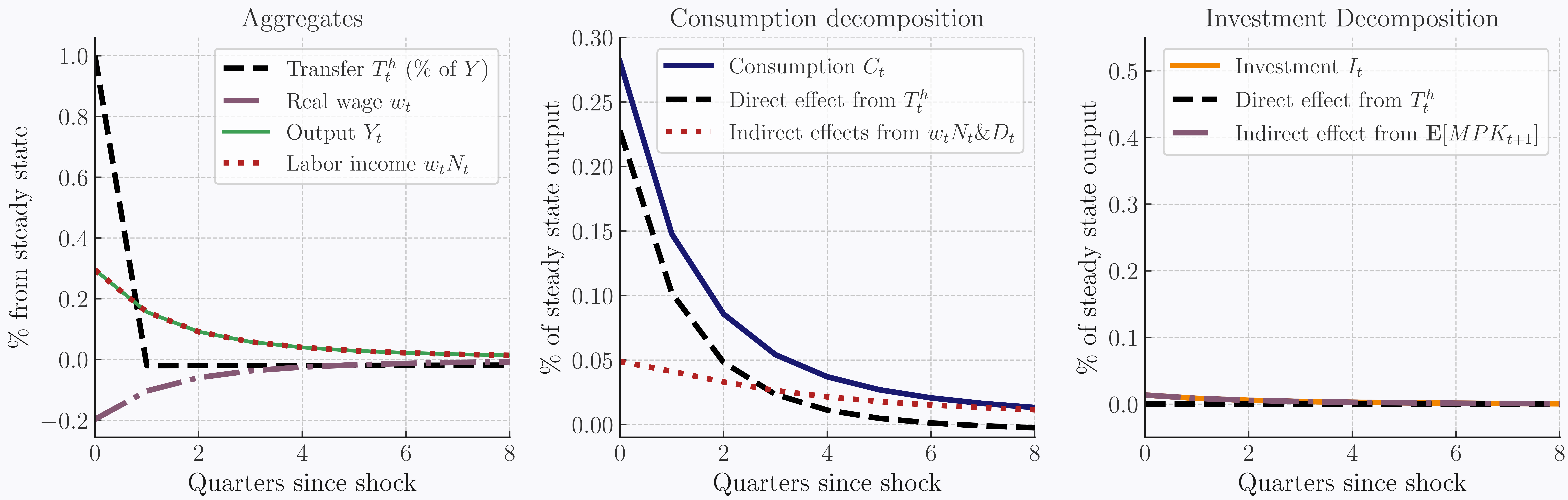

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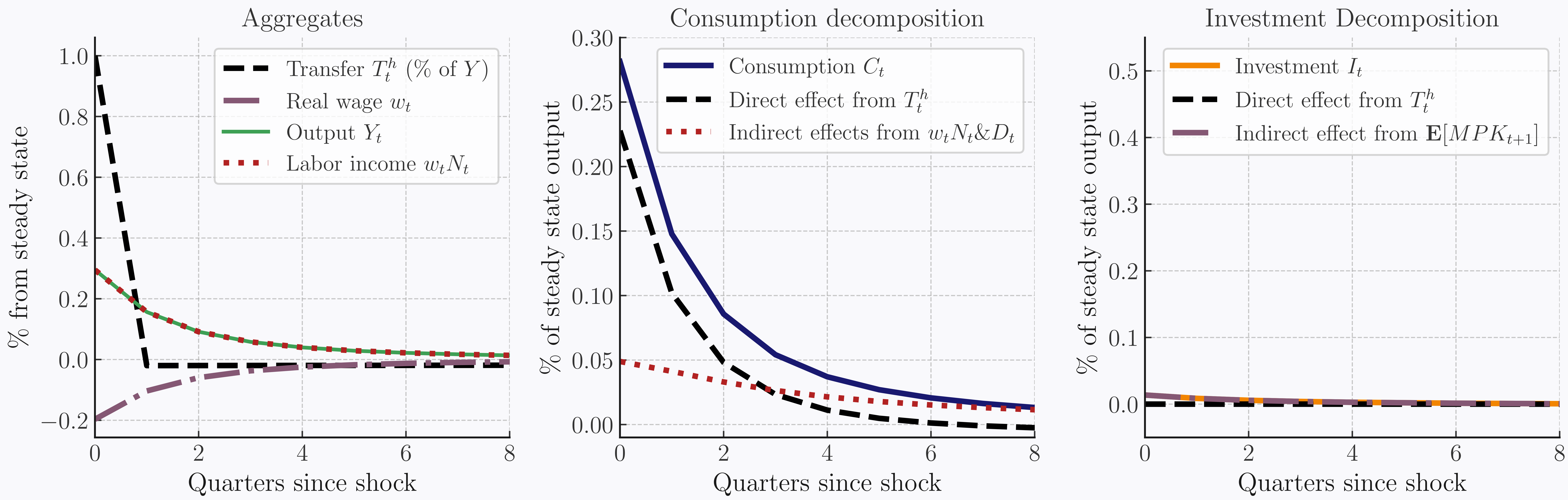

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- **Next**: what does firm heterogeneity do?

Adding heterogenous firms

Heterogeneous firm model

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- Firm in idiosyncratic productivity state z with incoming capital k and debt b solves

$$v_t\left(z,k,b\right) = \max_{n,k',b',d} d + \frac{1}{1+r_t}\mathbb{E}_t\left[\theta v_{t+1}\left(z',k',b'\right) + (1-\theta)\, v_{t+1}^{end}\left(z',k',b'\right)\right]$$

$$d = zk^{\alpha}n^{\nu} - w_t n - \left(k' - (1-\delta)\,k\right) - \varphi\left(\frac{k'-k}{k}\right)k - b + \frac{b'}{1+r_t} + T_t^f$$

$$d \geq 0,\ [\lambda] \quad b' \leq \chi k'\ [\mu]$$

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Cannot issue equity
Multiplier λ on equity issuance

