International Credit Flows and Pecuniary Externalities

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Motivation

- Old "Washington consensus" in decline
  - Free trade: flow of goods/services intratemporal
  - Free finance: flow of capital intertemporal
- When does full capital account liberalization reduce (capital controls/macropru regulation improve) welfare?

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   - Market illiquidity: redeployability/specificity – not this paper

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     - Type of capital flow matters: FDI, portfolio flows (equity), long-term debt

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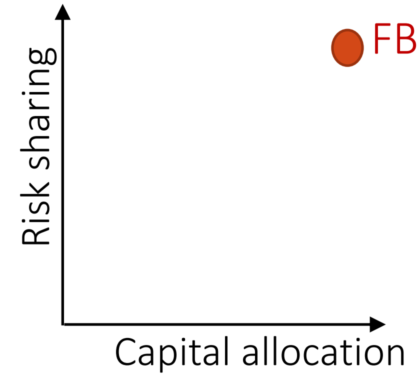
2. "Terms of trade hedge" (Cole-Obstfeld) can be undermined when
   - Industry's output is not easily substitutable.
     Consumers cannot easily find substitutes
   - No strong competitors in other countries
     - Natural resources: oil, copper for Chile,
     - Hard drives in Thailand, Bananas in Ecuador

Main results



- Inefficiencies (constrained) in equilibrium
  1. Capital misallocation/inefficient production
  2. Insufficient risk sharing of country risk
- Trade-off between capital allocation and risk sharing
  - "Terms of trade hedge"
- When are short-term credit flows excessive?
  - When can capital controls (financial liberalization) be welfare enhancing (reducing)?
  - Pecuniary externalities
    - Output price – terms of trade
    - Capital price – fire-sale externality
- Sudden stops (two types) – new form
  - Amplification of fundamental shocks
  - Runs due to sunspots
- Bailout/Restructuring
  - Can be Pareto improving if one country is sufficiently balance sheet impaired
  - Reduces output good price

Literature

- Macro, Money with financial frictions
    - BGG, Kiyotaki & Moore 1997/2008, Gertler & Kiyotaki, Mendoza, Bianchi, …
    - Brunnermeier & Sannikov 2012/14, He & Krishnamurthy 2013, Basak & Cuoco 1998 – includes *volatility dynamics + uncertainty how long crisis lasts*
- "terms of trade hedge"
    - Cole & Obstfeld 1991, Martin 2010
- Constrained inefficiency, pecuniary/firesale externalities
    - Incomplete markets:
        - Stiglitz 1982, Newsbury & Stiglitz 1984, Geanakoplos & Polemarchakis 1986, Coeurdacier, Rey & Winant 2013, He & Kondor 2013
    - Debt collateral constraint (that depends on price)
        - Stiglitz & Greenwald, Lorenzoni 2005, Bianchi 2011, Bianchi & Mendozza 2012, Jeanne & Korinek 2012, Stein 2012, …
- International
    - Complete markets: Heathcote & Perri 2013, Backus, Kehoe, Kydland 1994
    - ToT manipulation: Keynes 192X, Costinout, Lorezoni & Werning 2013
    - Sticky prices: Farhi & Werning 2013, Schmitt-Grohe & Uribe 2012/3,
    - Empirical: Obstfeld & Taylor 2004, Calvo 1998

Model setup - symmetric

- Preferences

$$E\left[\int_0^{\infty} e^{-rt} \frac{c_t^{1-\gamma}}{1-\gamma} dt\right]$$

  - Same preference discount rate r – "saving out of constraint"
- Two output goods y^a and y^b - imperfect substitutes

$$y_t = \left[\frac{1}{2}(y_t^a)^{\frac{s-1}{s}} + \frac{1}{2}(y_t^b)^{\frac{s-1}{s}}\right]^{s/(s-1)}$$

- (Comparative) advantages:

	Good $\boldsymbol{a}$	Good $\boldsymbol{b}$
Country A	$\bar{a}k_t$	$\underline{a}k_t$
Country B	$\underline{a}k_t$	$\bar{a}k_t$

Two country/sector model

- World capital shares:

$$\psi_t^{Aa} + \psi_t^{Ab} + \psi_t^{Ba} + \psi_t^{Bb} = 1$$

- World supply of (output) goods:

$$Y_t^a = \left(\psi_t^{Aa}\overline{a} + \psi_t^{Ba}\underline{a}\right)K_t \qquad Y_t^b = \left(\psi_t^{Bb}\overline{a} + \psi_t^{Ab}\underline{a}\right)K_t$$

- Price of output goods a and b in terms of price of y

$$P_t^a = \frac{1}{2}\left(\frac{Y_t}{Y_t^a}\right)^{1/s} \text{ and } P_t^b = \frac{1}{2}\left(\frac{Y_t}{Y_t^b}\right)^{1/s}$$

