Coordinating Business Cycles

Edouard Schaal
New York University

Mathieu Taschereau-Dumouchel
University of Pennsylvania
Wharton School

October 2015

Motivation

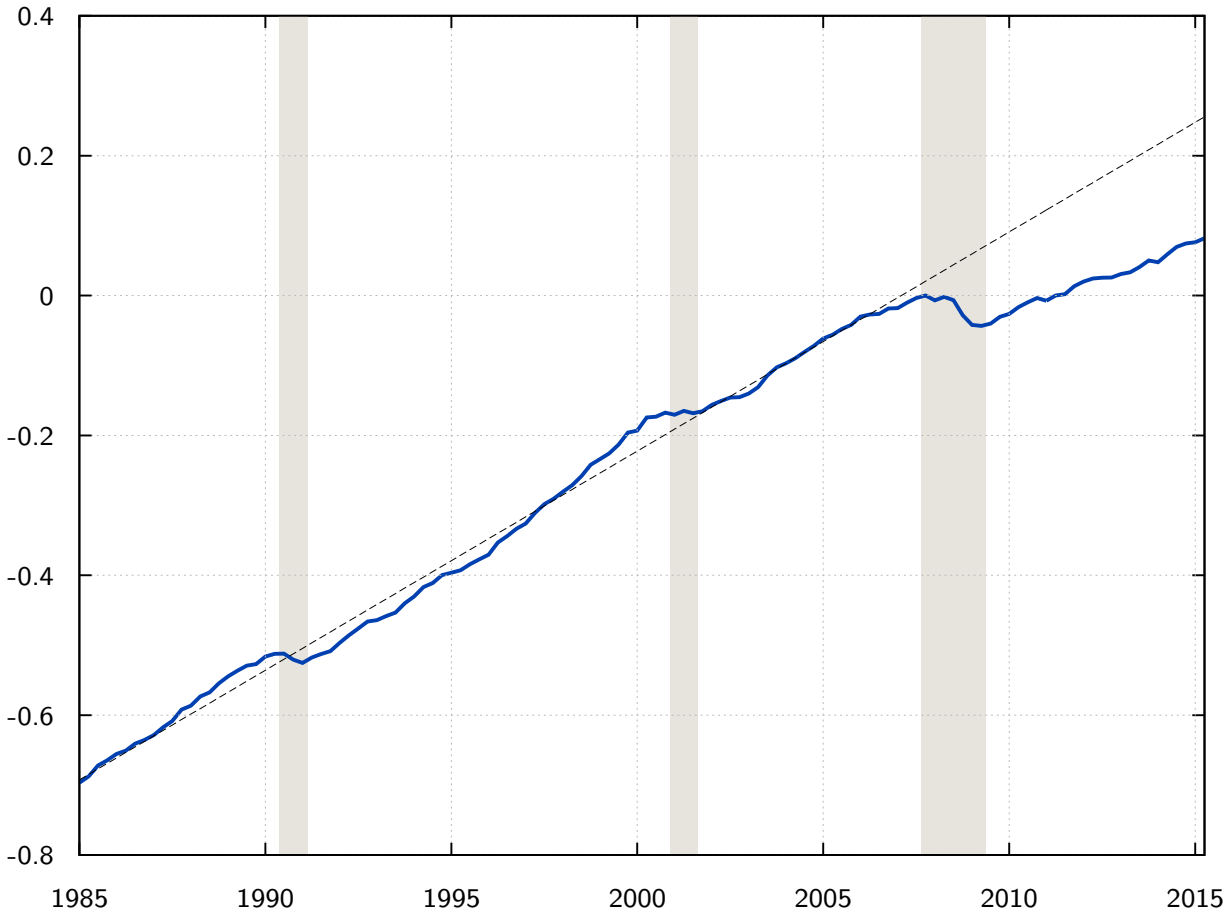


Figure: US real GDP (log) and linear trend 1985Q1-2007Q3 ▸ trend

The economy seems to have fallen to a lower steady state

Motivation

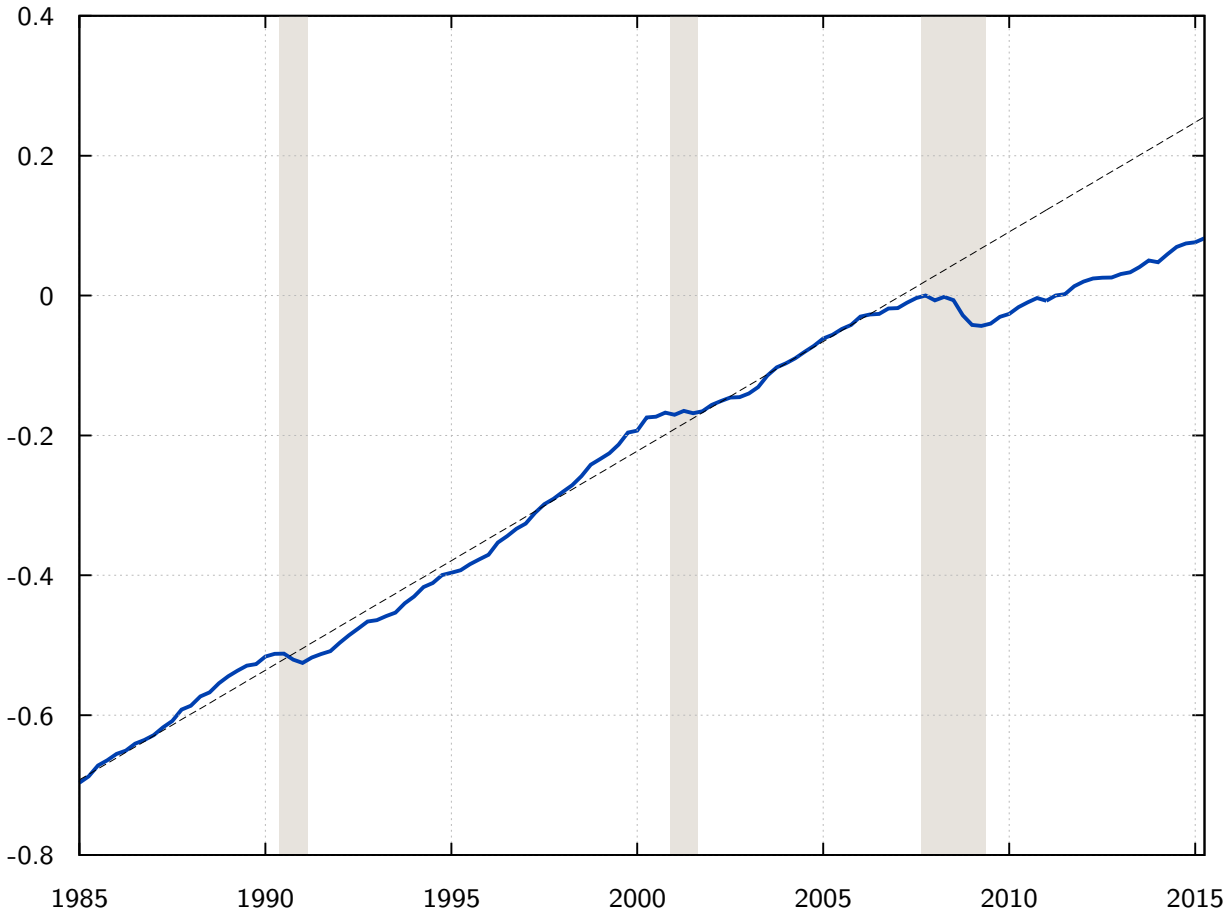


Figure: US real GDP (log) and linear trend 1985Q1-2007Q3 trend

The economy seems to have fallen to a lower steady state

Motivation

- We propose an explanation based on coordination failures
  - When complementarities are strong, the economy may have multiple equilibria
    - Diamond (1982); Kiyotaki (1988); Benhabib and Farmer (1994);...
  - Hypothesis: the economy is trapped in a low output equilibrium as agents fail to coordinate on higher production/demand

Our Contribution

- We develop a model of **coordination failures** and **business cycles**
- We respond to two key challenges in this literature:
  - Quantitative
    - Typical models are stylized or use unrealistic parameters,

    ⇒ Our model is a small deviation from standard neoclassical model with monopolistic competition
  - Methodological
    - Equilibrium indeterminacy limits welfare/quantitative analysis

    ⇒ We adopt a global game approach to discipline equilibrium selection
- The model can be used as a benchmark for quantitative and policy analysis

Our Contribution

- We develop a model of **coordination failures** and **business cycles**
- We respond to two key challenges in this literature:
  - Quantitative
    - Typical models are stylized or use unrealistic parameters,
    - $\Rightarrow$ Our model is a small deviation from standard neoclassical model with monopolistic competition
  - Methodological
    - Equilibrium indeterminacy limits welfare/quantitative analysis
    - $\Rightarrow$ We adopt a global game approach to discipline equilibrium selection
- The model can be used as a benchmark for quantitative and policy analysis

Our Contribution

- We develop a model of **coordination failures** and **business cycles**
- We respond to two key challenges in this literature:
  - Quantitative
    - Typical models are stylized or use unrealistic parameters,
    $\Rightarrow$ Our model is a small deviation from standard neoclassical model with monopolistic competition
  - Methodological
    - Equilibrium indeterminacy limits welfare/quantitative analysis
    $\Rightarrow$ We adopt a global game approach to discipline equilibrium selection
- The model can be used as a benchmark for quantitative and policy analysis

Our Contribution

- We develop a model of **coordination failures** and **business cycles**
- We respond to two key challenges in this literature:
  - Quantitative
    - Typical models are stylized or use unrealistic parameters,

    $\Rightarrow$ Our model is a small deviation from standard neoclassical model with monopolistic competition
  - Methodological
    - Equilibrium indeterminacy limits welfare/quantitative analysis

    $\Rightarrow$ We adopt a global game approach to discipline equilibrium selection
- The model can be used as a benchmark for quantitative and policy analysis

Model Structure

- Standard neoclassical model with:
  - Monopolistic competition
    - Aggregate demand externality provides a motive to coordinate
  - Feedback from variable capacity utilization
    - Wen (1998), Benhabib and Wen (2004)
    - Consistent with aggregate measures of capacity utilization and TFP after the recession ▸ Data
    - We model this as a non-convex decision ▸ Evidence

$$u_t \in \{u_h > u_l\}$$

- Multiplicity of equilibria?
  - *Multiplicity* for relevant parameters under complete information,
  - *Uniqueness* under incomplete information (*global game*)

Model Structure

- Standard neoclassical model with:
  - Monopolistic competition
    - Aggregate demand externality provides a motive to coordinate
  - Feedback from variable capacity utilization
    - Wen (1998), Benhabib and Wen (2004)
    - Consistent with aggregate measures of capacity utilization and TFP after the recession ▸ Data
    - We model this as a non-convex decision ▸ Evidence

$$u_t \in \{u_h > u_l\}$$

- Multiplicity of equilibria?
  - *Multiplicity* for relevant parameters under complete information,
  - *Uniqueness* under incomplete information (*global game*)

Main Results

- Dynamics
  - Unique equilibrium but multiple steady states
    - Non-linear response to shocks
    - Deep recessions after short-lived shocks
  - Quantitatively consistent with the recovery from 2007-2009 recession
- Policy
  - Government spending
    - In general: makes coordination problem worse and reduces welfare
    - When transitioning to deep recession: helps coordination and increases welfare
  - Optimal policy is a mix of input and profit subsidies

I. Model: Complete Information Case

Model

- Infinitely-lived representative household that solves

$$\max_{C_t, L_t, K_{t+1}} \mathbb{E} \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{1-\gamma} \left(C_t - \frac{L_t^{1+\nu}}{1+\nu} \right)^{1-\gamma} \right], \gamma \geqslant 0, \nu \geqslant 0$$

  under the budget constraints

$$C_t + K_{t+1} - (1-\delta) K_t \leqslant W_t L_t + R_t K_t + \Pi_t$$

Production

- Two types of goods:
  - Final good used for consumption and investment
  - Differentiated goods $j \in [0,1]$ used in production of final good
- Competitive final good industry with representative firm

$$Y_t = \left(\int_0^1 Y_{jt}^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}}, \sigma > 1$$

yielding demand curve and price index

$$Y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\sigma} Y_t \quad \text{and} \quad P_t = \left(\int_0^1 P_{jt}^{1-\sigma} dj \right)^{\frac{1}{1-\sigma}} = 1.$$

Intermediate Producers

- Unit continuum of intermediate goods producer under monopolistic competition

$$Y_{jt} = Ae^{\theta_t} u_{jt} K_{jt}^{\alpha} L_{jt}^{1-\alpha}$$

- Aggregate productivity θ_t follows an AR(1)

$$\theta_t = \rho\theta_{t-1} + \varepsilon_t^{\theta}, \quad \varepsilon_t^{\theta} \sim \text{iid } \mathcal{N}\left(0, \gamma_{\theta}^{-1}\right)$$

- Capacity utilization u_{jt}
  - Binary decision $u_{jt} \in \{1, \omega\}$ with $\omega > 1$
  - Operating at high capacity ω costs f
  - Acts as a TFP shifter:

$$A_h(\theta_t) \equiv \omega Ae^{\theta_t} > Ae^{\theta_t} \equiv A_l(\theta_t)$$

Equilibrium Definition

Definition

An equilibrium is policies for the household $\{C_t(\theta^t), K_{t+1}(\theta^t), L_t(\theta^t)\}$, policies for firms $\{Y_{jt}(\theta^t), K_{jt}(\theta^t), L_{jt}(\theta^t)\}, j \in \{h, l\}$, a measure $m_t(\theta^t)$ of high capacity firms, prices $\{R_t(\theta^t), W_t(\theta^t)\}$ such that

- Household and firms solve their problems, markets clear,
- Mass of firms with high capacity is consistent with firms' decisions

$$m_t(\theta^t) \equiv \begin{cases} 1 & \text{if } \Pi_{ht} - f > \Pi_{lt} \\ \in (0,1) & \text{if } \Pi_{ht} - f = \Pi_{lt} \\ 0 & \text{if } \Pi_{ht} - f < \Pi_{lt} \end{cases}$$

Characterization

- The intermediate producer faces a simple static problem
- Producers face a positive aggregate demand externality

$$\Pi_{jt} = Y_t^{\frac{1}{\sigma}} Y_{jt}^{\frac{\sigma-1}{\sigma}} - W_t L_{jt} - R_t K_{jt}$$

  where σ determines the strength of externality
- In partial equilibrium, the capacity choice collapses to