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- Additional parameters relative to representative firm model
  - Death probability $1 - \theta = 2\,\%$ ← firm exit rate [Business Dynamics Statistics]
  - Firm productivity process ← estimated log AR(1) [Syverson 2011]
  - $\chi = 0.35$ ← ability to recover assets in bankruptcy [Kermani-Ma 2023]
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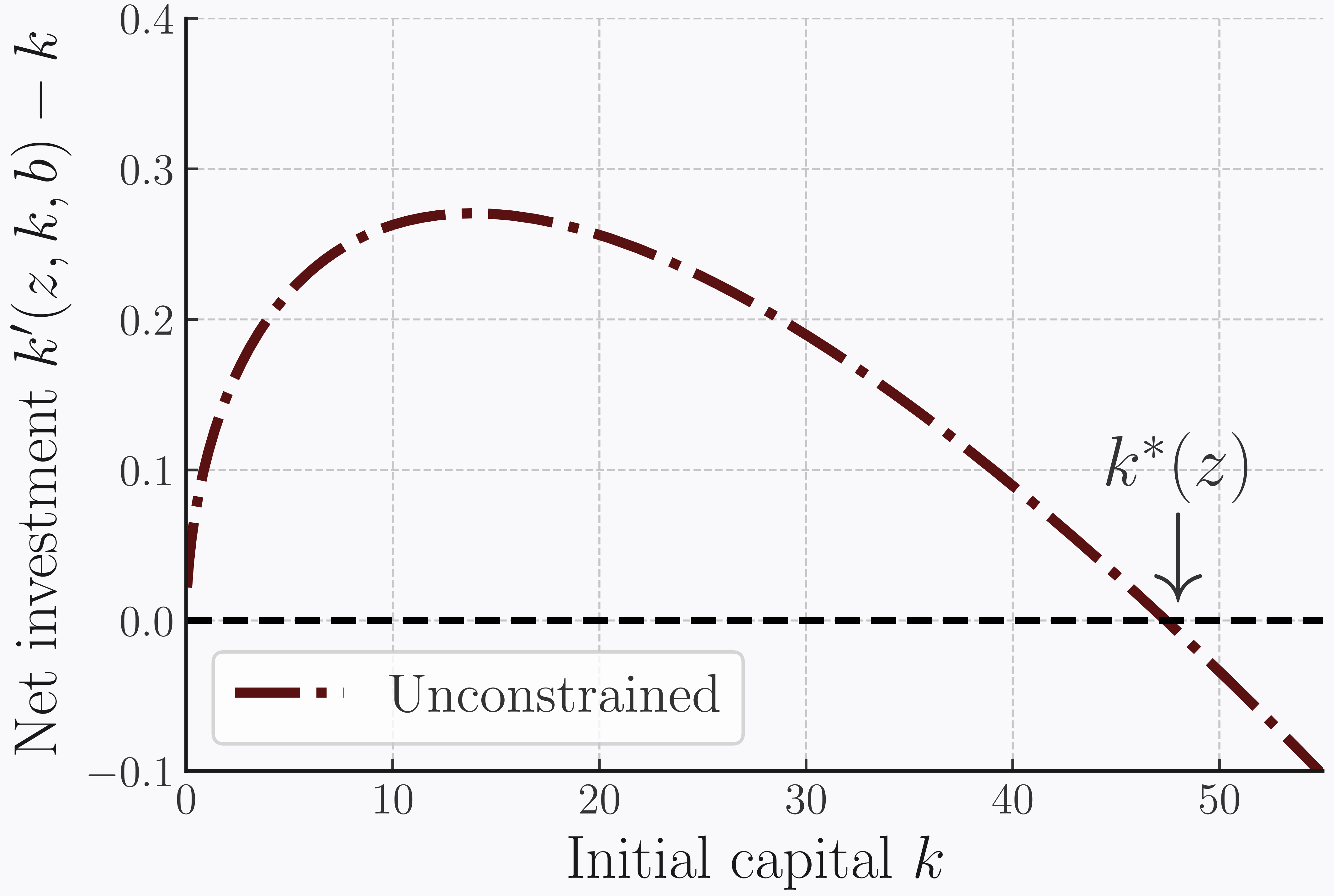
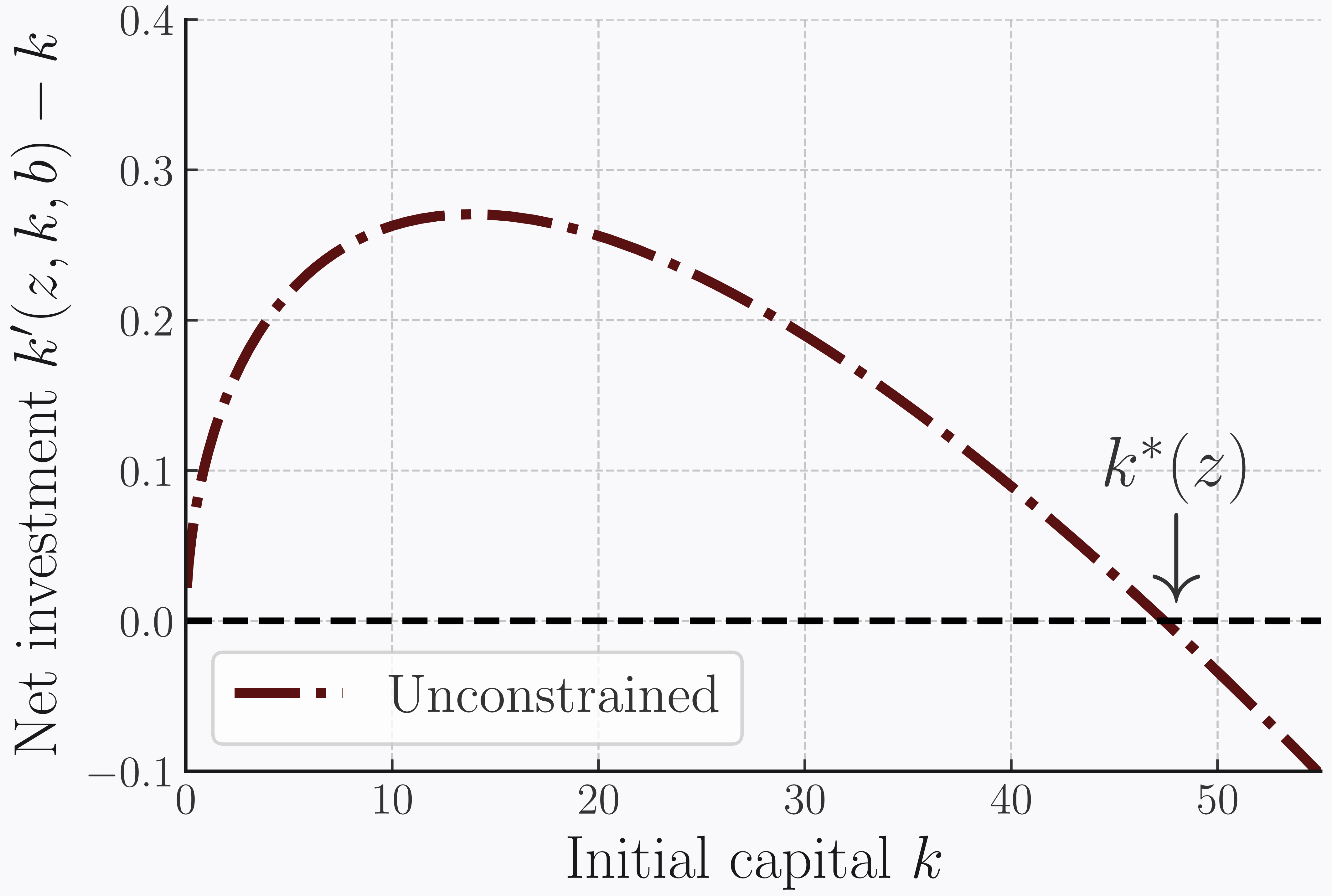
- Calibration generates average *MPI* = 0.50; ideally could use this as a data moment
- Not readily available: corporate finance *MPI* literature hasn't yet given us reliable estimates for broad set of firms (contrast with household finance *MPC* literature!)
  - [Some promising work using surveys or semi-structural estimation]

Steady state capital policy



- Consider an unconstrained firm ($b \ll 0$)
- Diminishing returns + adjustment costs generate target $k^*(z)$

Steady state capital policy



FOC for unconstrained (assuming no exit, $\theta = 1$):

$$\frac{k'-k}{k} = \frac{1}{\phi}\left(\frac{1}{1+r_t}\mathbb{E}\left[MPK(z',k',w_{t+1}) + \tilde{\varphi}(k',k'')\right] - 1\right)$$

Like rep. firm, unconstrained affected by m.p. via discounting and expected MPK effects

- Consider an unconstrained firm ($b \ll 0$)
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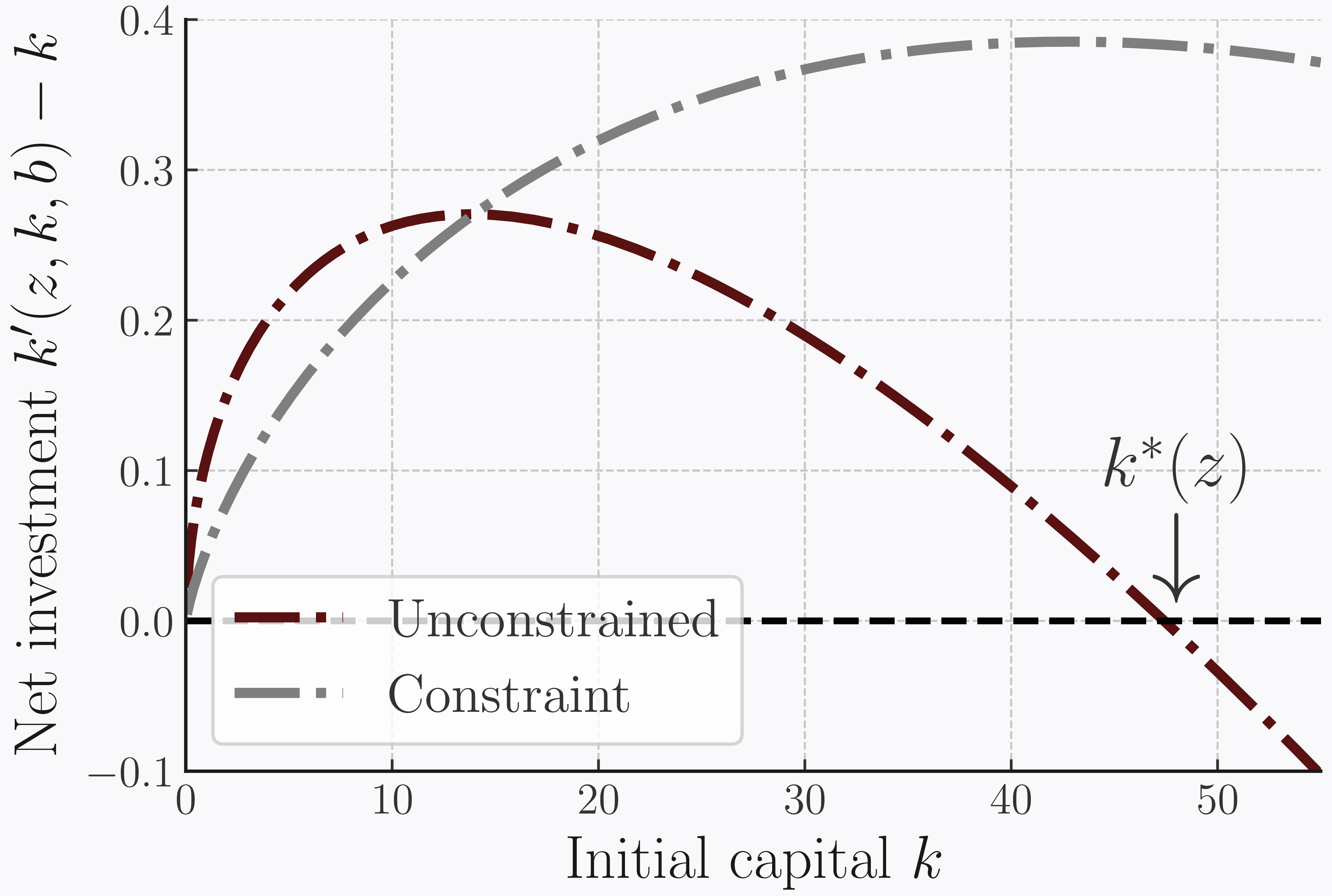
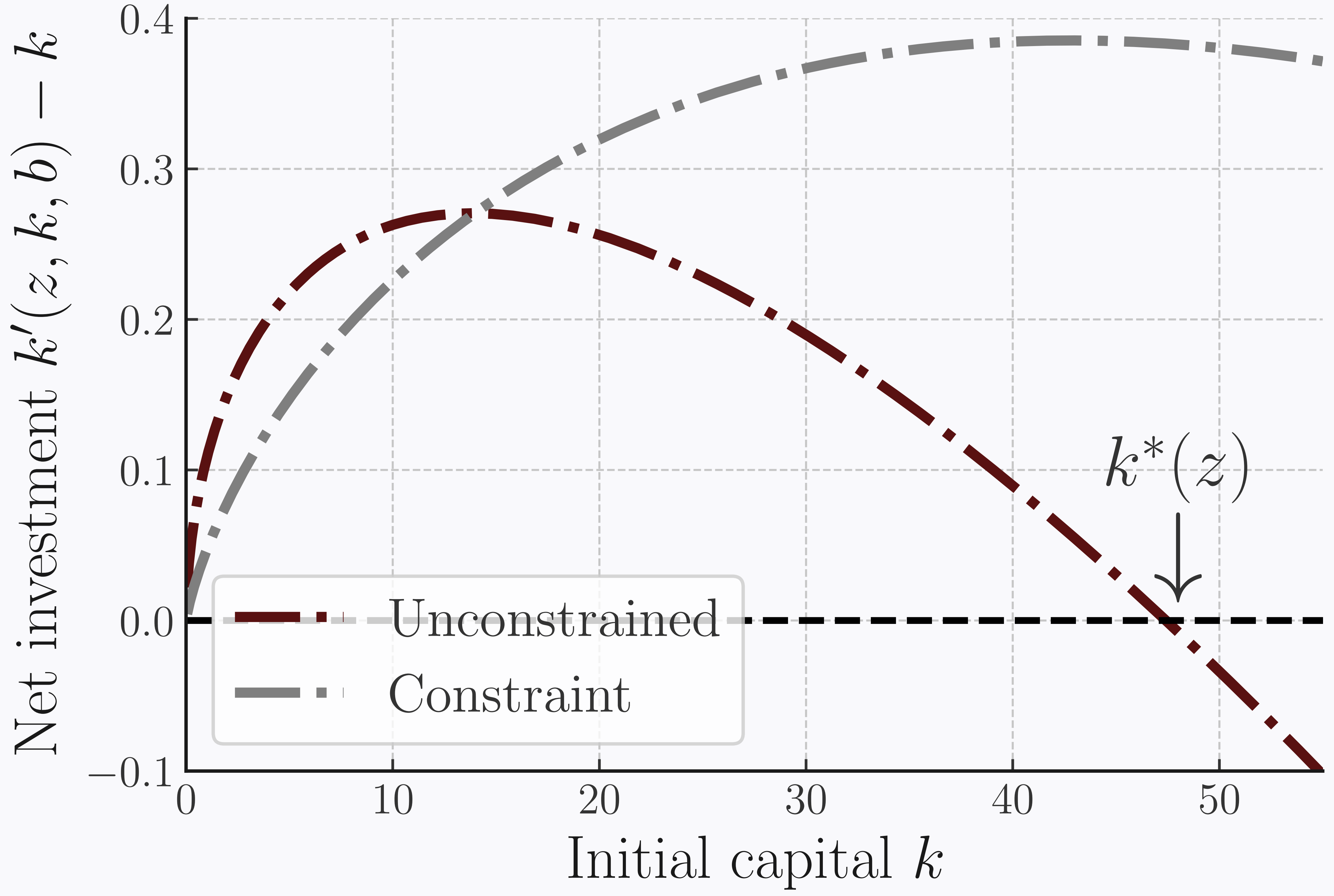
Steady state capital policy