  - Terms of trade P_t^a/P_t^b

Two country/sector model

- Capital evolution for
  - $dk_t = (\Phi(\iota_t) - \delta)k_t dt + \sigma^A k_t dZ_t^A$ in country A
  - $dk_t = (\Phi(\iota_t) - \delta)k_t dt + \sigma^B k_t dZ_t^B$ in country B
    - Φ concavity – technological illiquidity
    - Single type of capital
    - Investment in composite good

- Shocks are
  - Two dimensional
    - Affect global capital stock $dZ_t^A + dZ_t^B$
    - Redistributive (initial shock + amplification) $\Rightarrow$ affects wealth share, η_t
      - Example: Apple vs. Samsung lawsuit

Market structures

	Trade		Finance	
Markets	Output y^a, y^b	Physical capital K	Debt	Equity
Complete Markets Full integration/First Best	X	X	X	X
Open credit account (equity home bias)	X	X	X	
Closed credit account	X	X		

Add taxes/capital controls

intratemporal | intertemporal

Returns on physical capital

- $dk_t/k_t = (\Phi(\iota_t) - \delta)dt + \sigma^A k_t dZ_t^A$

- Postulate
  - $dq_t/q_t \;\; = \mu_t^q dt + \sigma_t^{qA} dZ_t^A + \sigma_t^{qB} dZ_t^B$

Ito product rule:
$d(X_t Y_t) = dX_t Y_t + X_t dY_t + \sigma_X \sigma_Y dt$

- Returns from holding physical capital
  - $dr_t^{Aa} = \left(\frac{\overline{a}P_t^a - \iota_t}{q_t} + \mu_t^q + \Phi(\iota_t) - \delta + \sigma^A \sigma_t^{qA}\right) dt +$

    $+(\sigma^A + \sigma_t^{qA}) dZ_t^A + \sigma_t^{qB} dZ_t^B$

  - $dr_t^{Ab} = \left(\frac{\underline{a}P_t^b - \iota_t}{q_t} + \mu_t^q + \Phi(\iota_t) - \delta + \sigma^A \sigma_t^{qA}\right) dt +$

    $+(\sigma^A + \sigma_t^{qA}) dZ_t^A + \sigma_t^{qB} dZ_t^B$

The 3 step solution procedure

1. Derive equilibrium conditions
   - Optimality and asset pricing conditions (from postulated processes)
     - Consumption
       with log-utility: $c_t = rN_t$ (no precautionary savings)
     - Asset pricing (from above)
       with log-utility: Sharpe Ratio of asset = volatility of net worth
     - Internal investment rate ι_t: $q\Phi'(\iota_t) - 1 = 0$
   - Market clearing conditions
2. Derive evolution of state variable $\eta_t = \frac{N_t}{q_t K_t}$
3. Express in terms of ODE
   - All $\mu^{\text{postolated}}$ and $\sigma^{\text{postulated}}$ are expressed in terms of $q'(\eta), q''(\eta), \ldots$

For any market structure

market structure specific

Asset pricing equations: equilibrium returns

- For stochastic discount factor

$$\theta_t^A = e^{-rt}\left(C_t^A / C_0^A\right)^{-\gamma}$$

- Postulate (equilibrium consumption process)
  - $dC_t^A / {C_t}^A \quad = \mu_t^{C^A} dt + \sigma_t^{C^A A} dZ_t^A + \sigma_t^{C^A B} dZ_t^B$ for agents A
  - … for agents B

$$\frac{d\theta_t^A}{\theta_t^A} = -[r + \gamma\mu_t^{C^A} - \frac{\gamma(\gamma+1)}{2}\left(\left(\sigma_t^{C^A A}\right)^2 + \left(\sigma_t^{C^A B}\right)^2\right)]dt - \gamma(\sigma_t^{C^A A} dZ_t^A + \sigma_t^{C^A B} dZ_t^B)$$

- Pricing of asset X:
  If wealth ϵ_t is invested in X, such that $\frac{d\epsilon_t}{\epsilon_t} = dr_t^X$, then $\theta_t^A \epsilon_t$ must follow a
  - Martingale $E_t[\theta_{t+s}^A \epsilon_{t+s}] = \theta_t^A \epsilon_t$ if portfolio position > 0
  - Supermartingle $E_t[\theta_{t+s}^A \epsilon_{t+s}] < \theta_t^A \epsilon_t$ if portfolio position = 0

Discrete time: $E_t\left[\frac{1}{(1+r)^{t+1}}\left(\frac{C_{t+1}^A}{C_0^A}\right)^{-\gamma} R_{t+1}^X\right] = \frac{1}{(1+r)^t}\left(\frac{C_t^A}{C_0^A}\right)^{-\gamma} 1$ follows martingale

Asset pricing equations: equilibrium returns

- For risk-free asset

$$\frac{dr_t^F}{dt} = -\mu_t^{\theta^A}$$
$$= r + \gamma\mu_t^{C^A} - \frac{\gamma(\gamma+1)}{2}\left(\left(\sigma_t^{C^A A}\right)^2 + \left(\sigma_t^{C^A B}\right)^2\right)$$