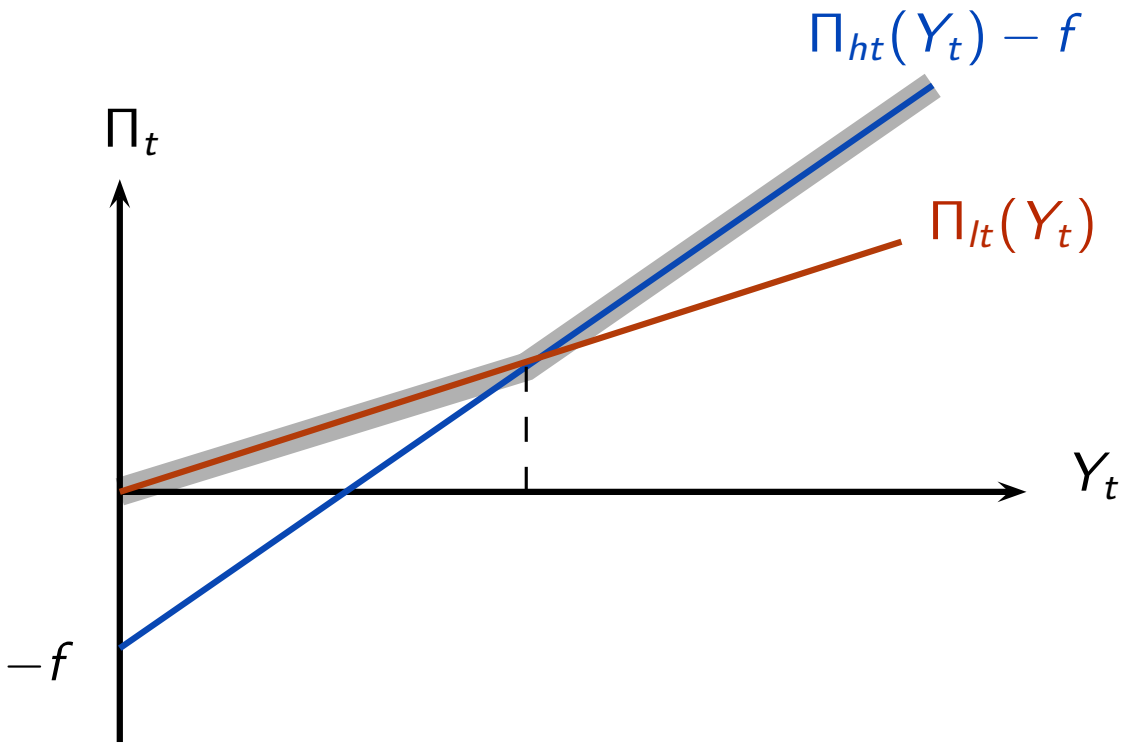
$$\Pi = \max \left[\frac{1}{\sigma} \frac{Y_t}{P_{ht}^{\sigma-1}} - f, \frac{1}{\sigma} \frac{Y_t}{P_{lt}^{\sigma-1}} \right]$$

  with the cost of a marginal unit of output

$$P_{jt} = \frac{\sigma}{\sigma - 1} MC_{jt} \quad \text{and} \quad MC_{jt} \equiv \frac{1}{A_{jt}(\theta)} \left(\frac{R_t}{\alpha} \right)^{\alpha} \left(\frac{W_t}{1-\alpha} \right)^{1-\alpha}$$

Characterization

- Incentives to use high capacity increase with aggregate demand Y_t



Static Equilibrium

- Simple aggregate production function:

$$Y_t = \overline{A}(\theta_t, m_t) K_t^{\alpha} L_t^{1-\alpha}$$

- *Endogenous* TFP:

$$\overline{A}(\theta, m) = \left(m A_h (\theta)^{\sigma-1} + (1-m) A_l (\theta)^{\sigma-1} \right)^{\frac{1}{\sigma-1}}$$

Static Equilibrium

- Simple aggregate production function:

$$Y_t = \overline{A}(\theta_t, m_t) K_t^{\alpha} L_t^{1-\alpha}$$

- *Endogenous* TFP:

$$\overline{A}(\theta, m) = \left(m A_h(\theta)^{\sigma-1} + (1-m) A_l(\theta)^{\sigma-1} \right)^{\frac{1}{\sigma-1}}$$

Static Equilibrium

- Simple aggregate production function:

$$Y_t = \overline{A}(\theta_t, m_t) K_t^{\alpha} L_t^{1-\alpha}$$

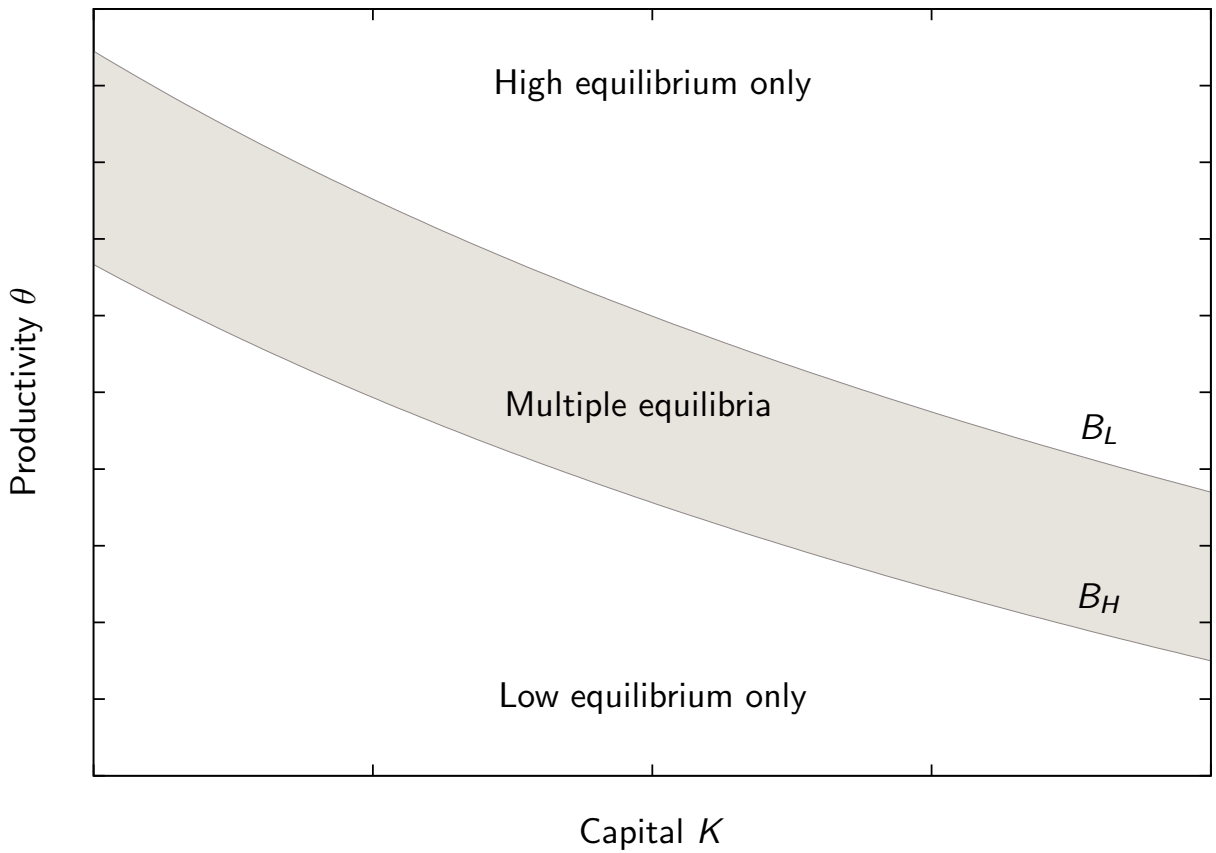
- *Endogenous* TFP:

$$\overline{A}(\theta, m) = \left(m A_h (\theta)^{\sigma-1} + (1-m) A_l (\theta)^{\sigma-1} \right)^{\frac{1}{\sigma-1}}$$

Static Equilibrium: Multiplicity

Proposition 1

Suppose that $\frac{1+\nu}{\alpha+\nu} > \sigma - 1$, *then there exists cutoffs* $B_H < B_L$ *such that there are multiple static equilibria for* $B_H \leqslant e^{\theta} K^{\alpha} \leqslant B_L$. ▸ Intuition

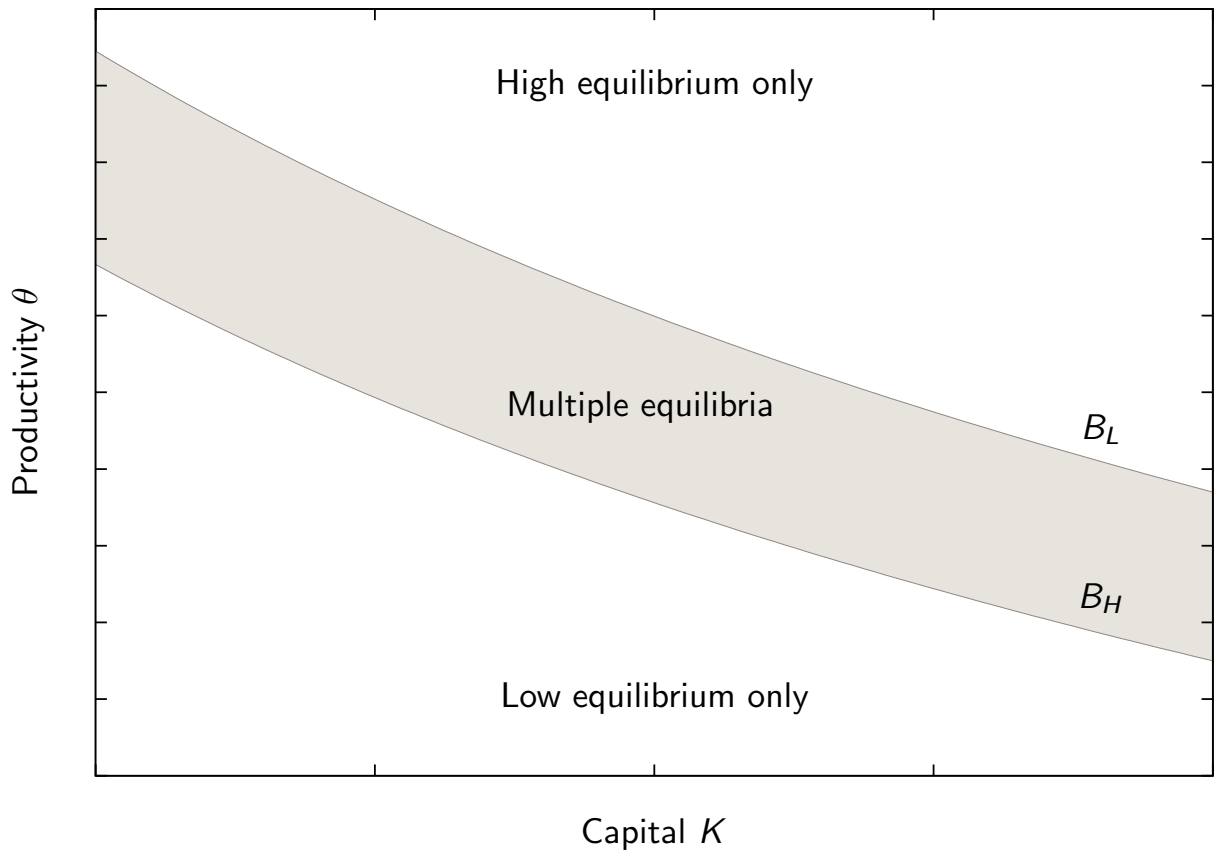


Abundance of capital helps coordination ⇒ Coordination persistence

Static Equilibrium: Multiplicity

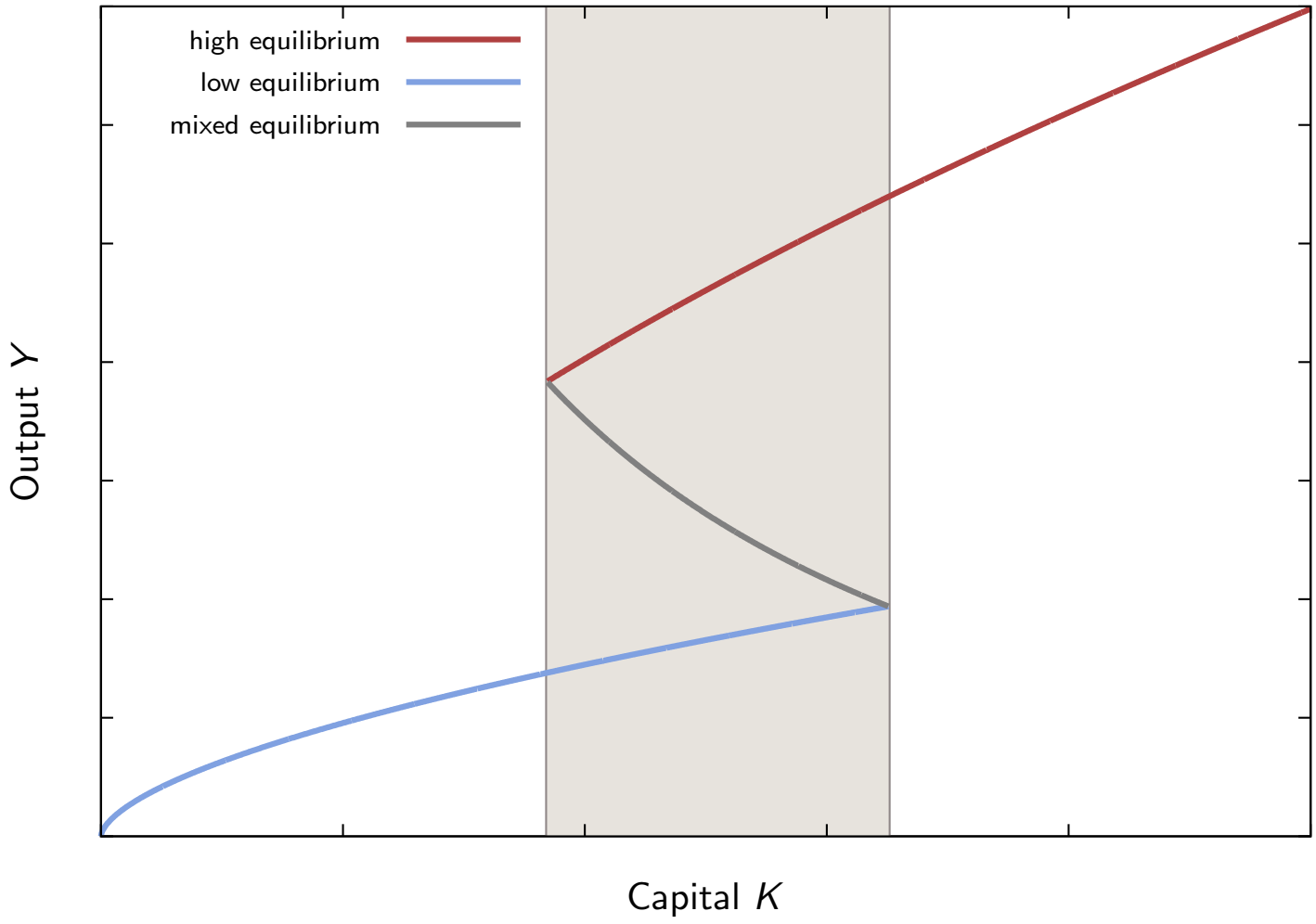
Proposition 1

Suppose that $\frac{1+\nu}{\alpha+\nu} > \sigma - 1$, *then there exists cutoffs* $B_H < B_L$ *such that there are multiple static equilibria for* $B_H \leqslant e^{\theta} K^{\alpha} \leqslant B_L$. ▸ Intuition



Abundance of capital helps coordination ⇒ Coordination persistence

Static Equilibrium: Multiplicity



▸ Multiplicity vs. Uniqueness

Static Equilibrium: Efficiency

Is the static equilibrium efficient?