- Next consider a firm that pays $d = 0$ and borrows maximally $b' = \chi k'$

Steady state capital policy



For borrowing and dividend constrained firm:

$$k' - (1-\delta)k + \varphi\left(\frac{k'-k}{k}\right)k = \pi_t(z,k) + T_t^f - b + \frac{\chi k'}{1+r_t}$$

where π_t is profits, so $k' = \bar{k}\left(z,k,b;r_t,w_t,T_t^f\right)$

Constrained firms affected by a cash flow effect: lower w_t today → higher π_t → higher I_t

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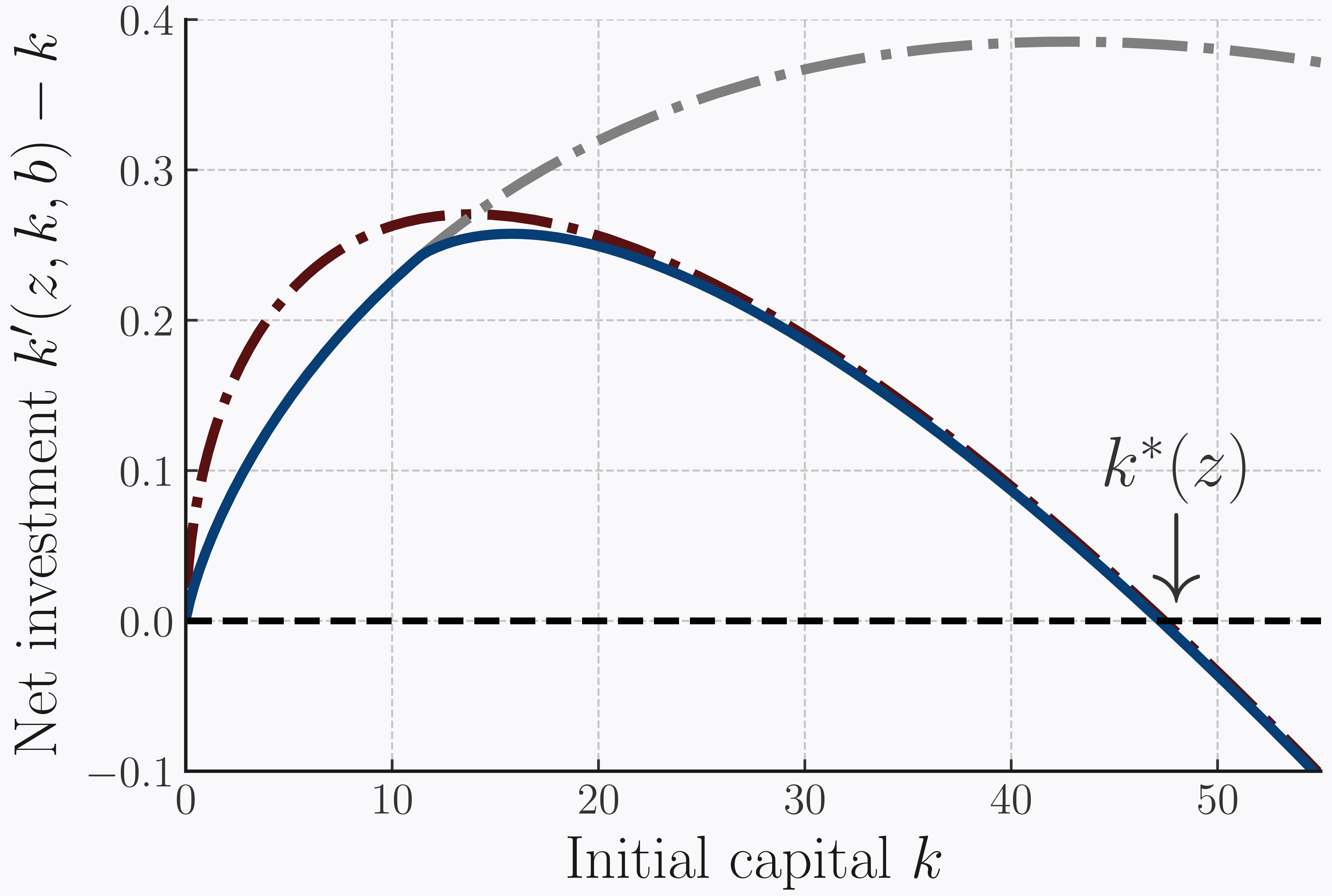
Steady state capital policy



- Full policy pastes the two, with additional intermediate $\lambda > 0$, $b' < \chi k'$ region

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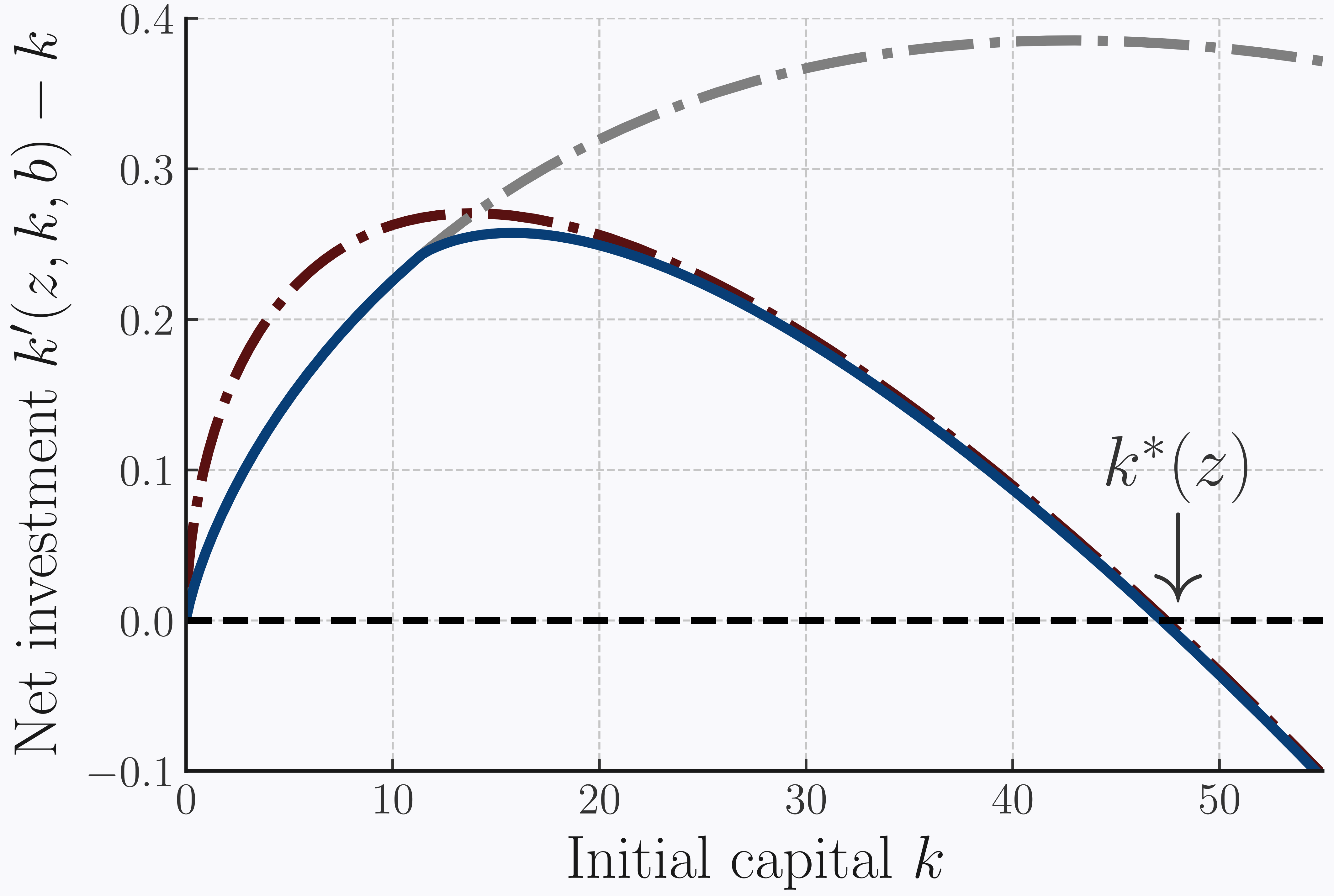