- For capital used to produce output a

$$\frac{E[dr^{Aa}]}{dt} + \mu_t^{\theta^A} = \underbrace{\gamma\sigma_t^{C^A A}(\sigma^A + \sigma_t^{qA}) + \gamma\sigma_t^{C^A B}\sigma_t^{qB}}_{-Cov[dr_t^{Aa}, d\theta_t^A/\theta_t^A]}$$

- For capital used to produce output b

$$\frac{E[dr^{Ab}]}{dt} + \mu_t^{\theta^A} \leq \underbrace{\gamma\sigma_t^{C^A A}(\sigma^A + \sigma_t^{qA}) + \gamma\sigma_t^{C^A B}\sigma_t^{qB}}_{-Cov[dr_t^{Ab}, d\theta_t^A/\theta_t^A]}$$

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Add taxes/capital controls

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Market structures

1. Complete markets ⇒ First best
2. Incomplete markets (equity home bias)
   - Levered short-term debt financing
   - Sudden stops: (varying technological illiquidity)
     - Amplification
     - Runs due to sunspots
3. Closed capital account: capital controls (no equity, no debt)
4. Welfare analysis

1. Complete markets: First Best

1. Perfect specialization

- Full specialization $\psi_t^{Aa} = \psi_t^{Bb} = 1/2$
- Investment rate equalization $\iota_t^A = \iota_t^B$
- Output equalization $y_t^a = y_t^b$ $\quad Y_t = \overline{a}\frac{K_t}{2}$

2. Perfect risk sharing

- Consumption (intensity) shares $\zeta_t^A = \lambda^A \zeta_t, \zeta_t^B = \lambda^B \zeta_t$
  where λ^A and λ^B are Pareto weights
- $\frac{dZ_t^A + dZ_t^B}{\sqrt{2}} \equiv dZ_t$ (standard Brownian)
- Global capital evolution

$$dK_t = [\Phi(\iota_t) - \delta]K_t dt + \frac{\sigma}{\sqrt{2}} K_t \underbrace{\frac{dZ_t^A + dZ_t^B}{\sqrt{2}}}_{:= dZ_t} \text{x}$$

1. First Best Prices

- SDF: $\theta_t^A = e^{-rt}\left(\frac{c_t^A}{c_0^A}\right)^{-\gamma} = e^{-rt}\left(\frac{\zeta^A K_t}{\zeta^A K_0}\right)^{-\gamma} = e^{-rt}\left(\frac{c_t^B}{c_0^B}\right)^{-\gamma}$

$$\frac{d\theta_t}{\theta_t} = \underbrace{\left\{-r - \gamma[\Phi(\iota_t) - \delta] + \frac{\gamma(\gamma+1)\sigma^2}{4}\right\}}_{=E\left[\frac{d\theta_t}{\theta_t dt}\right]} dt - \frac{\gamma\sigma}{\sqrt{2}} dZ_t$$

- Risk-free rate: $r^F = r + \gamma[\Phi(\iota) - \delta] - \frac{\gamma(\gamma+1)\sigma^2}{4}$
  - Invest ϵ_t with dr_t^K, i.e. $\frac{d\epsilon_t}{\epsilon_t} = dr_t^K$, then $\theta_t \epsilon_t = E_t[\theta_{t+s}\epsilon_{t+s}]$
  - From $E\left[\frac{dr_t^K \theta_t}{\theta_t dt}\right] = 0$, $\underbrace{\mu_t^\theta}_{-dr_t^F/dt} + \mu_t^{r^K} + \sigma_t^{r^K}\sigma_t^\theta = 0$

- Price of capital: $q = \frac{\overline{a} - \iota_t}{r_t^F + \frac{\gamma}{2}\sigma^2 - [\Phi(\iota) - \delta]}$

Gordon Growth Formula $\frac{d}{r-g}$

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1. Complete markets: First Best Remarks

- Perfect capital allocation + perfect risk sharing

- Prices are constant and independent of shocks
- Economy shrinks/expands with (multiplicative) shocks
- Elasticity of substitution, s, has no impact on prices

Market structures

1. Complete markets $\Rightarrow$ First best
2. Incomplete markets (equity home bias)
   - Levered (short-term) debt financing
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2. Equilibrium characterization: state variable

- Equilibrium is a map

  Histories of shocks $\{Z_s^A, Z_s^B, s \leq t\}$ → prices allocation $q_t, \psi_t^{Aa} \ldots, \iota_t^A, \iota_t^B, \zeta_t^A, \zeta_t^B$

  wealth distribution

  $$\eta_t = \frac{N_t}{q_t K_t} \in (0,1) \quad \text{A's wealth share}$$

- $\psi_t^{Aa} + \psi_t^{Ab} + \psi_t^{Ba} + \psi_t^{Bb} = 1$ and $C_t^A + C_t^B = Y_t - \iota_t K_t$
- Portfolio weights: $\frac{\psi_t^{Aa}}{\eta_t}, \frac{\psi_t^{Ab}}{\eta_t}, 1 - \frac{\psi_t^{Aa} + \psi_t^{Ab}}{\eta_t}$
- Consumption rates: $\zeta_t^A = C_t^A / N_t \quad \zeta_t^B = C_t^B / (q_t K_t - N_t)$