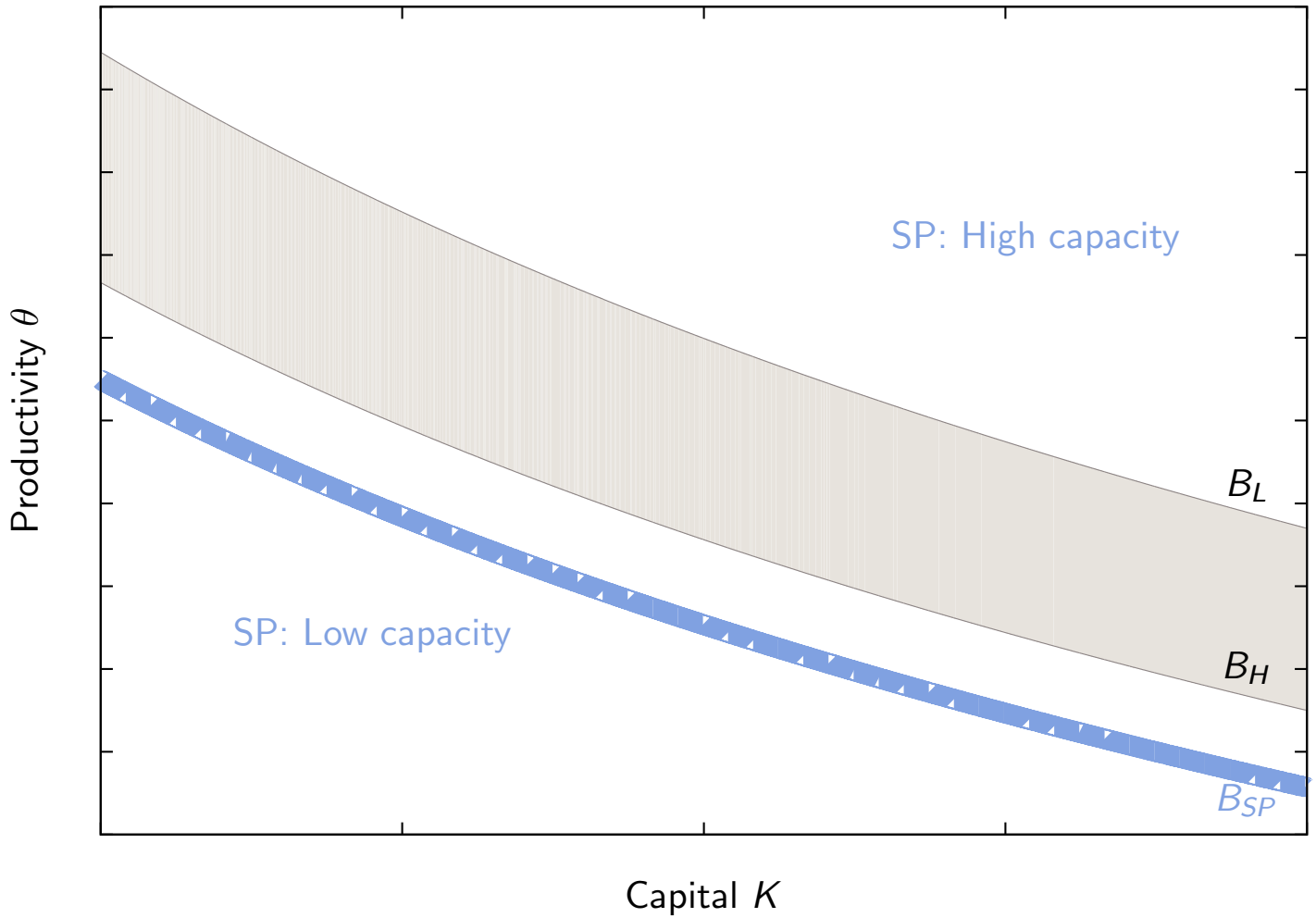
Proposition 2

For $\frac{1+\nu}{\alpha+\nu} > \sigma - 1$, *there exists a threshold* $B_{SP} < B_L$ *such that*

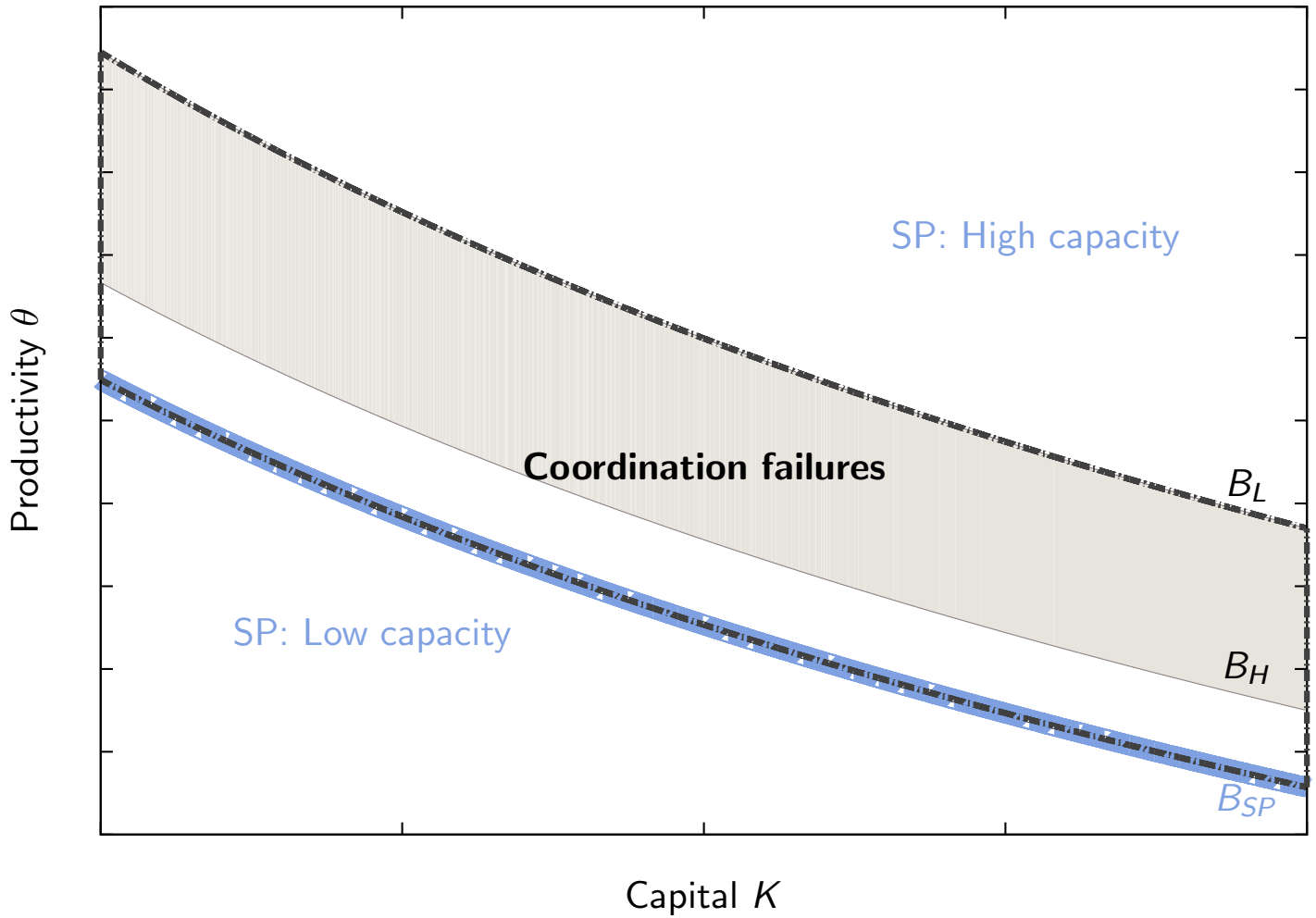
- *For* $e^{\theta} K^{\alpha} \leqslant B_{SP}$, *the planner chooses* $m = 0$,
- *For* $e^{\theta} K^{\alpha} \geqslant B_{SP}$, *the planner chooses* $m = 1$.

In addition, for σ *low enough,* $B_{SP} < B_H$.

Static Equilibrium: Efficiency



Static Equilibrium: Coordination Failure



II. Model: Incomplete Information Case

Model: Incomplete Information

- Model remains the same, except:
  - Capacity choice is made under uncertainty about current θ_t
- New timing:
  1. Beginning of period: $\theta_t = \rho\theta_{t-1} + \varepsilon_t^\theta$ is drawn
  2. Firm j observes private signal $v_{jt} = \theta_t + \varepsilon_{jt}^v$ with $\varepsilon_{jt}^v \sim$ iid $\mathcal{N}\left(0, \gamma_v^{-1}\right)$
  3. Firms choose their capacity $u_j \in \{u_l, u_h\}$
  4. θ_t is observed, production takes place, C_t and K_{t+1} are chosen

Uniqueness

Proposition 3

For γ_v large and if

$$\frac{\sqrt{\gamma_v}}{\gamma_\theta} > \frac{1}{\sqrt{2\pi}} \frac{\omega^{\sigma-1}-1}{\sigma-1},$$

then the equilibrium of the static global game is unique and takes the form of a cutoff rule $\hat{v}(K, \theta_{-1}) \in \mathbb{R} \cup \{-\infty, \infty\}$ such that firm j choose high capacity if and only if $v_j \geqslant \hat{v}(K, \theta_{-1})$. In addition, $\hat{v}$ is decreasing in its arguments.

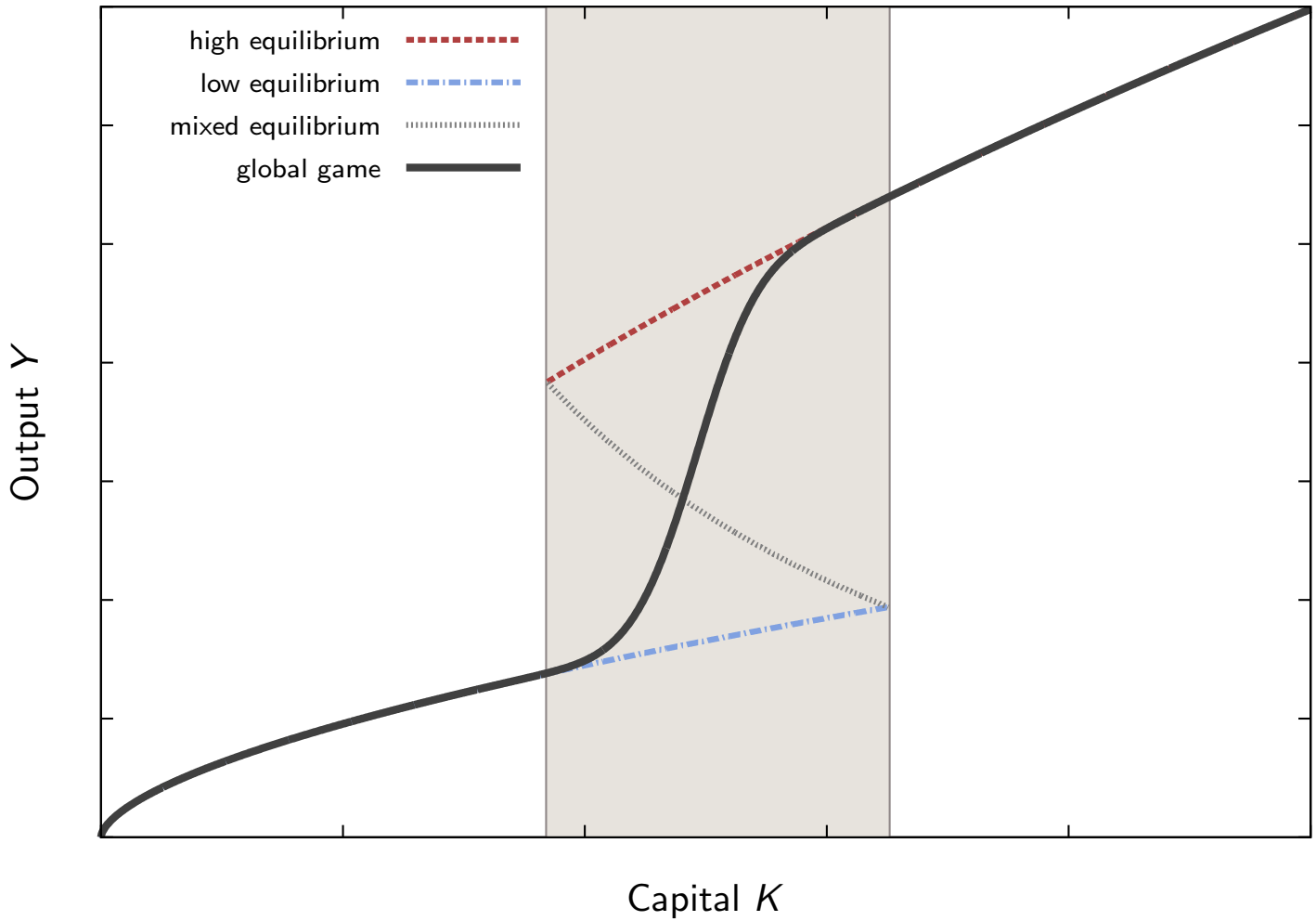
Proposition 4

Under the same conditions as proposition 3 and with f sufficiently small, there exists a unique dynamic equilibrium for the economy.