Multiplier dynamics (with $\theta = 1$)

$$\lambda_t(z,k,b) = (1+r_t)\mu_t(z,k,b) + \mathbb{E}[\lambda_{t+1}(z',k',b')]$$

pay divs only if can avoid constraint forever

General investment FOC:

$$\frac{k'-k}{k} = \frac{1}{\phi}\frac{1}{1+r_t}\mathbb{E}\left[\frac{\lambda_{t+1}(z',k',b')}{\lambda_t(z,k,b)}\left(MPK(z',k',w_{t+1}) + \tilde{\varphi}(k',k'')\right)\right]$$

Variation in λ acts like effective risk aversion

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Investment policy, MPIs and distribution

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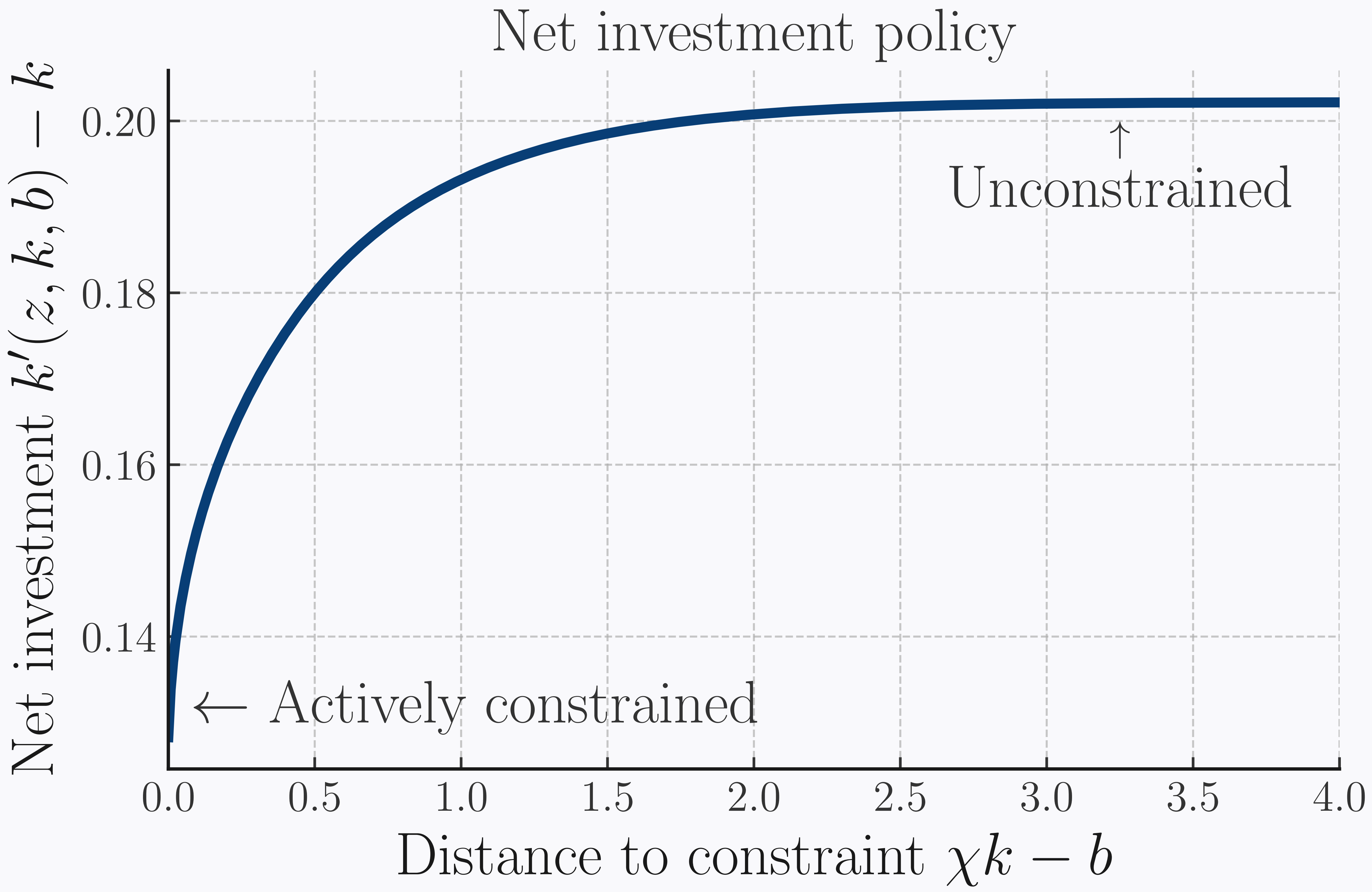

- Concave investment function: MPIs negatively correlated with dist. to constraint