2. State variable: 3 regions

- Wealth share η
  - Three regions

		Full specialization	
A produces	a	a	a, b
B produces	a, b	b	b

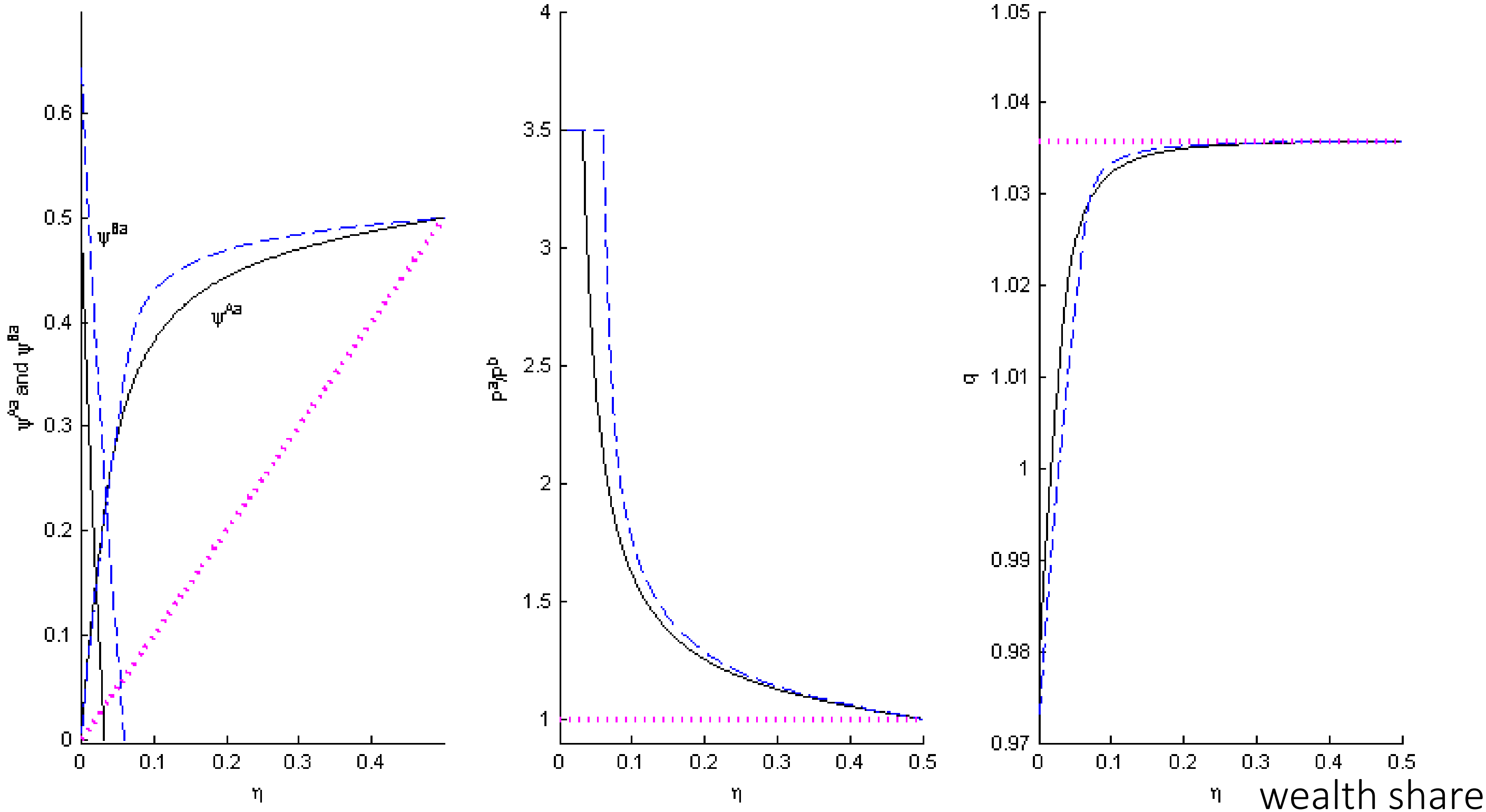
0 — 1/2 — 1 η

  - Symmetric

$$\psi_t^{Aa} = \eta_t$$
$$\psi_t^{Bb} = 1 - \eta_t$$
$$\psi_t^{Ba} = \psi_t^{Ab} = 0$$

2. Capital share, terms of trade, price of capital

- Numerical: $r = 5\%, \bar{a} = 14\%, \underline{a} = 4\%, \delta = 5\%, \kappa = 2, \sigma^A = \sigma^B = 10\%$