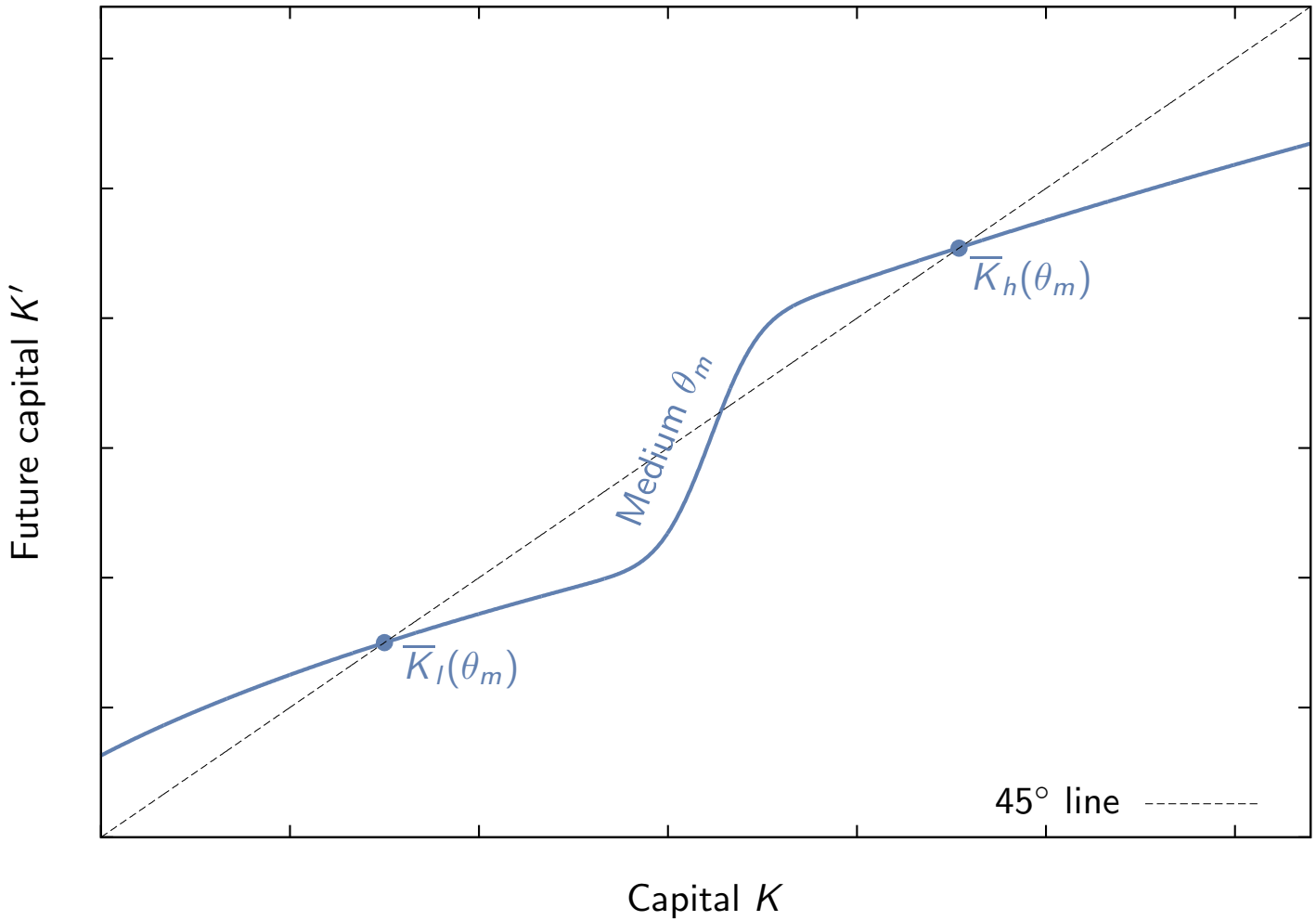
- Proof based on lattice-theoretic arguments (Coleman and John, 2000)

▸ Details

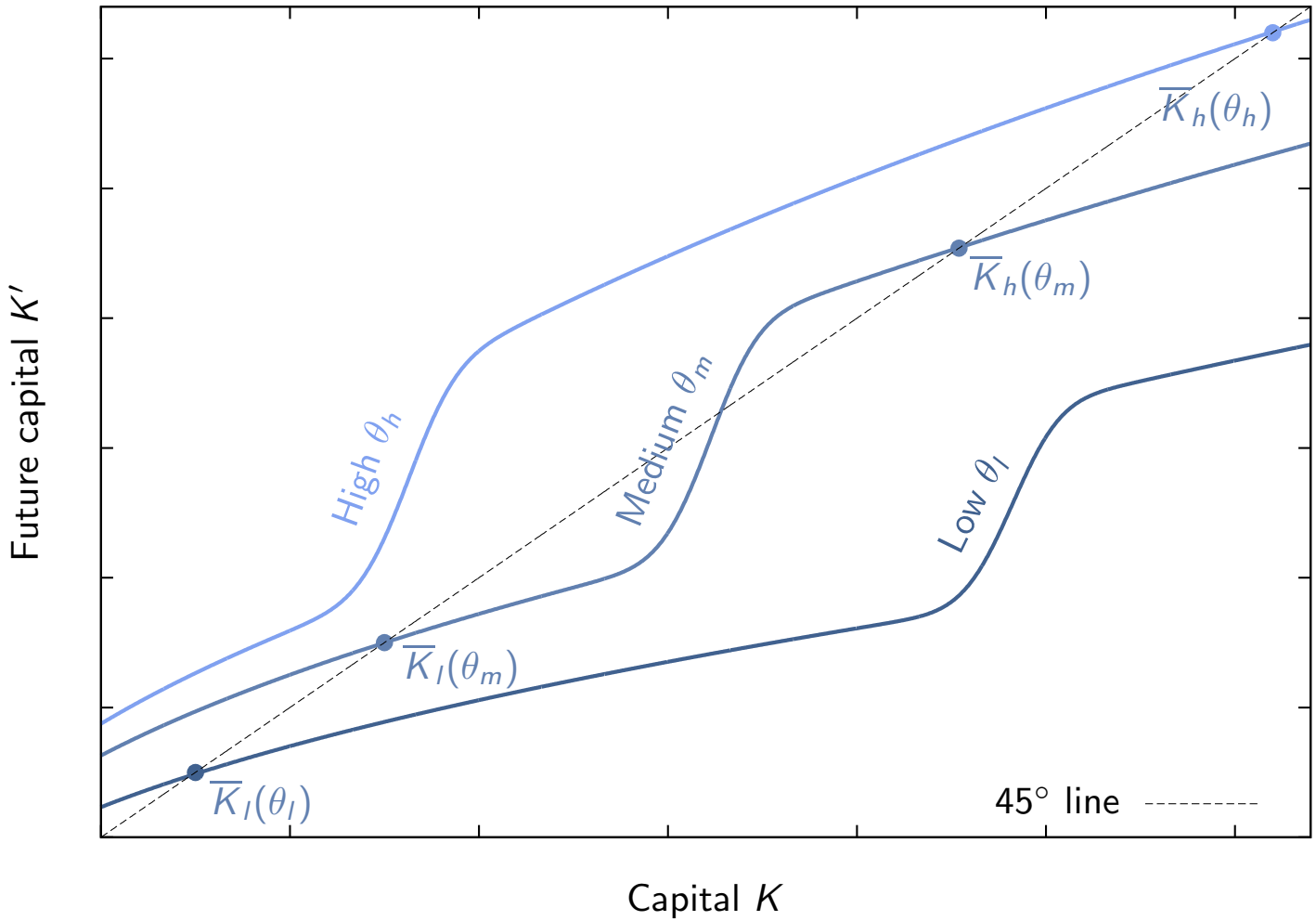
Uniqueness of Static Game



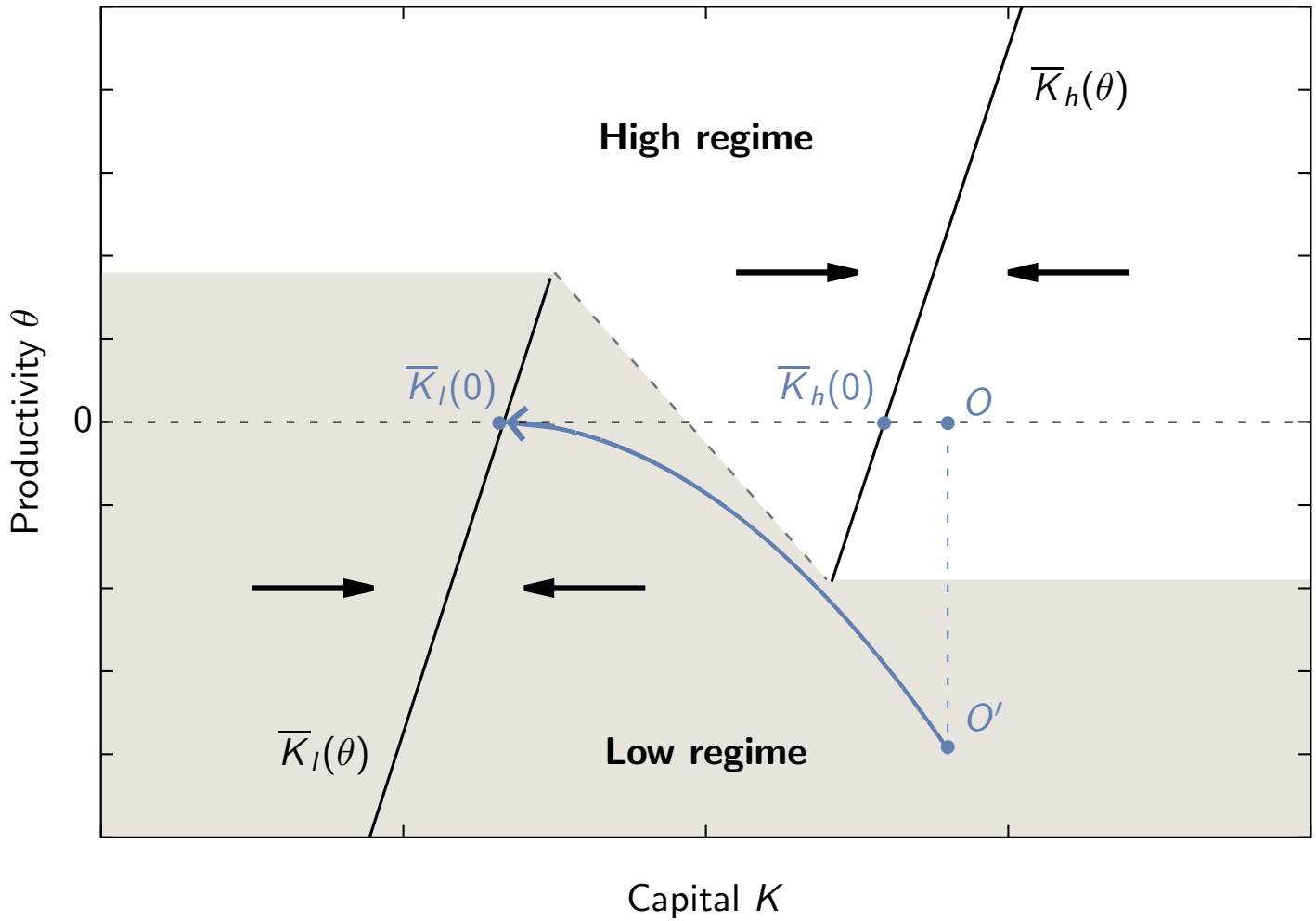
Dynamics: Multiple Steady States



Dynamics: Multiple Steady States



Dynamics: Phase Diagram



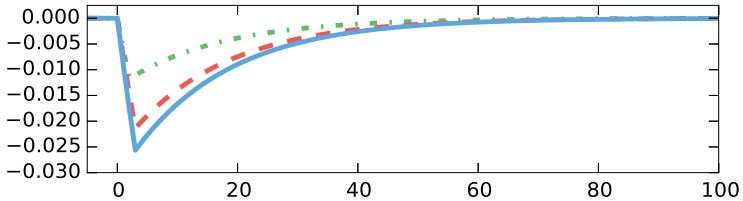
III. Quantitative Evaluation

Quantitative Exercise

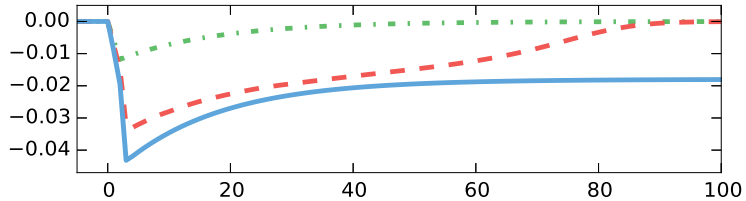
- The model is calibrated in a fairly standard way ▸ Calibration
- We then evaluate the model on the following dimensions:
  - Business cycle moments: similar performance to standard RBC model ▸ RBC moments
  - Asymmetry: negative skewness and bimodality, as in the data ▸ Asymmetry
  - Persistence: impulse responses and the 2007-2009 recession

Impulse Responses

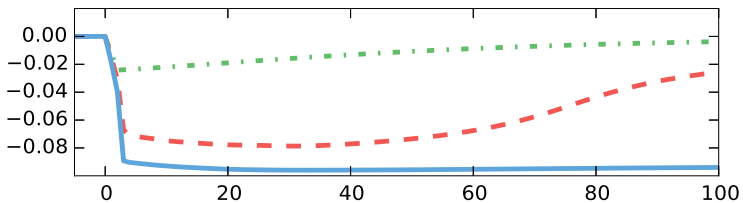
(a) θ



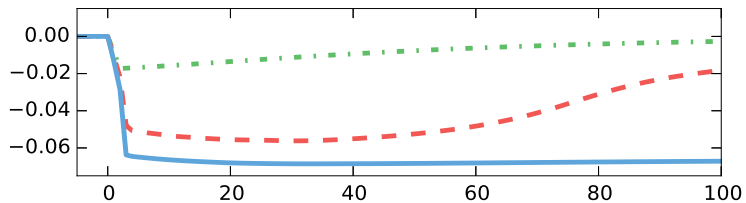
(b) TFP



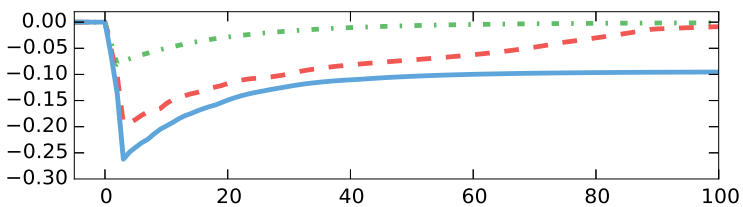
(c) Output



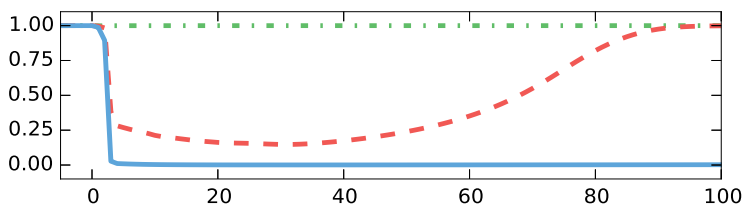
(d) Labor



(e) Investment



(f) Capacity m



▸ $\sigma = 5$

2007-2009 Recession

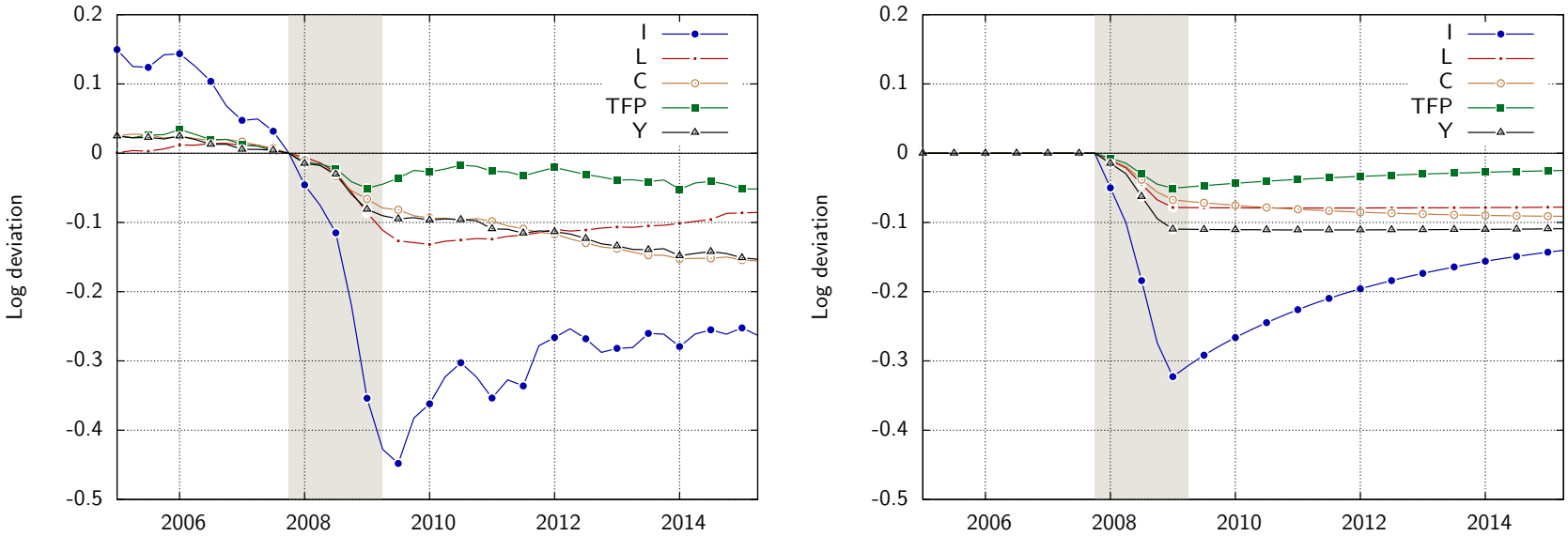


Figure: US series centered on 2007Q4 (left) vs model (right)