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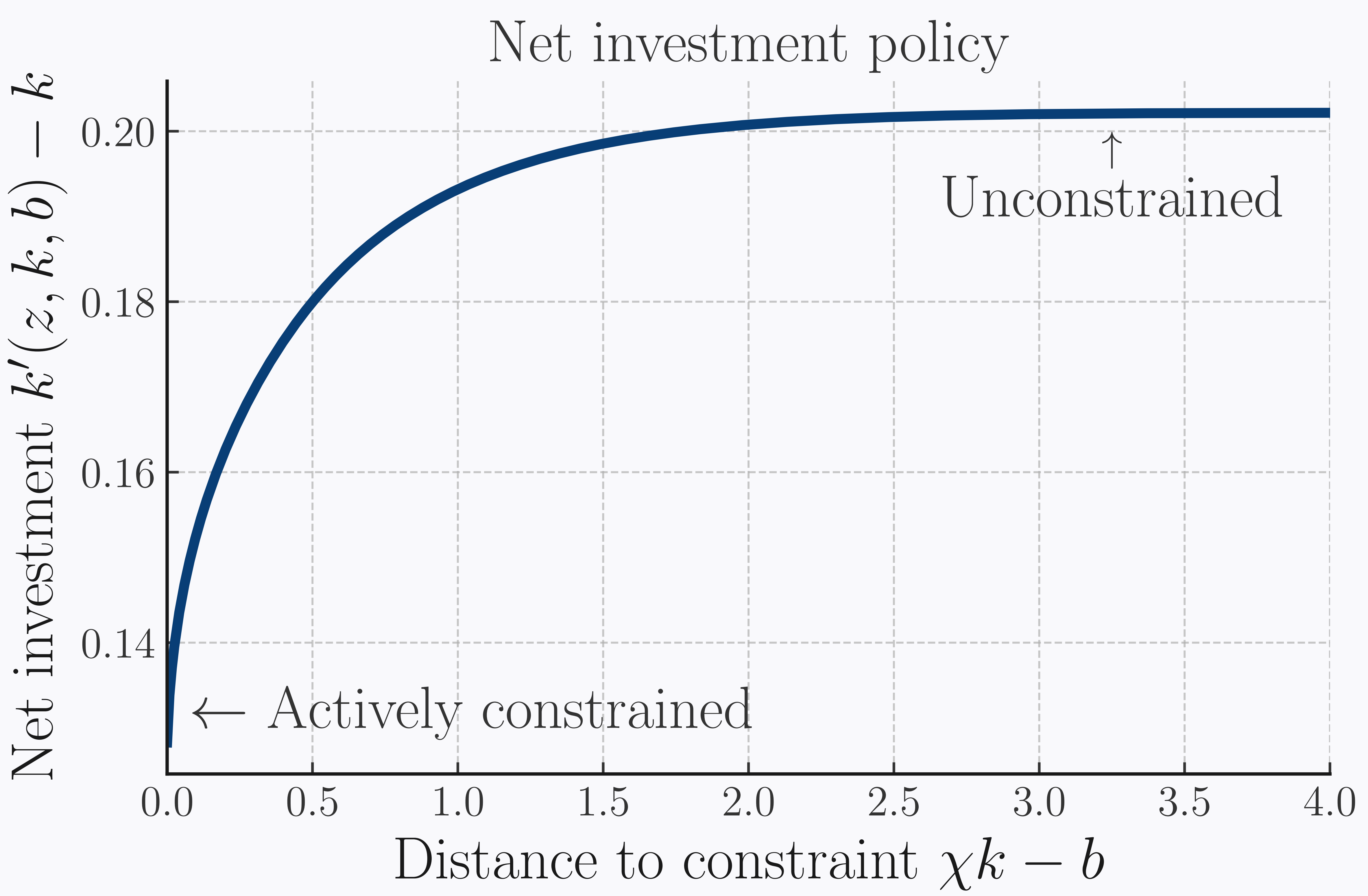
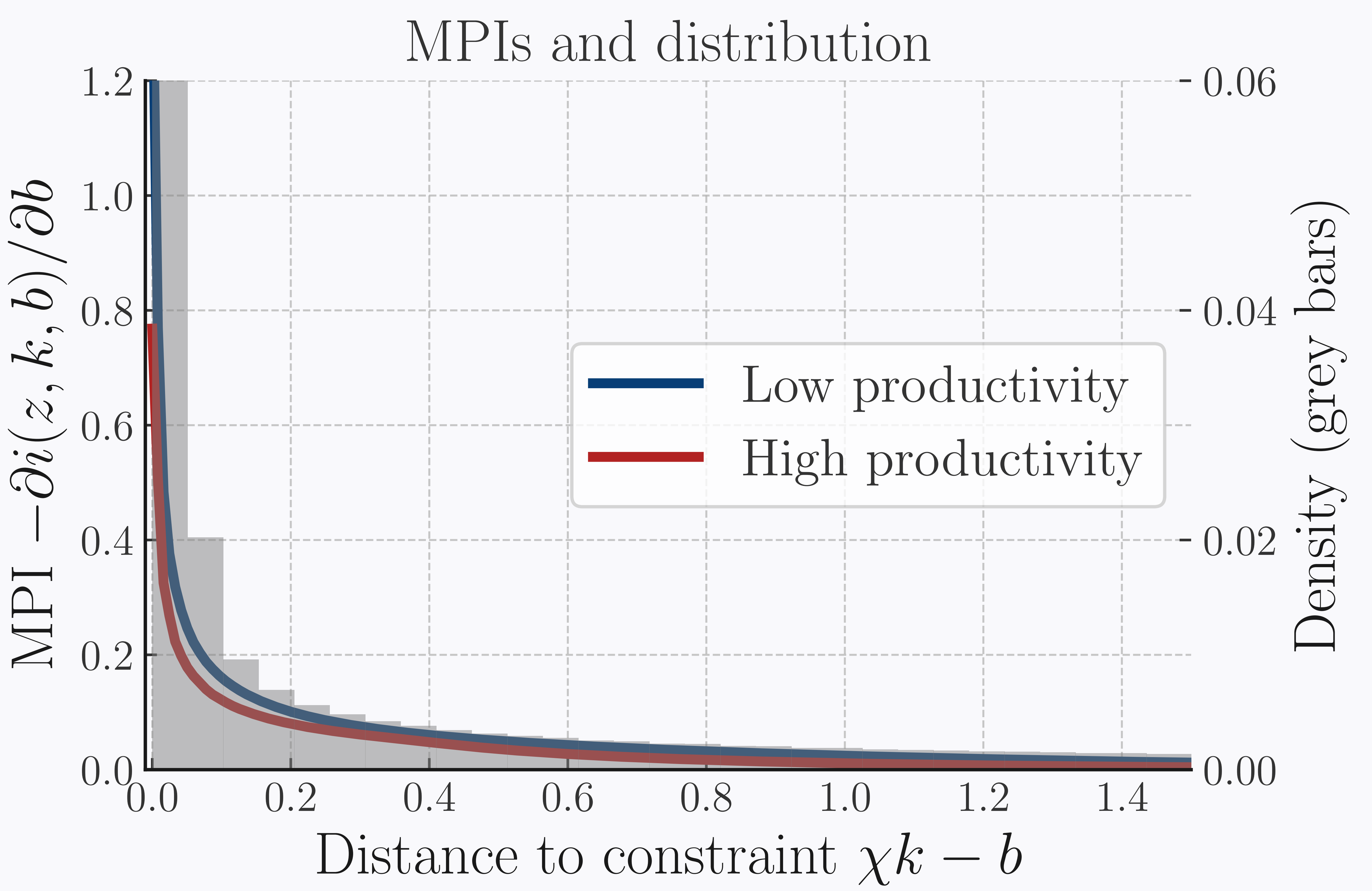
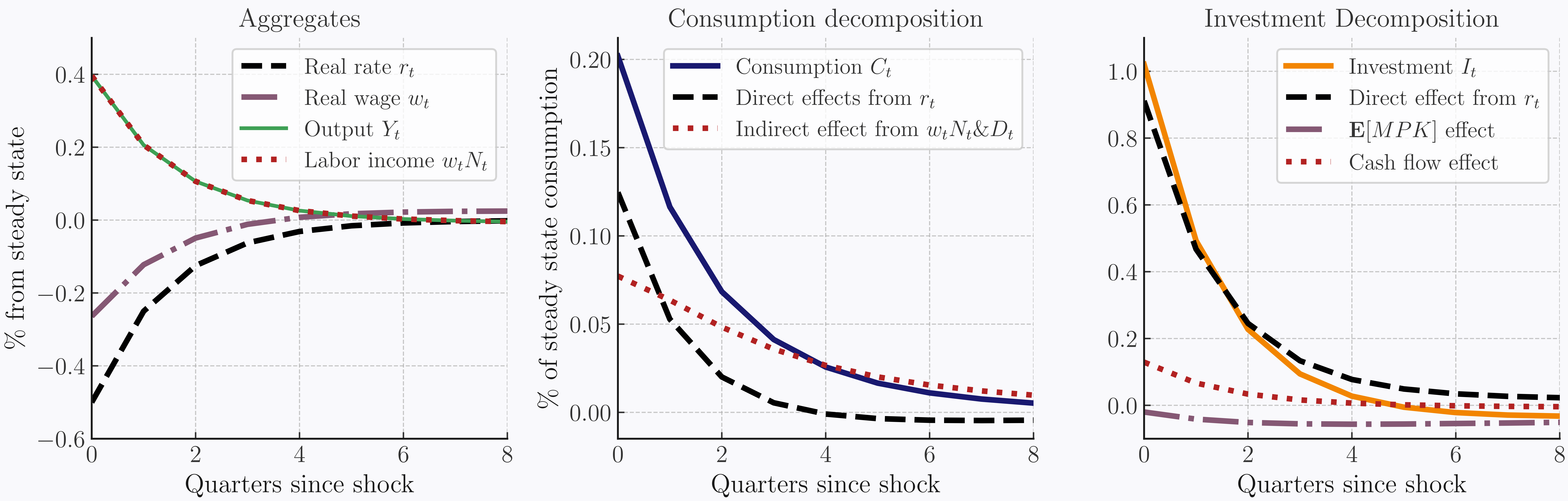




- Concave investment function: MPIs negatively correlated with dist. to constraint
- $MPI > 1$ possible due to ability to lever up $1/(1-\chi)$ - contrary to household model

Impulse response to monetary shock



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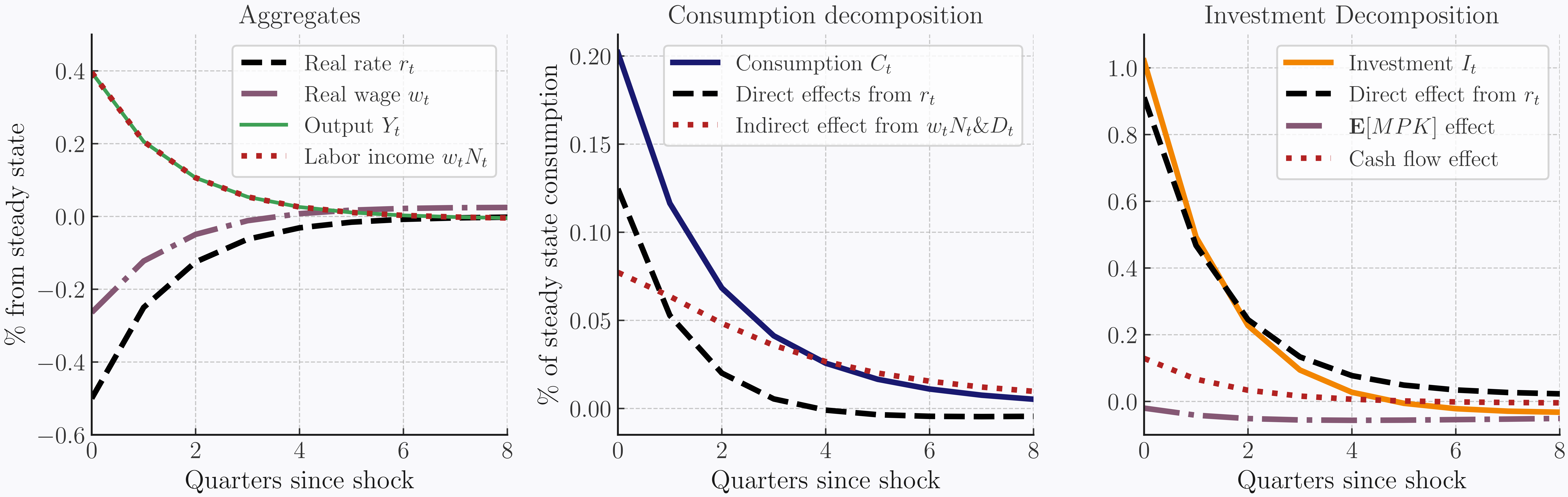

- New cash flow channel of monetary policy to investment: $w_t \downarrow \rightarrow \pi_t \uparrow \rightarrow I_t \uparrow$