- Three different elasticities of substitution: $s = \{.5, 1, \infty\}$

TOT: Supply vs. demand shock

- Supply versus demand shock

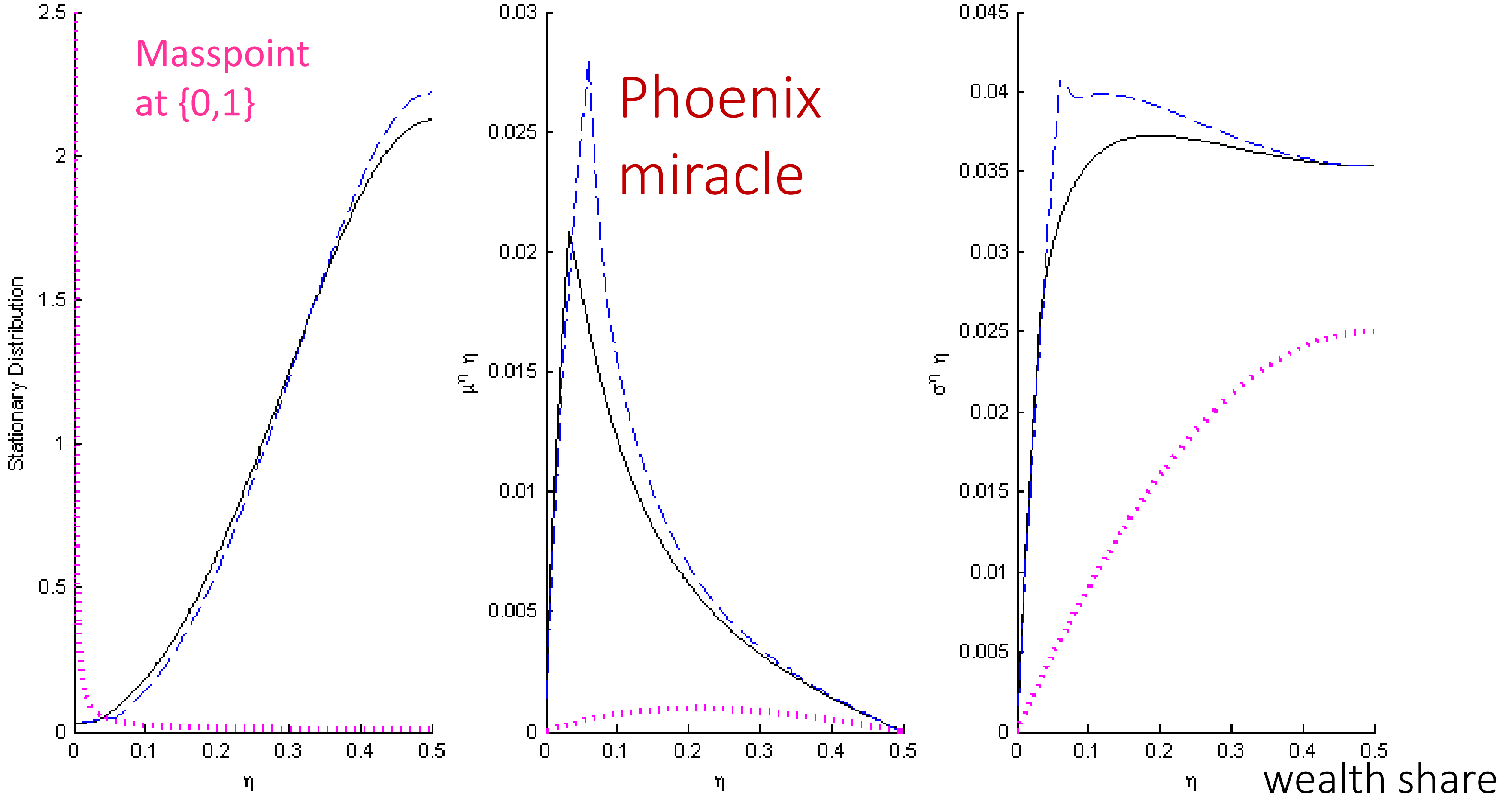
  TOT improve for A as η_t declines for $\eta_t \in [\overline{\eta}, .5)$ can be due to
  - $dZ^A < 0$: Negative supply shock — World recession
  - $dZ^B > 0$: Positive demand shock — World boom

- TOT: Output price

- …but fire-sale of (physical) capital stock k_t

2. Stability, Phoenix Miracle for different s

- Stationary distribution drift volatility



- Three different elasticities of substitution: $s = \{.5, 1, \infty\}$
- Difference to Cole & Obstfeld 1994: persistence of capital, $\delta < \infty$

Overview

1. Complete markets ⇒ First best
2. Incomplete markets (equity home bias)
   - Levered short-term debt financing
   - Sudden stops: (varying technological illiquidity)
     - Amplification
     - Runs due to sunspots
3. Closed capital account: capital controls (no equity, no debt)
4. Welfare analysis