IV. Policy Implications

Policy Implications

- The competitive economy suffers from two (related) inefficiencies:
  1. Monopoly distortions on the product market,
  2. Inefficient capacity choice due to aggregate demand externality.
- We analyze:
  - Impact of fiscal policy
  - Optimal policy and implementation

Policy: Summary of Results

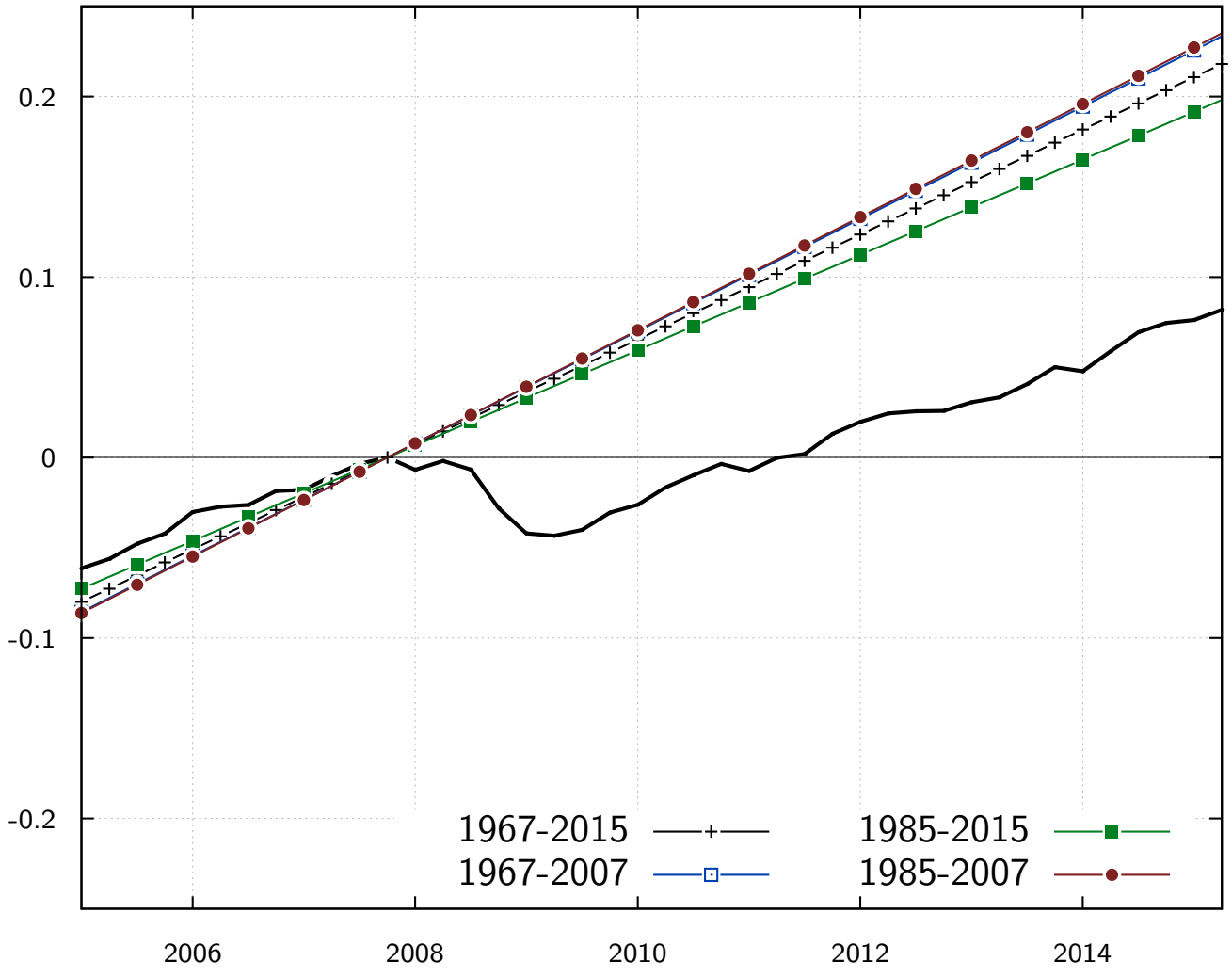
- Fiscal policy:
  - Government spending is in general detrimental to coordination
    - Crowding out effect *magnified* by coordination problem ▸ Crowding
    - This effect dominates in most of the state space
  - But negative wealth effect can overturn this result
    - When preferences allow for wealth effect on labor supply, fiscal policy may be *welfare improving* by helping coordination ▸ Welfare
    - Possibly large multipliers without nominal rigidities ▸ Multiplier
- Optimal policy:
  - A mix of constant input and profit subsidies implement the constrained efficient allocation ▸ Optimal Policy

V. Conclusion

Conclusion

- We construct a dynamic stochastic general equilibrium model with coordination failures
  - Provides a foundation for demand-deficient effects without nominal rigidities
- The model generates:
  - Deep recessions: secular stagnation?
  - Fiscal policy can be welfare improving
- Future agenda:
  - Quantitative side:
    - Understand the role of firm-level heterogeneity
    - Use micro-data to discipline the non-convexities
  - Learning, optimal fiscal policy, etc.

Impact of Detrending on GDP



Return

Capacity Utilization and TFP

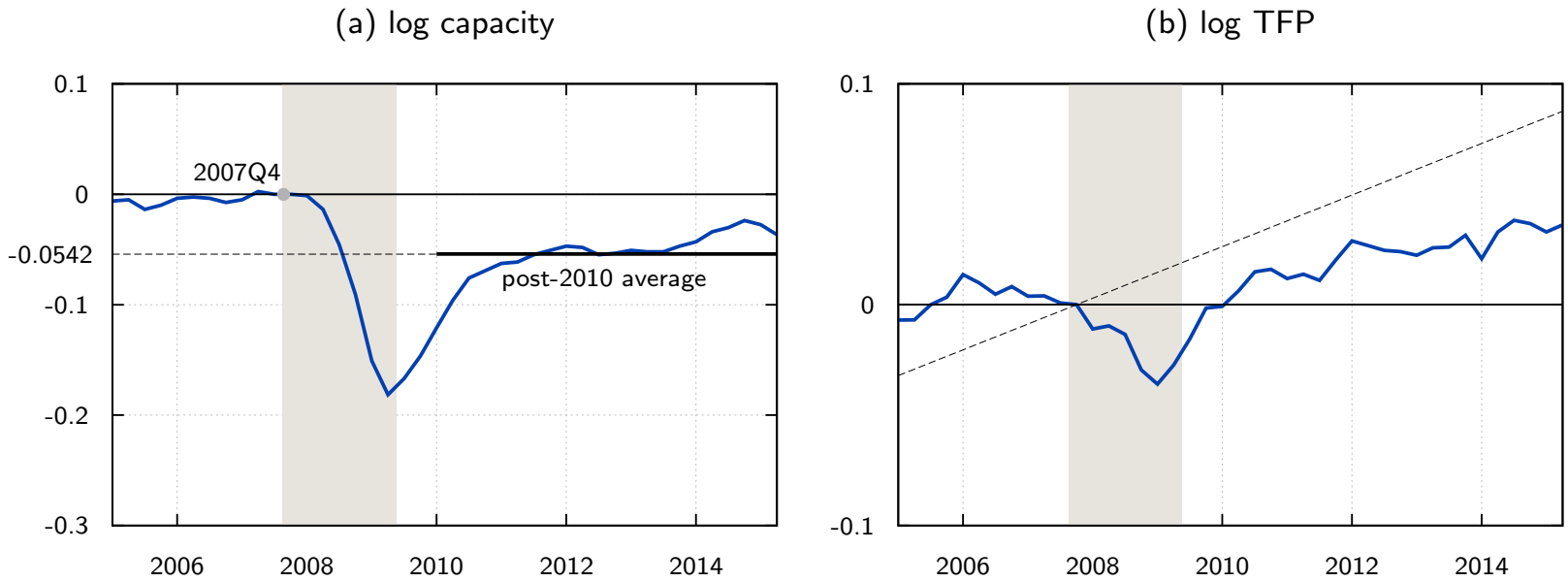
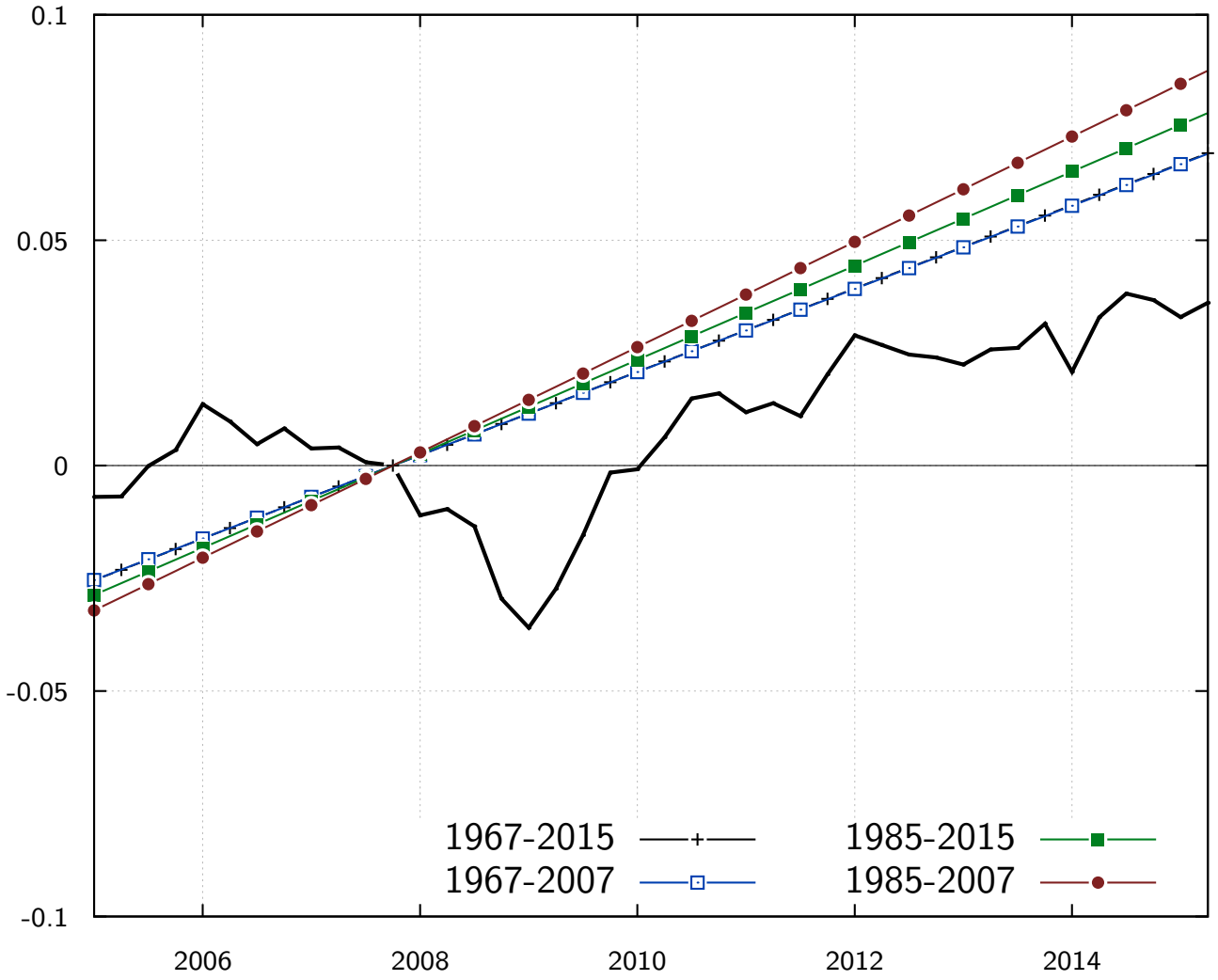


Figure: Capacity Utilization and Measured TFP

▸ Detrending ▸ Measures

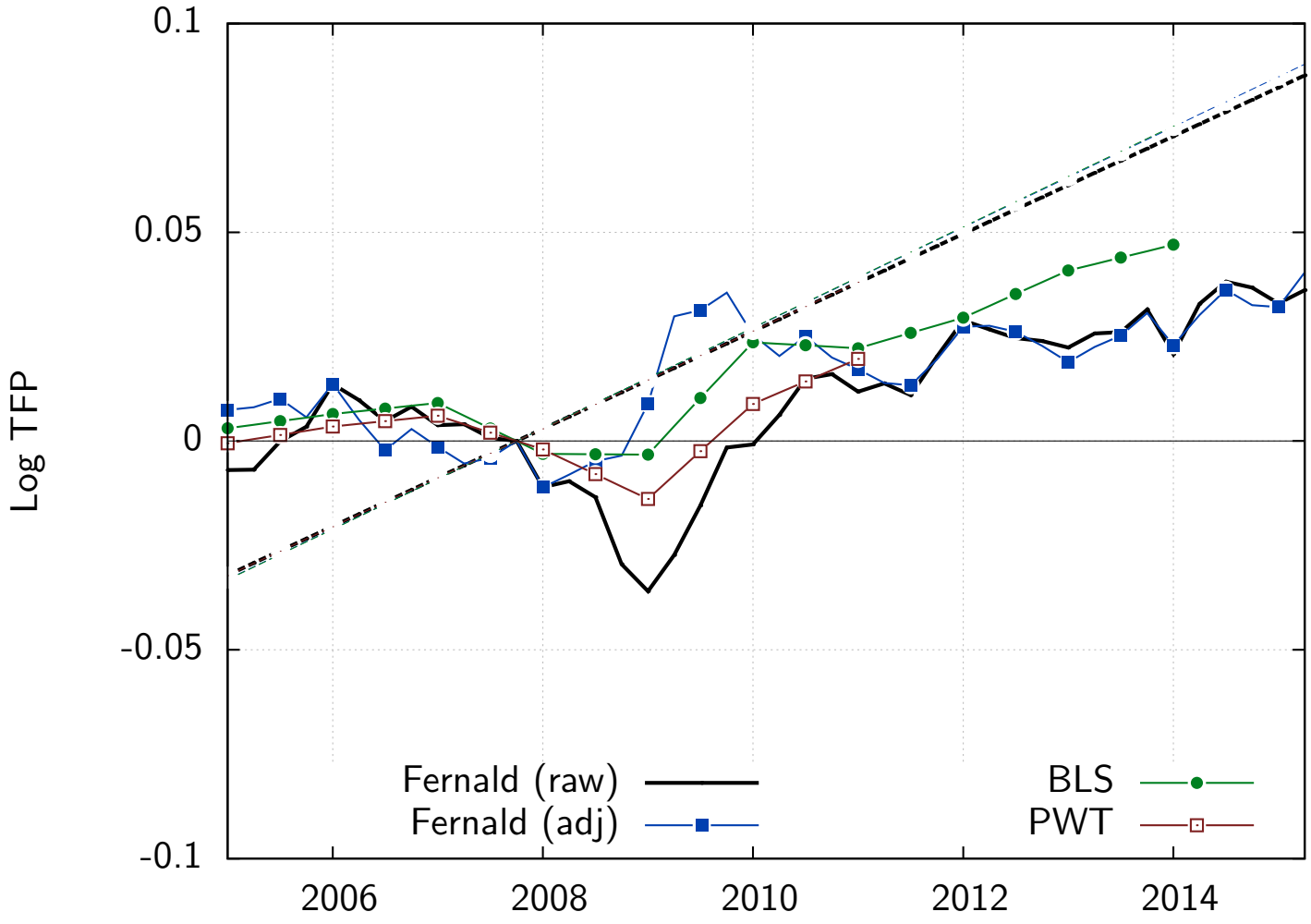
◂ Return

Impact of Detrending on TFP



Return

Various Measures of TFP



Return

Evidence of Non-Convexities

- Typical neoclassical model assumes convex cost functions
  - Well-defined maximization problem with unique equilibrium
- However, large evidence of non-convexities in cost functions:
  - Firms adjust output along various margins which differ in lumpiness/adjustment/variable costs
    - Cooper and Haltiwanger (2006): lumpy adjustments in labor and investment,
    - Bresnahan and Ramey (1994): lumpy changes in production at plant-level with plant shutdowns/restart,
    - Hall (1999): non-convexities in shift adjustments across Chrysler assembly plants.