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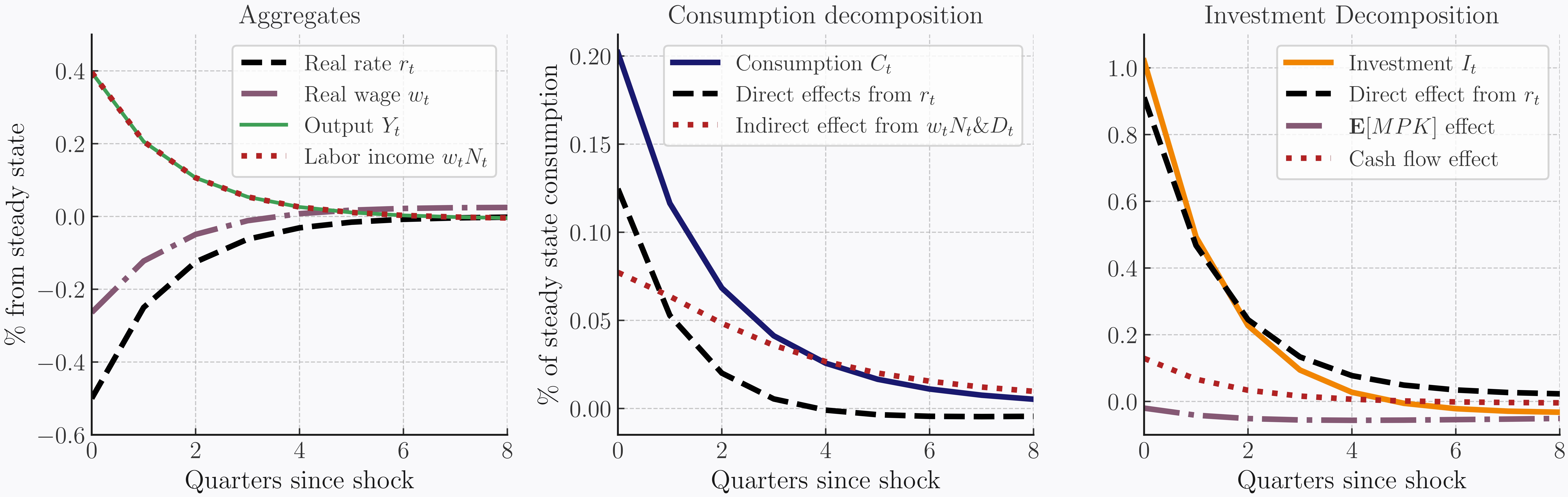
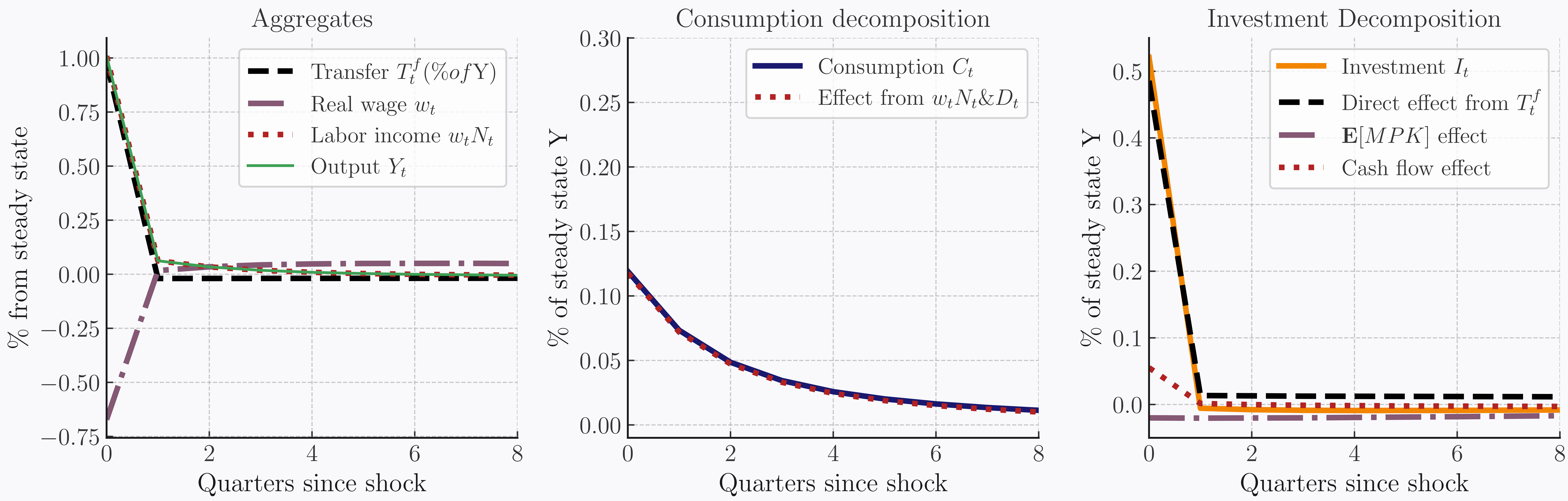


- New cash flow channel of monetary policy to investment: $w_t \downarrow \to \pi_t \uparrow \to I_t \uparrow$
- Magnitude controlled by profit-weighted *MPI* (since $\pi_{it} \propto Y_t$). Here, $\overline{MPI}$ small.

Impulse response to firm transfer shock



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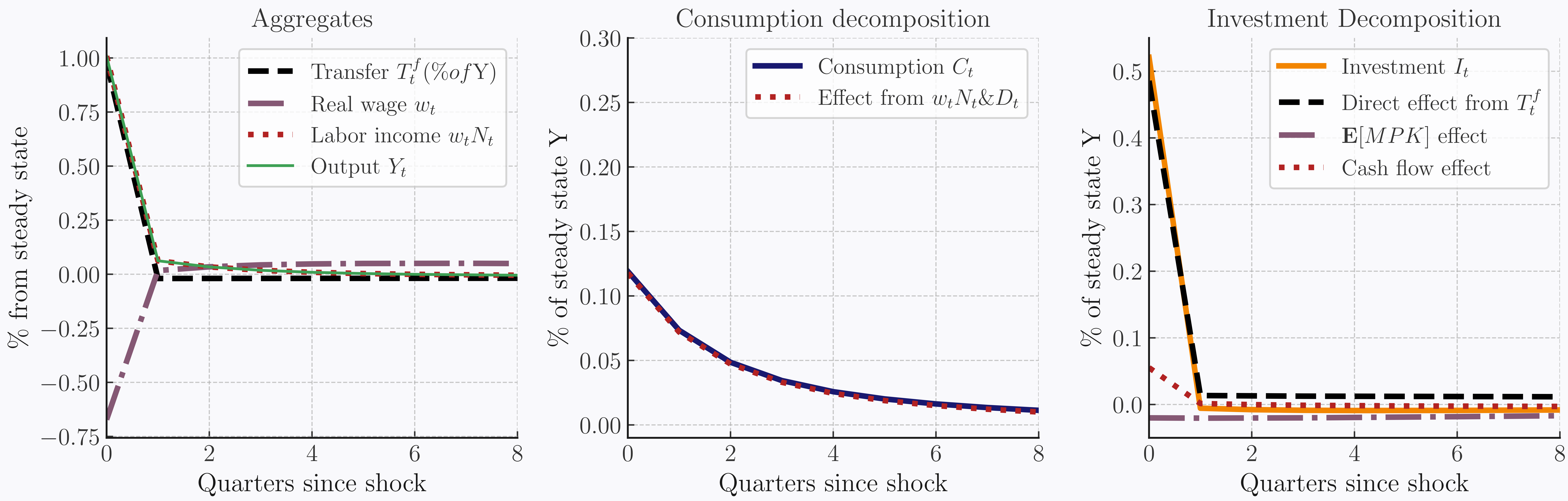

- Inside ≠ outside liquidity: PV-0 transfers to firms boost output today!

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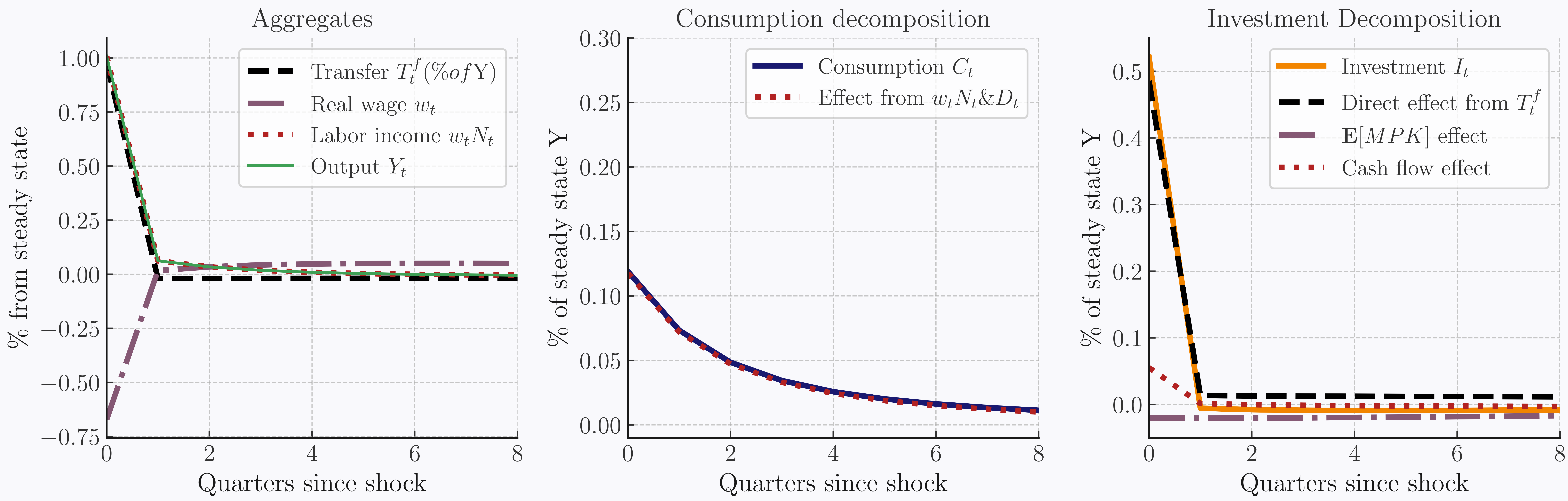

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- Large direct effect from firm transfer (large *MPI*), small multiplier (small $\overline{MPI}$)

Analogies…

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	Heterogeneous households	Heterogeneous firms

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Steady state	MPCs / iMPCs	MPIs / iMPIs
	Concave consumption function out of liquidity	Concave investment function out of free cash flow
	Prudence	Concern about hitting constraints
	Target (buffer) stock of assets	Target stock of capital (diminishing returns)
	Impatience	Life cycle (entry-exit)
	Income vs substitution effects	Income vs substitution effects

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Response to shocks	Income vs substitution effects	Income vs substitution effects
	Indirect effects of monetary policy	Cash flow effects of monetary policy
	Departure from Ricardian equivalence	Departure from inside = outside liquidity
	Income-weighted MPC governs multiplier	Profit-weighted MPI governs multiplier

How much do we get from the combination?