2. Amplification

$$\sigma_t^{\eta A} = \frac{\frac{\psi_t^{Aa}}{\eta_t}(1-\eta_t)}{1 - [\psi_t^{Aa} - \eta_t]\frac{q'(\eta_t)}{q(\eta_t)}} \sigma^A$$

2. Amplification

leverage

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- Leverage effect ψ_t^{Aa}/η_t

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leverage

Market illiquidity (price impact)

- Leverage effect ψ_t^{Aa}/η_t
- Loss spiral $1/\{1-[\psi_t^{Aa}-\eta_t]\frac{q'(\eta_t)}{q(\eta_t)}\}$ (infinite sum)

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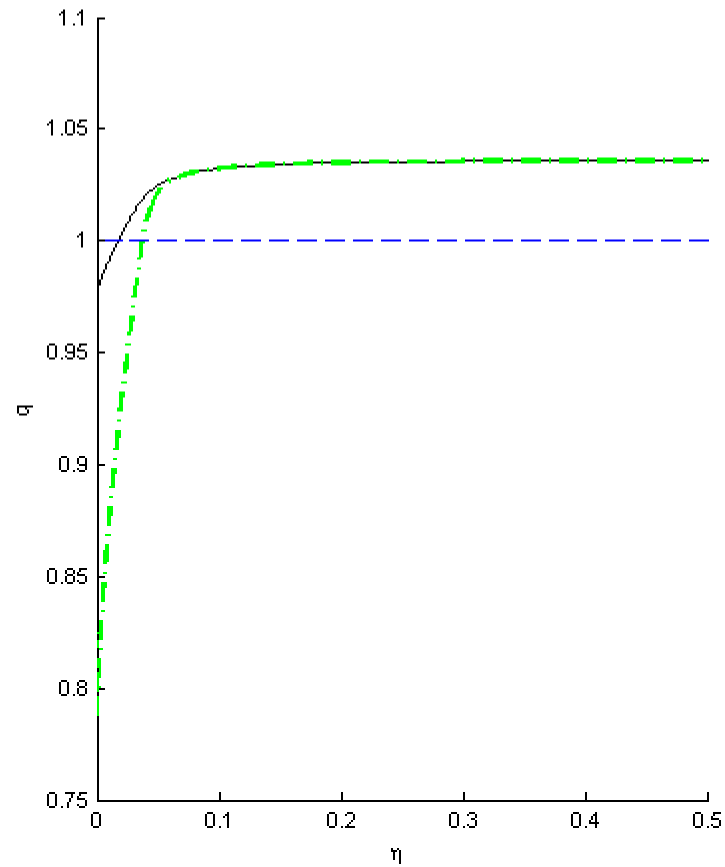
- Leverage effect ψ_t^{Aa}/η_t
- Loss spiral $1/\{1 - [\psi_t^{Aa} - \eta_t]\frac{q'(\eta_t)}{q(\eta_t)}\}$ (infinite sum)
- Technological illiquidity $(\kappa, \delta) \Rightarrow$ market illiquidity $q'(\eta)$
  - (dis)investment adjustment cost

2. Technological $(\kappa, \delta) \Rightarrow$ market illiquidity $q'(\eta)$

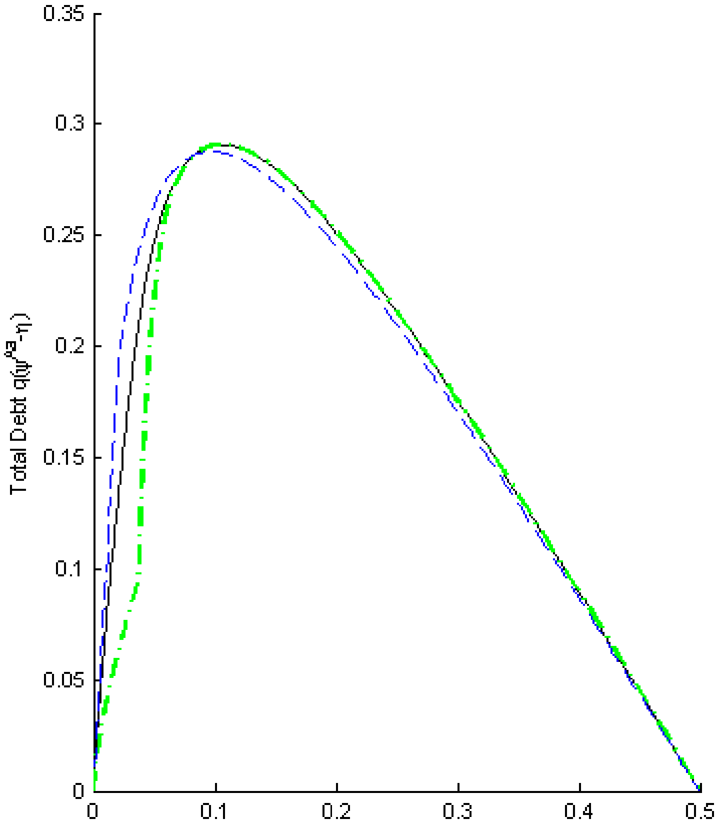
- Quadratic adjustment cost
- Investment rate of $\Phi + \frac{1}{\kappa}\Phi^2$ generates new capital at rate Φ
- $\Phi(\iota) = \frac{1}{\kappa}\left(\sqrt{1 + 2\kappa\iota} - 1\right)$