Evidence of Non-Convexities

- Ramey (JPE 1991) estimates cost functions
  - Example food industry:

$$C_t(Y) = 23.3 w_t Y - 7.78^{**} Y^2 + 0.000307^{*} Y^3 + \ldots$$

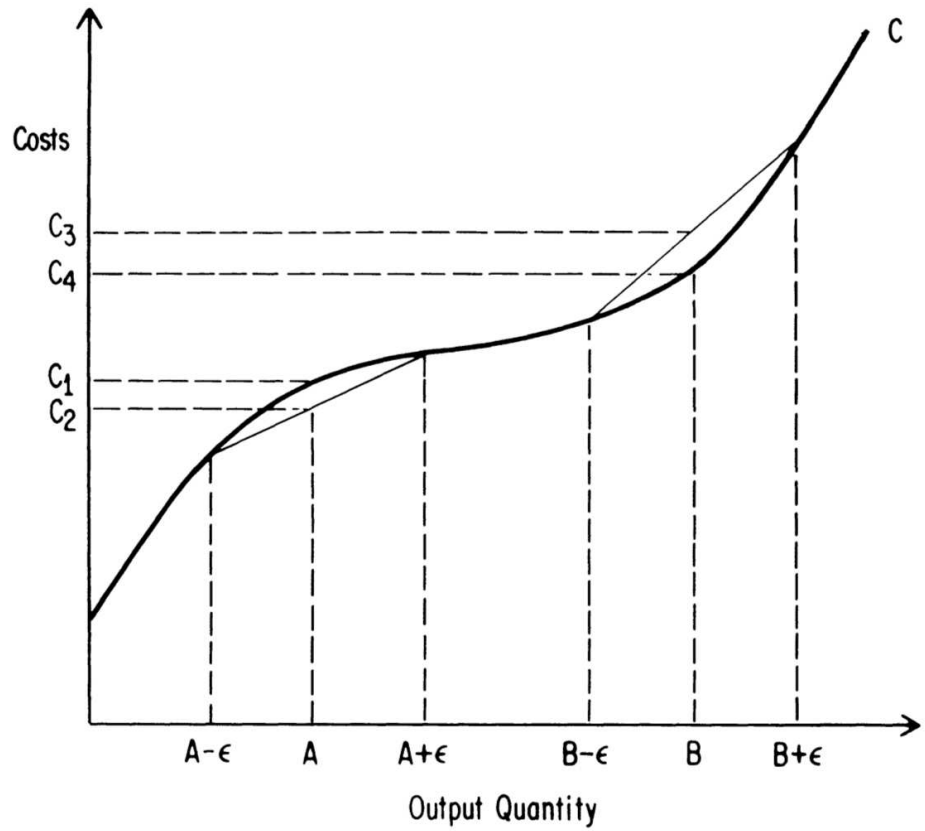


Figure: Non-convex cost curve (Ramey, 1991)

Return

Static Equilibrium: Multiplicity

- Condition for multiplicity is

$$\frac{1+\nu}{\alpha+\nu} > \sigma - 1$$

- This condition is more likely to be satisfied if
  - σ is small: high complementarity through demand,
  - ν is small: low input competition (sufficiently flexible labor),
  - α is small: production is intensive in the flexible factor (labor).

◂ Return

Parametrization

Standard parameters:

Parameter	Value	Source/Target
Time period	one quarter	
Capital share	$\alpha = 0.3$	Labor share 0.7
Discount factor	$\beta = 0.95^{1/4}$	0.95 annual
Depreciation rate	$\delta = 1 - 0.9^{1/4}$	10% annual
Risk aversion	$\gamma = 1$	log utility
Elasticity of labor supply	$\nu = 0.4$	Jaimovich and Rebelo (2009)
Persistence θ process	$\rho_\theta = 0.94$	Autocor log output
Stdev of θ	$\sigma_\theta = 0.009$	Stdev log output
Elasticity of substitution	$\sigma = 3$ and 5	Hsieh and Klenow (2014)

Parametrization

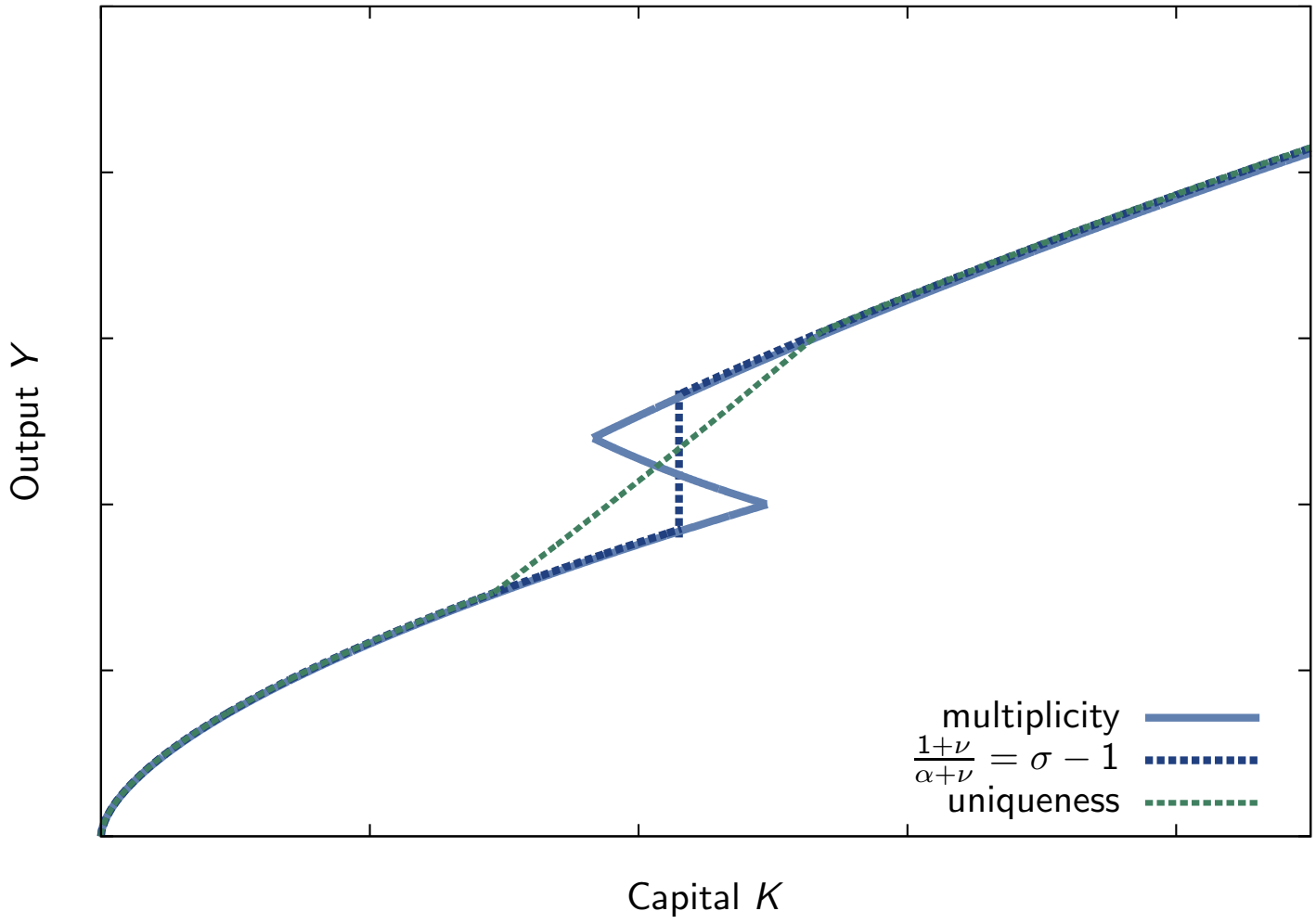
- Elasticity of substitution σ:
  - Broda and Weinstein (2006): $\sigma = 3$ corresponds to the median estimates at various levels of aggregation.
  - Bernard, Eaton, Jensen and Kortum (2003) estimate a value of $\sigma = 3.79$ in a model of plant-level export behavior.
  - Hsieh and Klenow (2014) use $\sigma = 3$ to study the life cycle of plants in India and Mexico.
  - Christiano, Eichenbaum and Trabandt (2015) estimate a New-Keynesian model with financial friction and find an elasticity of $\sigma = 3.78$.
  - We use $\sigma = 3$ as benchmark and $\sigma = 5$ for robustness.

Parametrization

- Precision of private information γ_v:
  - Governs the dispersion of beliefs about θ and other variables
  - Target dispersion in forecasts about GDP growth of 0.24% in SPF
  - $\gamma_v = 1,154,750 \simeq 0.1\%$ stdev of noise
- Capacity utilization ratio $\omega = \frac{u_h}{u_l}$:
  - Post-2009 average decline in individual output is -5.42%
  - Ratio of output $\frac{Y_h}{Y_l} = \omega^\sigma$, so $\omega \simeq 1.0182$
- Fixed cost f:
  - Governs the frequency of regime switches
  - Use probabilistic forecast from SPF
  - Target probability GDP (with trend) falls $< -2\%$ of 0.63%, $f = 0.021 \simeq 1\%$ of GDP

Return

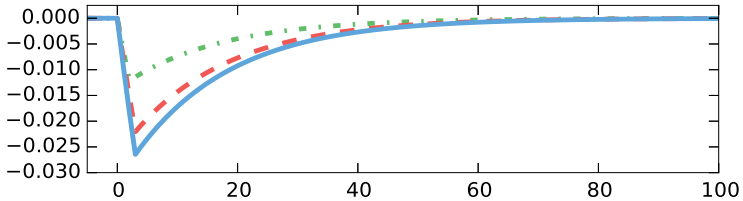
Static Equilibrium: Multiplicity vs. Uniqueness



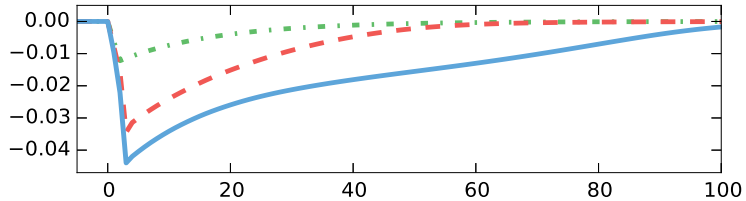
◀ Multiplicity

Impulse Responses for $\sigma = 5$

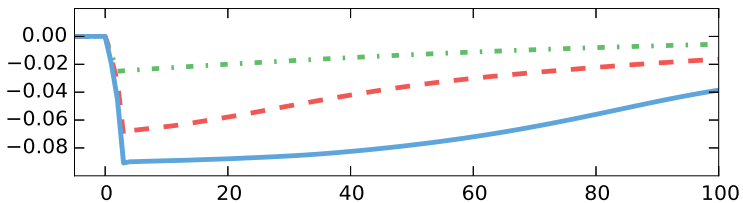
(a) θ



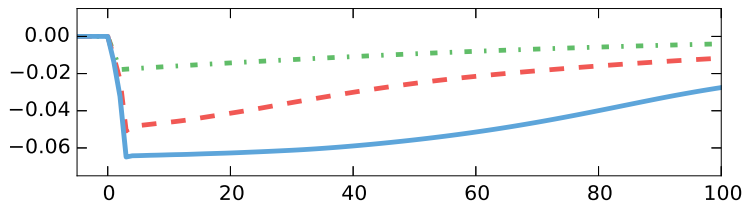
(b) TFP



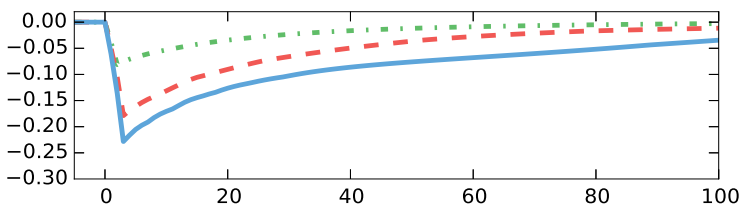
(c) Output



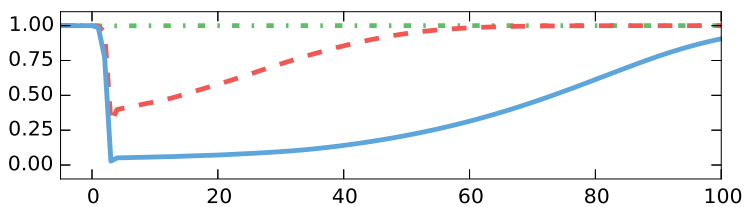
(d) Labor



(e) Investment



(f) Capacity m



◀ Return

Constrained Planner Problem

- The planner's capacity decision

$$E\left[U_c\left(C,L\right)m_{\hat{v}}\left(\theta,\hat{v}\right)\left(\overline{A}_m\left(m,\theta\right)K^{\alpha}L^{1-\alpha}-f\right)|\theta_{-1}\right]=0$$

  is equivalent to

$$\mathbb{E}\left\{U_c\left(C,L\right)\left[\frac{1}{\sigma-1}\left(\left(\frac{A_h\left(\theta\right)}{\bar{A}\left(m,\theta\right)}\right)^{\sigma-1}-\left(\frac{A_l\left(\theta\right)}{\bar{A}\left(m,\theta\right)}\right)^{\sigma-1}\right)\bar{A}\left(m,\theta\right)K^{\alpha}L^{1-\alpha}-f\right]|\theta_{-1},\hat{v}\right\}=0$$

- Coincides with the competitive economy with profit subsidy when $1+s_{\pi}=\frac{\sigma}{\sigma-1}$:

$$\mathbb{E}\left\{U_c\left(C,L\right)\left[\frac{1+s_{\pi}}{\sigma}\left(\left(\frac{A_h\left(\theta\right)}{\bar{A}\left(m,\theta\right)}\right)^{\sigma-1}-\left(\frac{A_l\left(\theta\right)}{\bar{A}\left(m,\theta\right)}\right)^{\sigma-1}\right)\bar{A}\left(m,\theta\right)K^{\alpha}L^{1-\alpha}-f\right]|\theta_{-1},\hat{v}\right\}=0$$