Households vs firm transfers

Impact on GDP (net of adj. cost) of 1% of GDP transfer…

To households

	Rep firm	Het firm
Rep household	0	0
Het household	0.29	0.31

To firms

	Rep firm	Het firm
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- Implications for stimulus policy ultimately depend on our views of *MPC*s vs *MPI*s !

Bringing firm heterogeneity to HANK

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- Firms have been left out but have their rightful place in HANK !

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  - … cash flow transmission channel to I, paralleling indirect effect on C
  - … PV-0 transfers to firms have large and persistent effects on Y
  - … activates Keynesian feedback effects: $Y \rightarrow I \rightarrow Y \rightarrow C$ and $Y \rightarrow C \rightarrow Y \rightarrow I$

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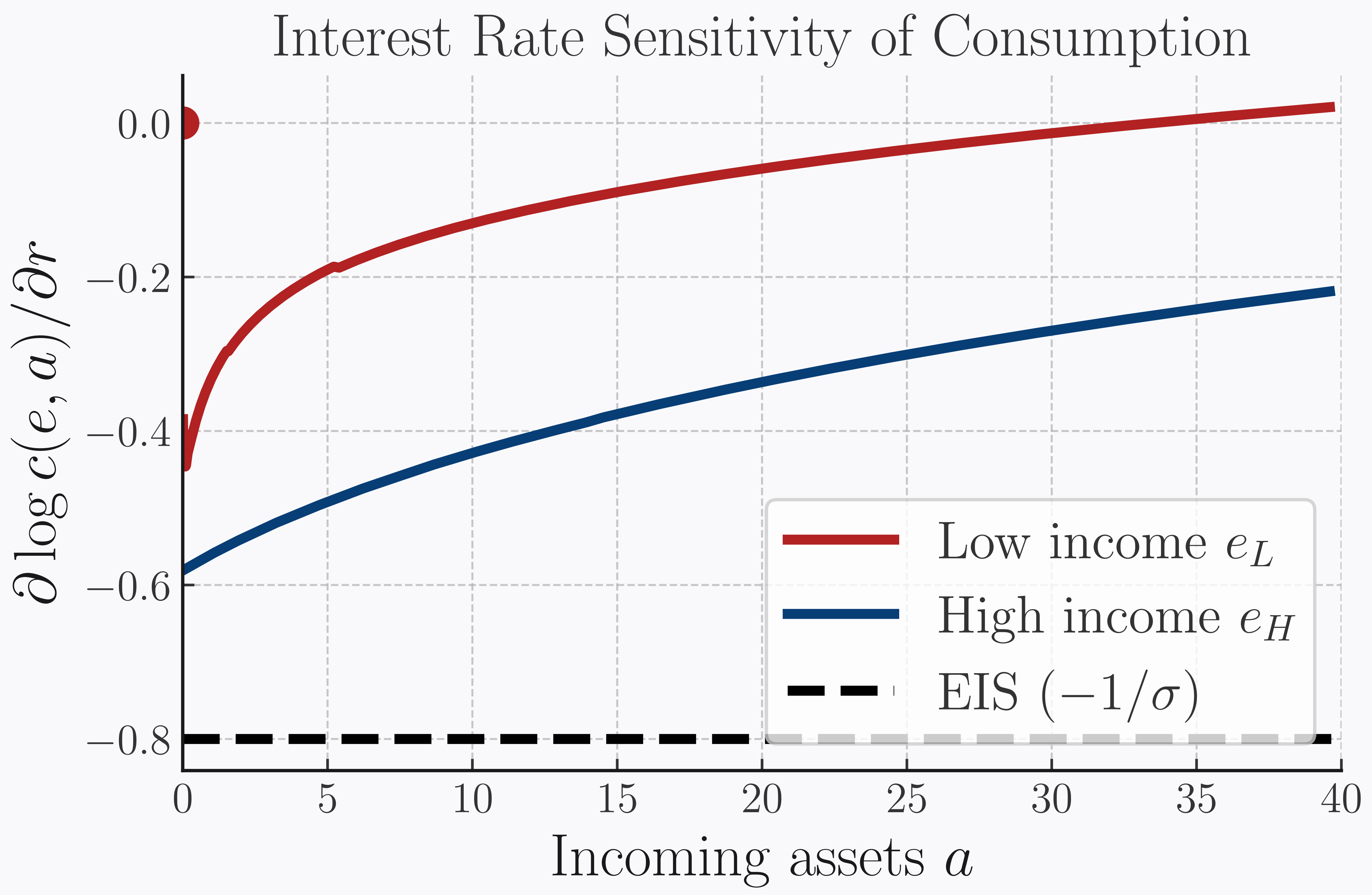
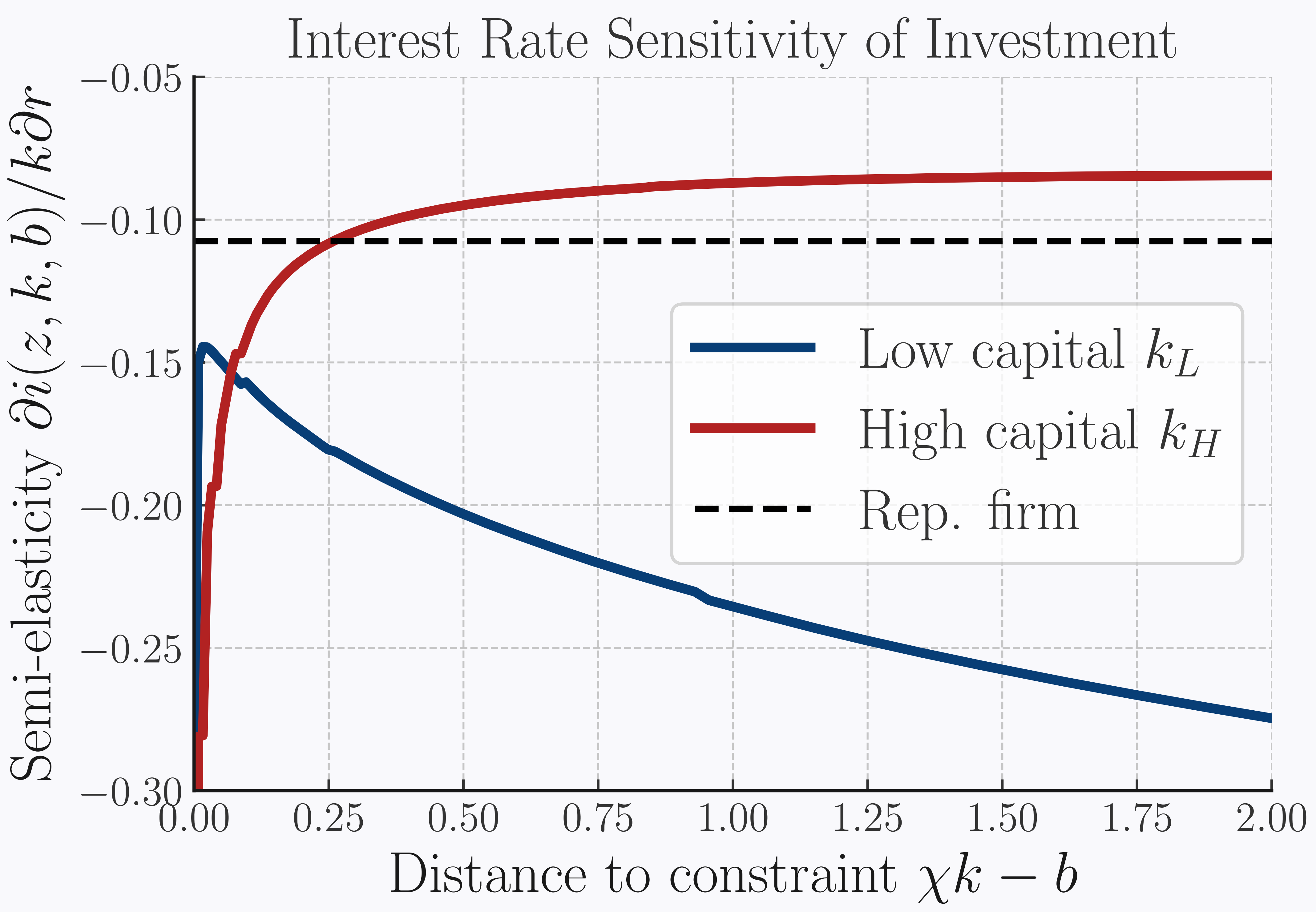
- More empirical work needed to measure MPIs & covariance with firm observables

Thanks!!!