- Three cases
  - $\kappa = 0 \Rightarrow q = 1$
  - $\kappa = 2$
  - $\kappa_{\iota<0} = 100$ and $\kappa_{\iota>0} = 2$



Sudden stops: amplification & runs

- Sudden stop
  - Adverse fundamental triggers %-decline in debt that exceeds %-decline in net worth; $\frac{\partial(\psi^{Aa}-\eta)}{\partial\eta}\frac{\eta}{\psi^{Aa}-\eta} > 1 \Leftrightarrow \frac{\partial\psi^{Aa}}{\partial\eta} > \frac{\psi^{Aa}}{\eta}$ $\Leftrightarrow$ pro-cyclical leverage



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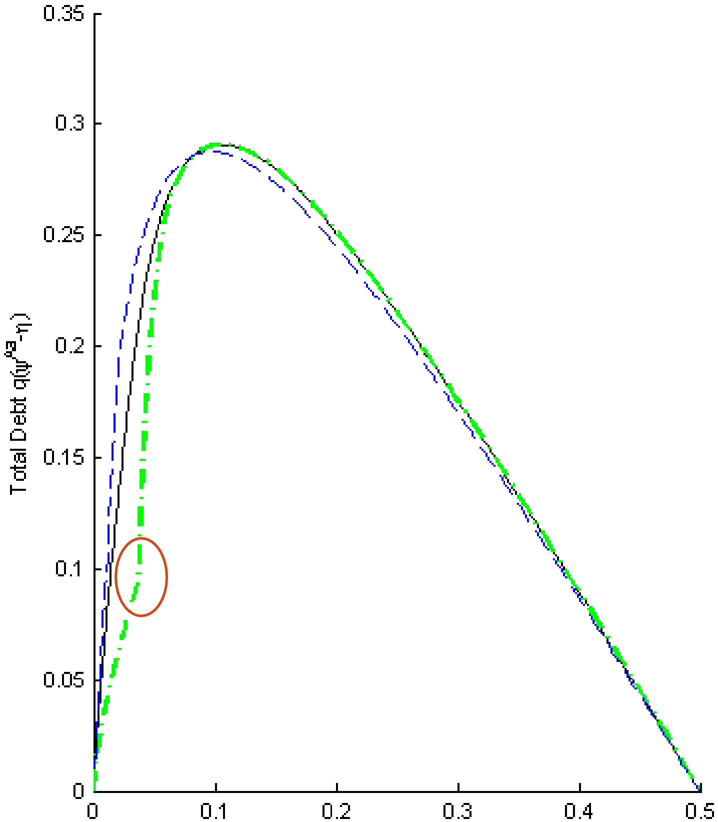
Slope of tangent vs. secant



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    $\Leftrightarrow$ pro-cyclical leverage
  - An unanticipated sunspot triggers a sudden capital price drop from q to $\tilde{q}$, accompanied by a drop in η to $\tilde{\eta}$.

$$\tilde{q}\tilde{\eta} = \max\{\eta q + \psi^{Aa}(\tilde{q} - q), 0\}$$

Sudden stops: amplification & runs

Sudden stop

- Adverse fundamental triggers %-decline in debt that exceeds %-decline in net worth; $\frac{\partial(\psi^{Aa}-\eta)}{\partial\eta}\frac{\eta}{\psi^{Aa}-\eta} > 1 \Leftrightarrow \frac{\partial\psi^{Aa}}{\partial\eta} > \frac{\psi^{Aa}}{\eta}$
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$$\tilde{q} = \frac{\max\{\eta q + \psi^{Aa}(\tilde{q} - q), 0\}}{\tilde{\eta}}$$