◂ Return

Uniqueness of Static Game

- Condition for uniqueness

$$\frac{\sqrt{\gamma_v}}{\gamma_\theta} > \frac{1}{\sqrt{2\pi}} \frac{\omega^{\sigma-1}-1}{\sigma-1}$$

- This condition requires:
  1. Uncertainty in fundamental θ (γ_θ low),
  2. High precision in private signals (γ_v high)
     - Ensure that beliefs about fundamental (in γ_v) dominates feedback from others (in $\sqrt{\gamma_v}$)

Return

Business Cycle Moments

	Output	Investment	Hours	Consumption
		Correlation with output		
Data	1.00	0.90	0.91	0.98
Full model	1.00	0.90	1.00	0.99
RBC model	1.00	0.95	1.00	0.99
		Standard deviation relative to output		
Data	1.00	3.09	1.03	0.94
Full model	1.00	1.44	0.71	0.88
RBC model	1.00	1.30	0.71	0.95

Table: Standard business cycle moments

- The full model behaves similarly to a standard RBC model

◂ Return

Skewness

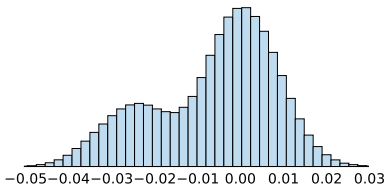
- The model explains between 46%-93% of the emprical skewness:

	Output	Investment	Hours	Consumption
Data	-1.24	-0.92	-0.62	-1.31
Full model	-0.58	-0.44	-0.58	-0.53
RBC model	-0.00	-0.03	-0.00	-0.00

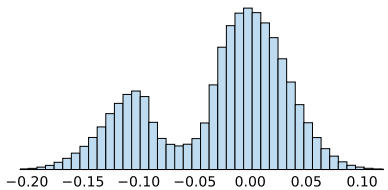
Table: Skewness

Skewness and Bimodality

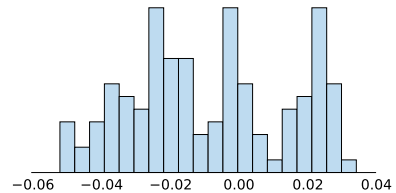
(g) Model TFP



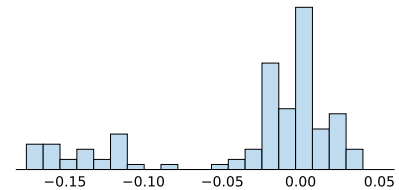
(h) Model Y



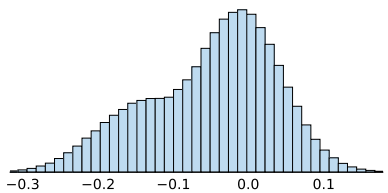
(i) Data TFP



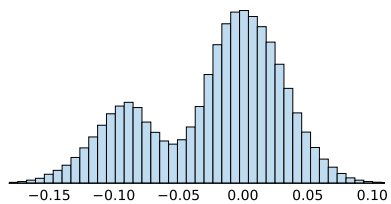
(j) Data Y



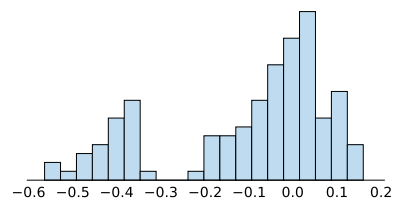
(k) Model I



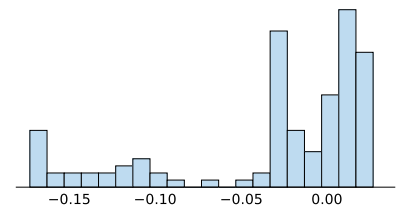
(l) Model C



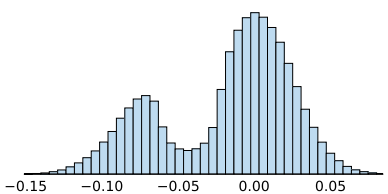
(m) Data I



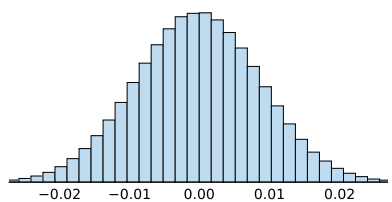
(n) Data C



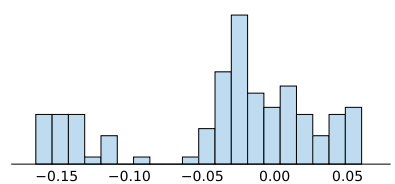
(o) Model L



(p) Model θ



(q) Data L



◀ Return

Solution of the Model

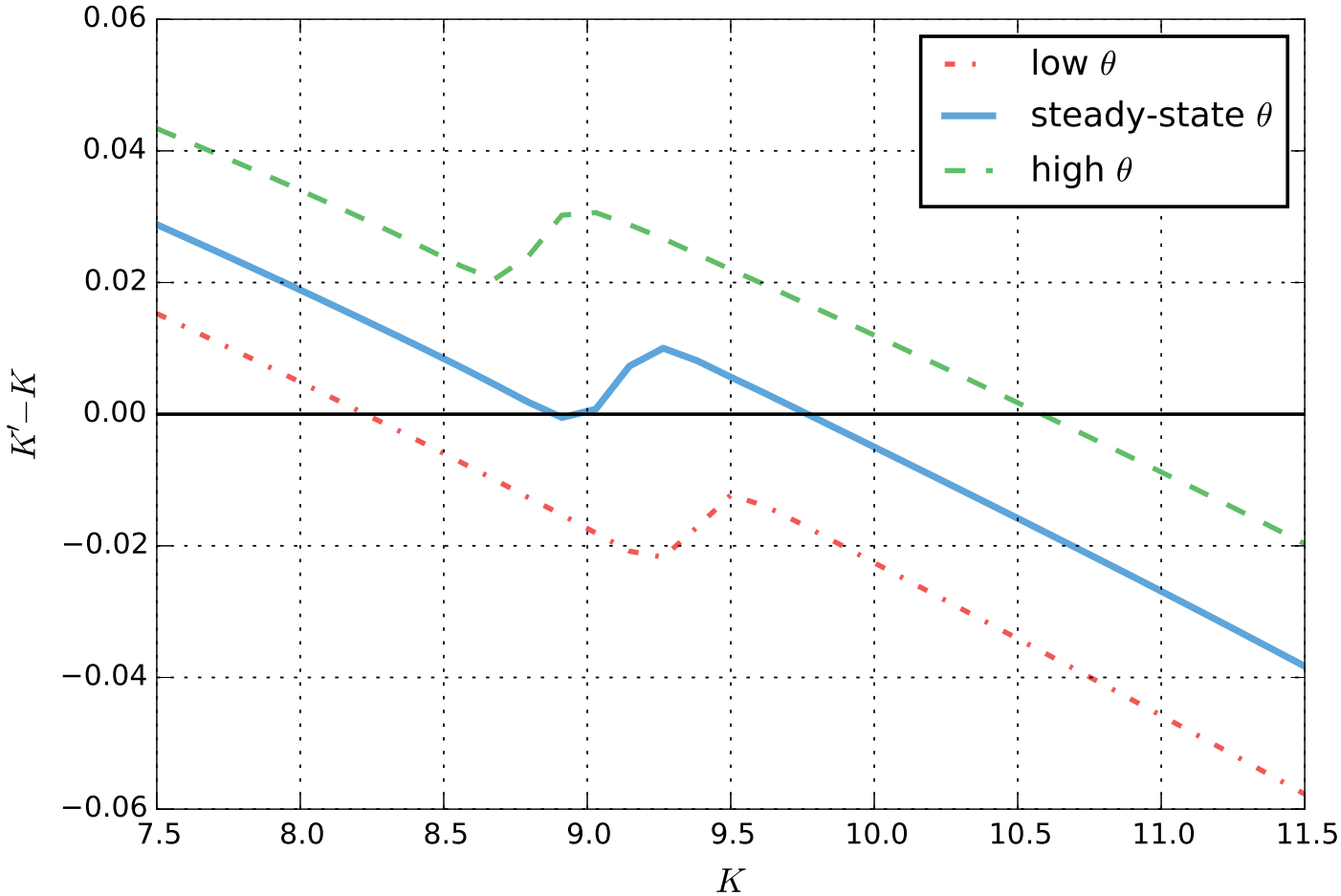
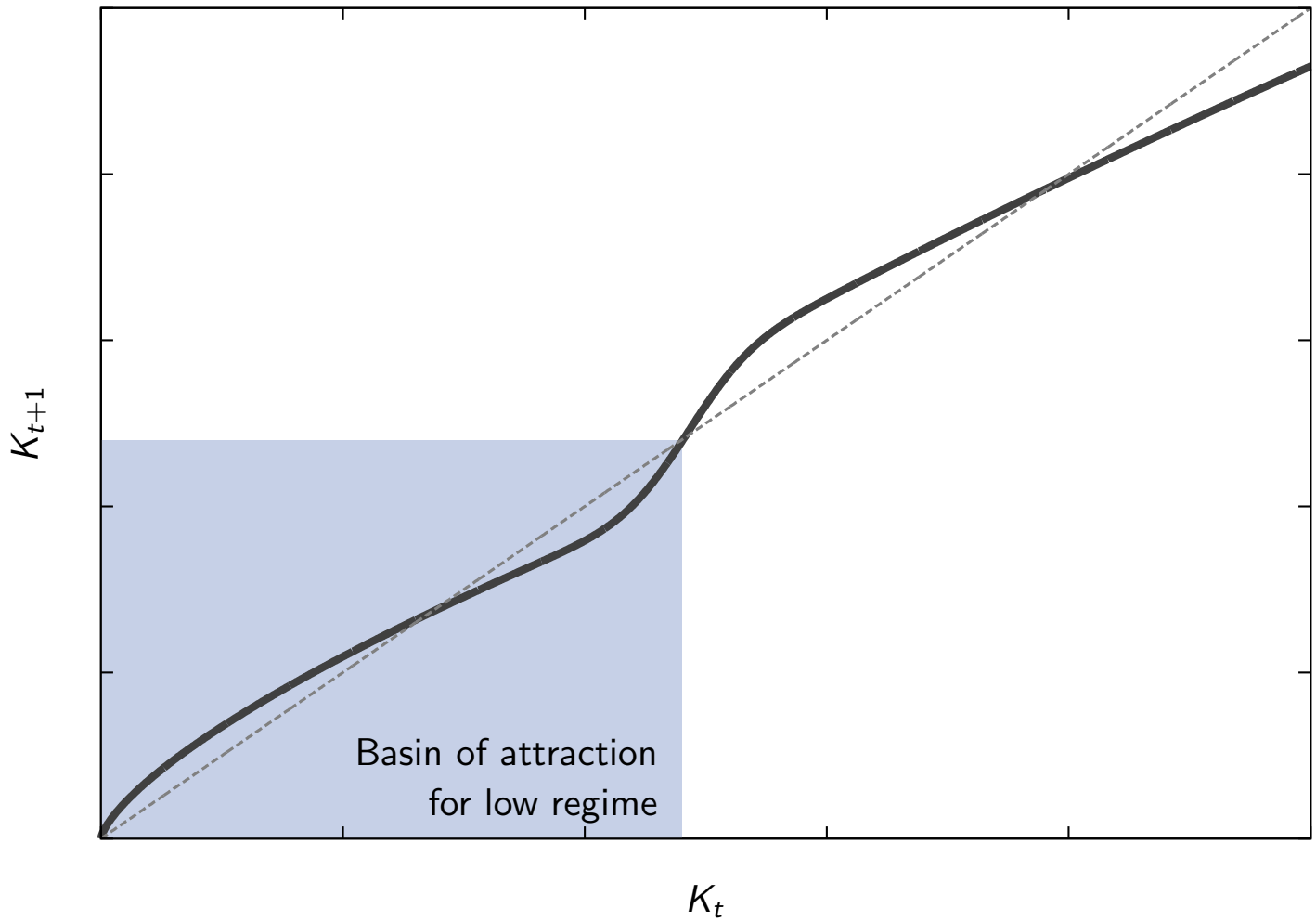


Figure: Two steady states in K for $\theta = 0$

◂ Return

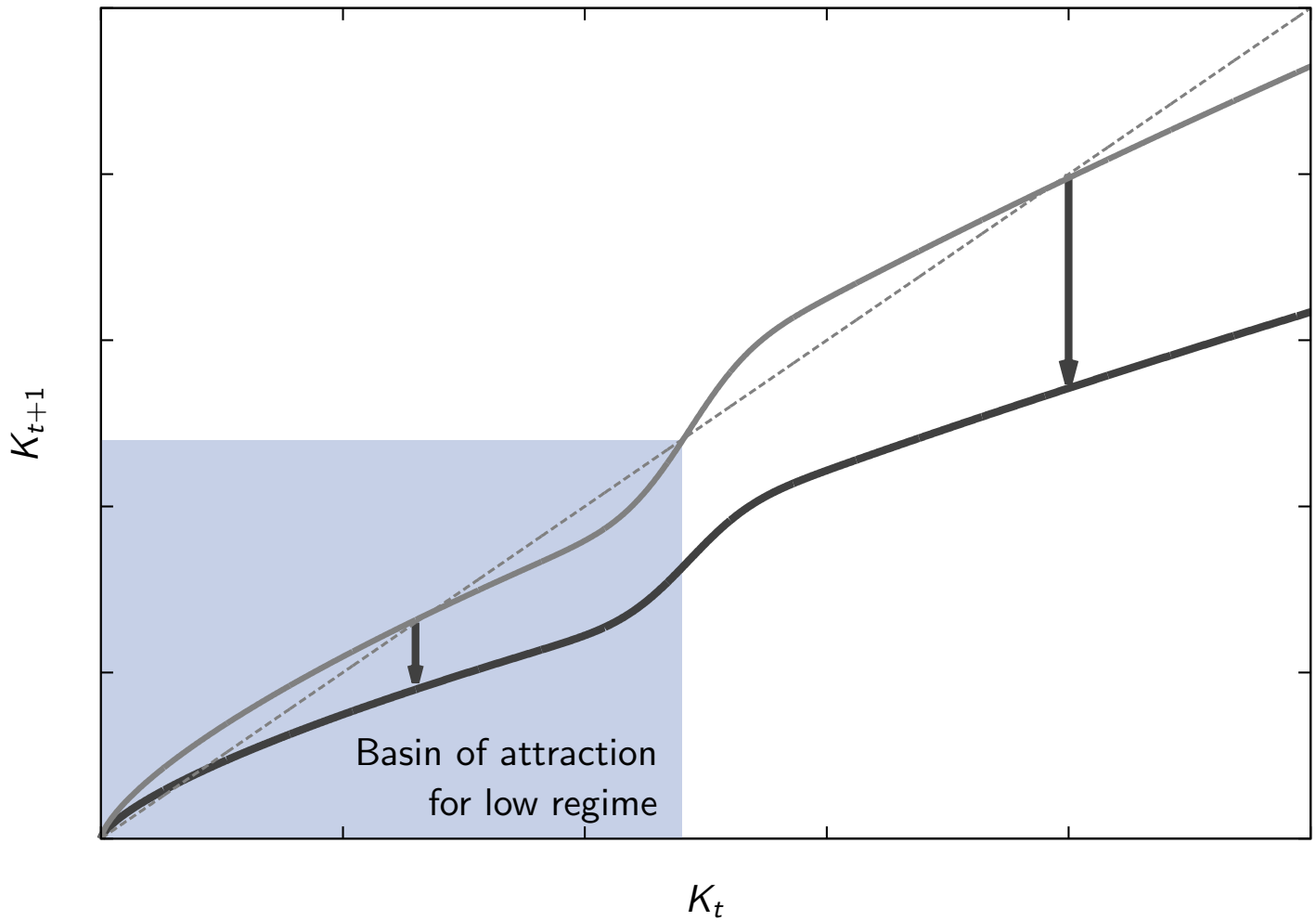
Fiscal Policy: Crowding Out

- Crowding out:



Fiscal Policy: Crowding Out

- Crowding out: decline in investment



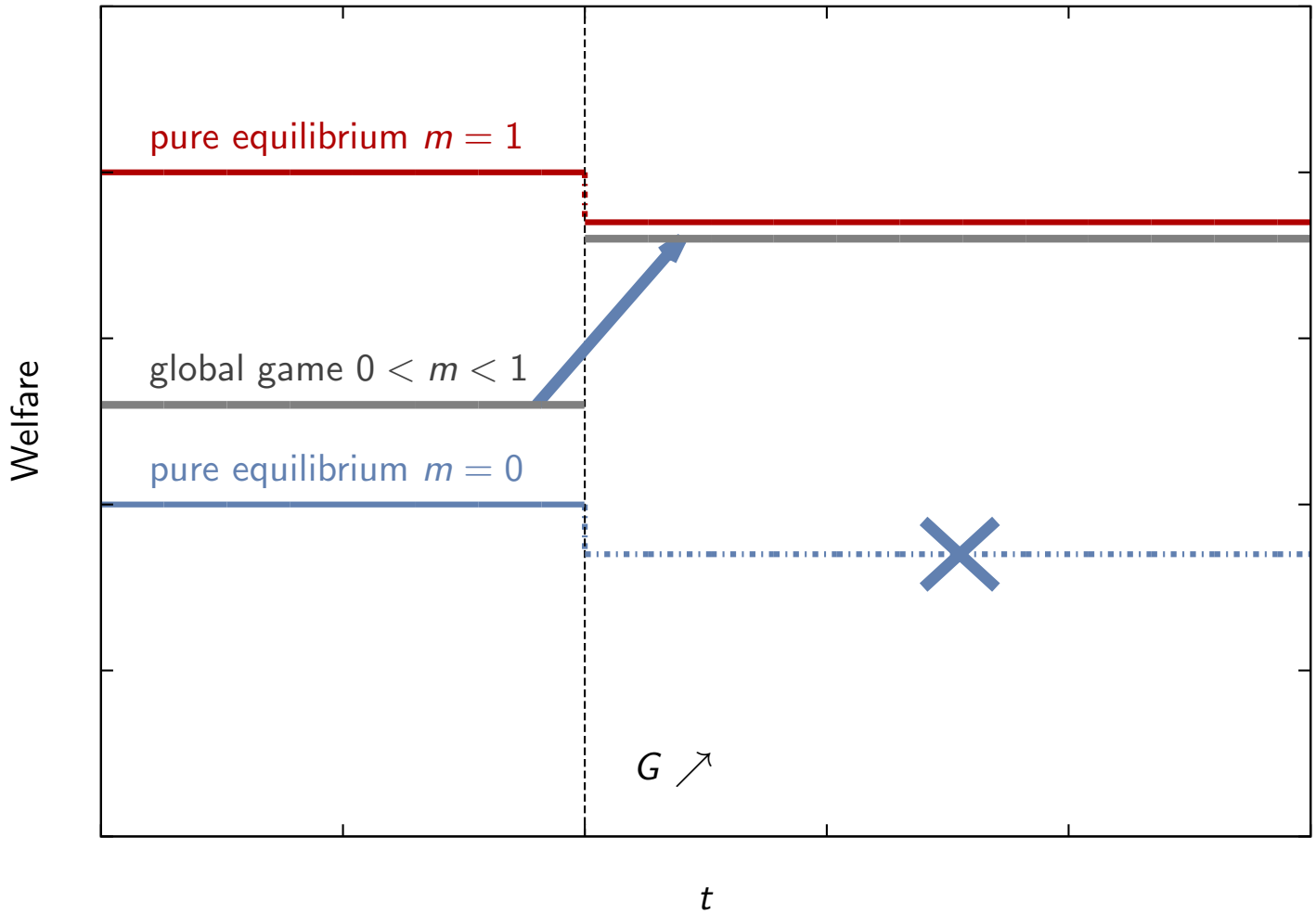
Fiscal Policy: Crowding Out

- Coordination is worsened by crowding out:
  - Capital K plays a crucial role for coordination,
  - By crowding out private investment, government spending makes coordination on high regime less likely in the future!
  - Large dynamic welfare losses
- Result: Under GHH preferences,
  - For γ_v large, firms' choice of m unaffected by G,
  - Government spending is *always* welfare reducing

Return

Fiscal Policy: Wealth Effect

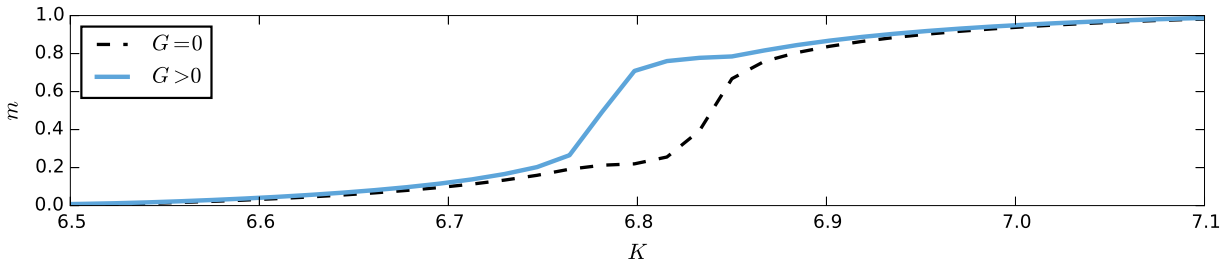
- How can a negative wealth effect be welfare improving?



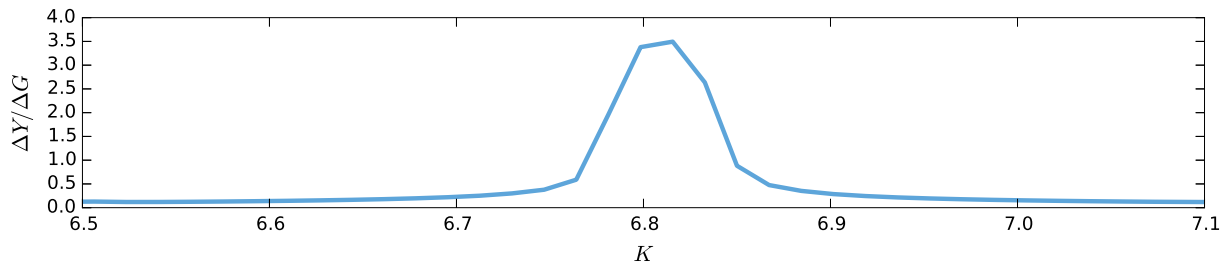
Return

Fiscal Policy

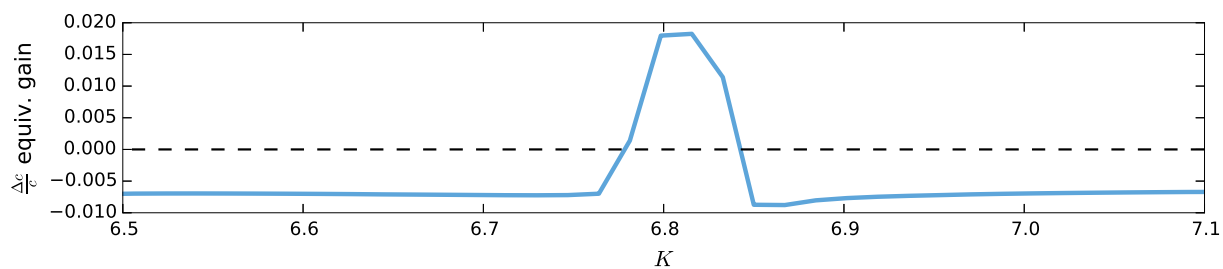
(a) Impact of G on capacity choice m



(b) Fiscal multiplier



(c) Welfare gains in consumption equivalent



Parameters Return

Optimal Policy

- We study a constrained planner with same information as outside observer:
  - At the beginning of period, only knows θ_{-1}
  - Does not observe firms' private signals

Constrained Planner Problem

- The planner chooses a probability to choose high capacity $z(v_j)$ for all signals v_j

$$V(K, \theta_{-1}) = \max_{z, C, L, K'} \mathbb{E}_\theta \left[\frac{1}{1-\gamma} \left(C - \frac{L^{1+\nu}}{1+\nu} \right)^{1-\gamma} + \beta V(K', \theta) \right]$$

subject to

$$C + K' = \overline{A}(\theta, m) K^\alpha L^{1-\alpha} + (1-\delta) K - mf$$

$$m(\theta) = \int \sqrt{\gamma_v} \phi\left(\sqrt{\gamma_v}(v-\theta)\right) z(v)\, dv$$

$$\overline{A}(\theta, m) = \left(m A_h(\theta)^{\sigma-1} + (1-m) A_l(\theta)^{\sigma-1} \right)^{\frac{1}{\sigma-1}}$$

Proposition 5

The competitive equilibrium with imperfect information is inefficient, but the efficient allocation can be implemented with:

1. *An input subsidy* $1 - s_{kl} = \frac{\sigma - 1}{\sigma}$ *to correct for monopoly distortions,*
2. *A profit subsidy* $1 + s_{\pi} = \frac{\sigma}{\sigma - 1}$ *to induce the right capacity choice.*

- **Remark:**
  - The profit subsidy is just enough to make firms internalize the impact of their capacity decision on others

Return

Calibration Government Spending

- Utility function: $U(C, L) = \log C - (1+\nu)^{-1} L^{1+\nu}$

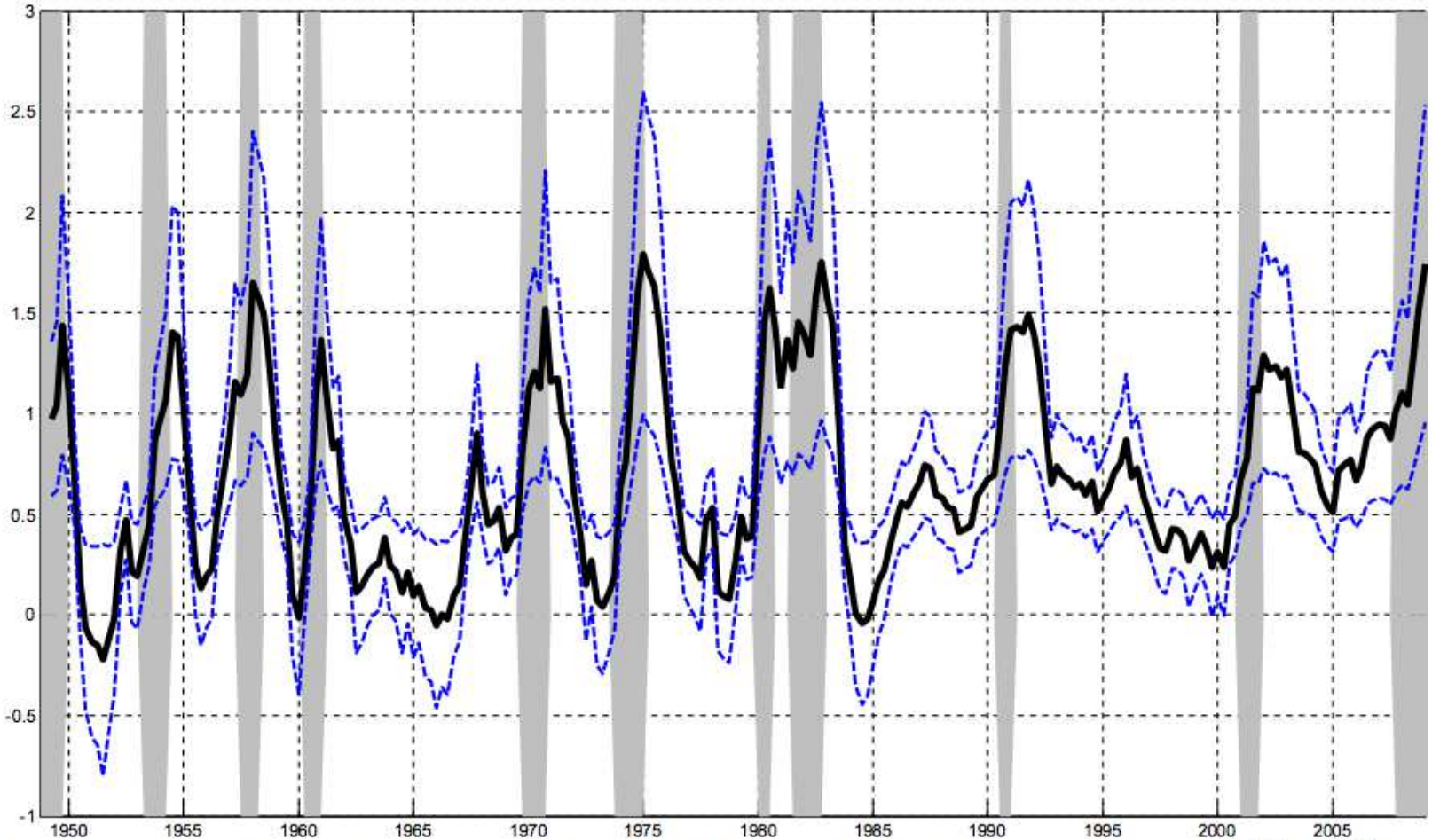
Parameter	Value	Source/Target
Time period	one quarter	
Capital share	$\alpha = 0.3$	Labor share 0.7
Discount factor	$\beta = 0.95^{1/4}$	0.95 annual
Depreciation rate	$\delta = 1 - 0.9^{1/4}$	10% annual
Elasticity of substitution	$\sigma = 3$	Hsieh and Klenow (2014)
Risk aversion	$\gamma = 1$	log utility
Elasticity of labor supply	$\nu = 0.4$	Jaimovich and Rebelo (2009)
Persistence θ process	$\rho_\theta = 0.94$	Cooley and Prescott (1985)
Stdev of θ	$\sigma_\theta = 0.006$	Stdev output
Fixed cost	$f = 0.016$	
High capacity	$\omega = 1.0182$	
Precision of private signal	$\gamma_\nu = 1,013,750$	
Government spending	$G = 0.00662$	0.5% of steady-state output

Return

Fiscal Policy

- Gorodnichenko and Auerbach (2012)

Figure 5. Historical multiplier for total government spending



Notes: shaded regions are recessions defined by the NBER. The solid black line is the cumulative multiplier computed as $\sum_{h=1}^{20} Y_h / \sum_{h=1}^{20} G_h$, where time index h is in quarters. Blue dashed lines are 90% confidence interval. The multiplier incorporates the feedback from G shock to the business cycle indicator z. In each instance, the shock is one percent increase in government spending.

◀ Return