Back

Background: interest rate sensitivities (hh & firm)





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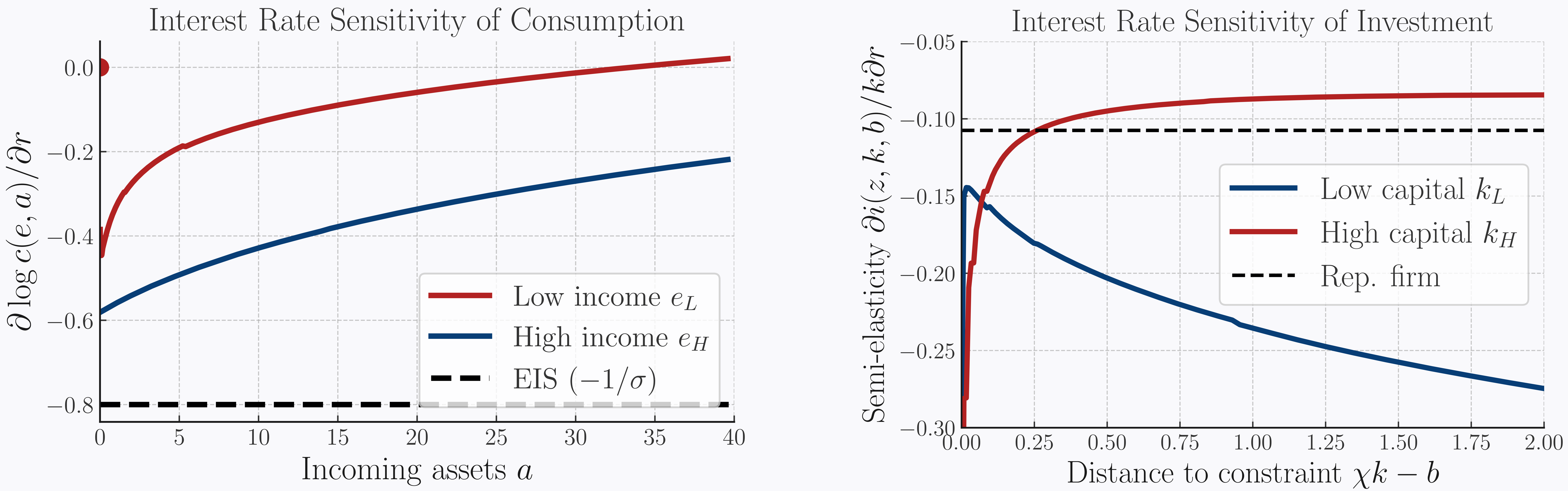

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Back

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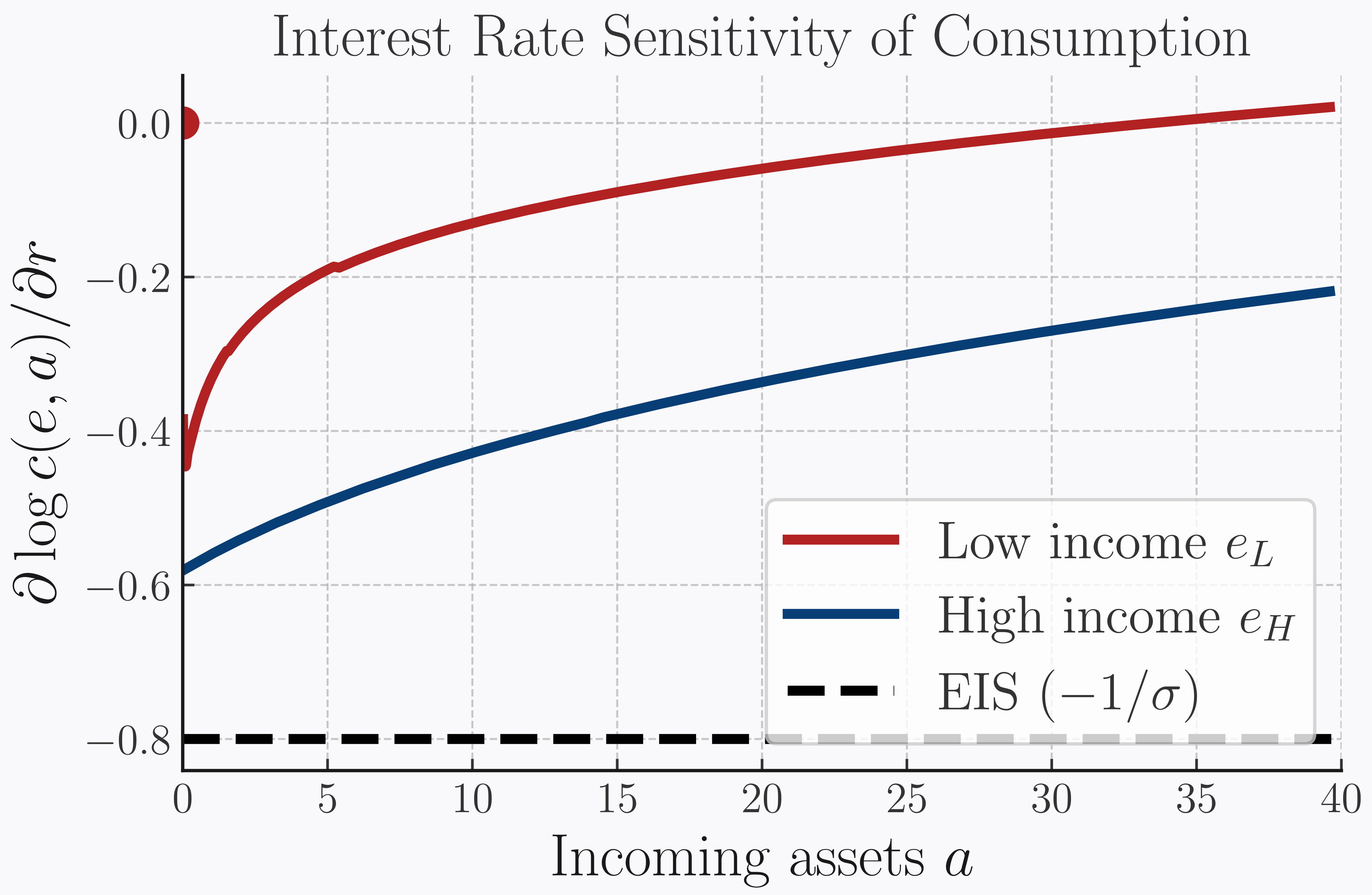

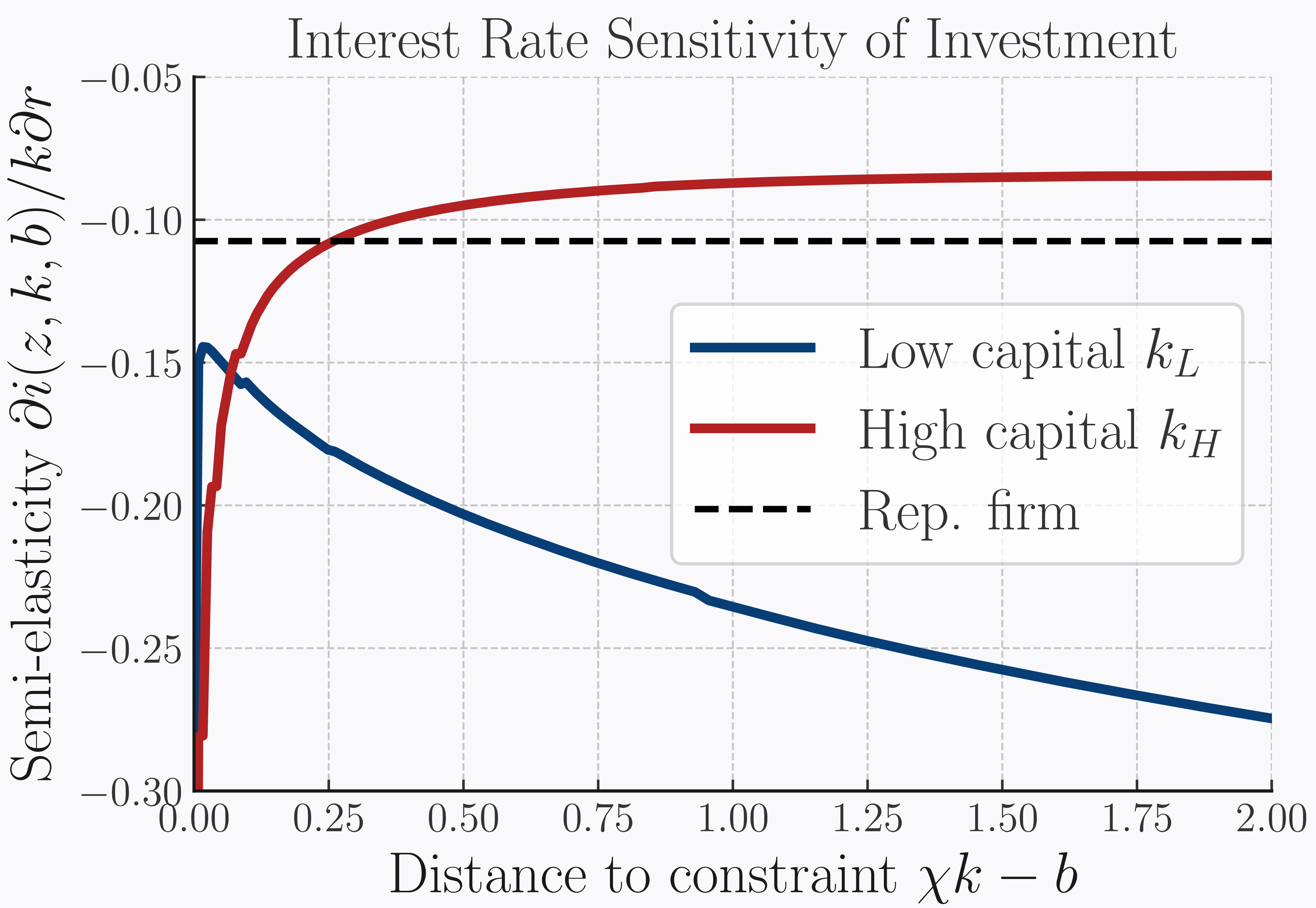

- Large heterogeneity in sensitivities of households and firms to rates
- Income vs substitution effects for both!

Back

Multiplier on $d \geq 0$ constraint