hyperbola

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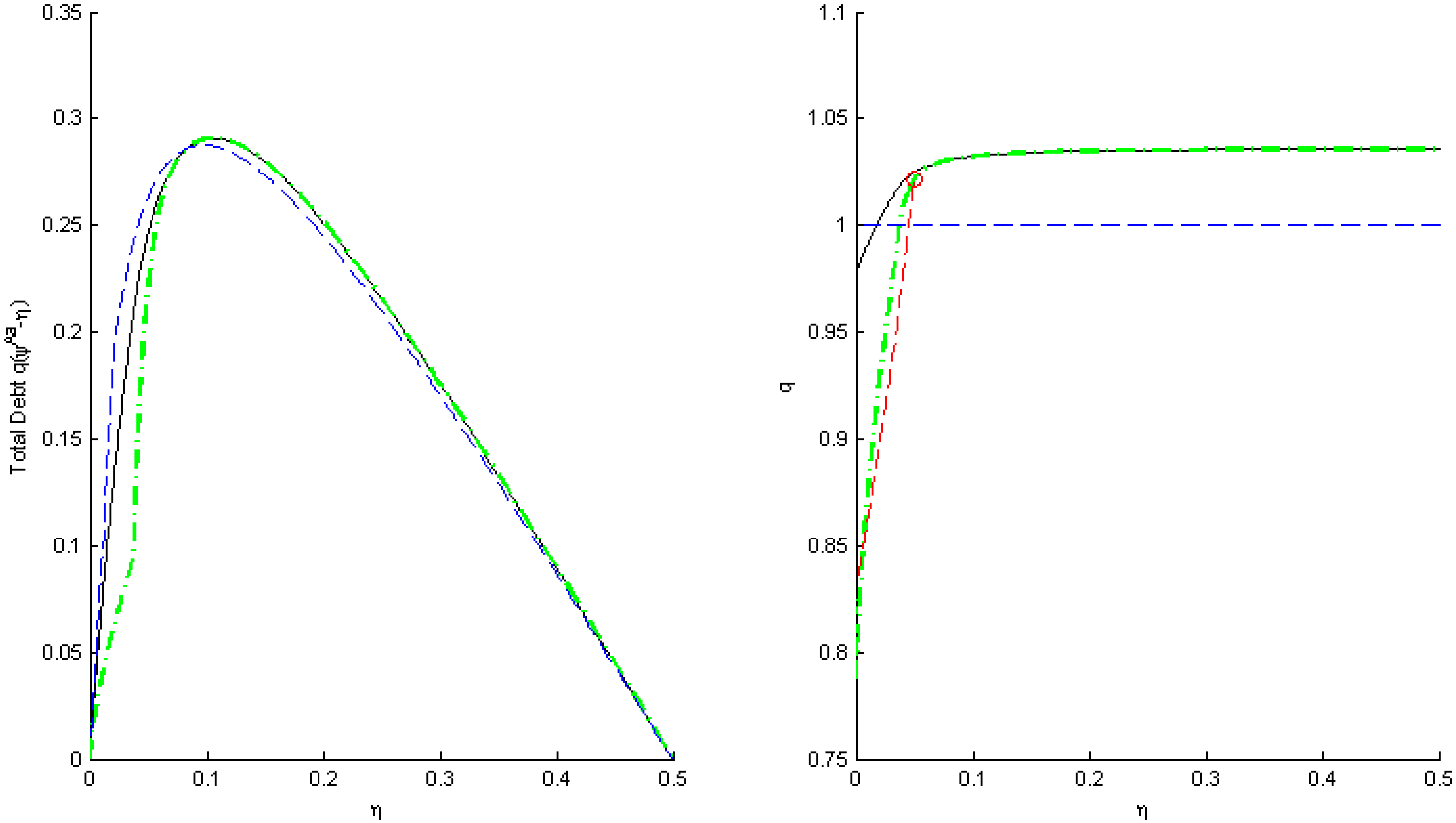
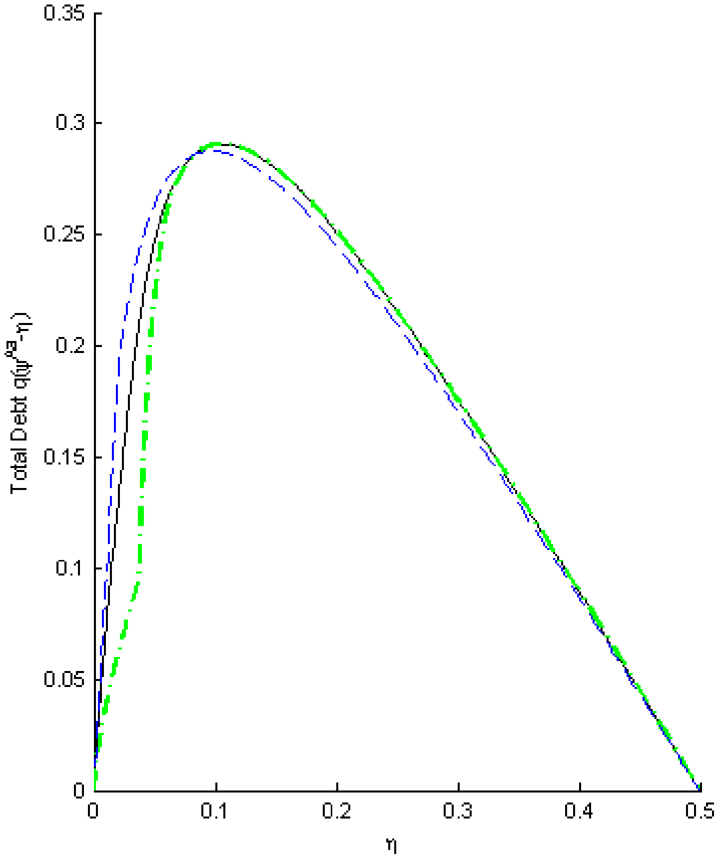
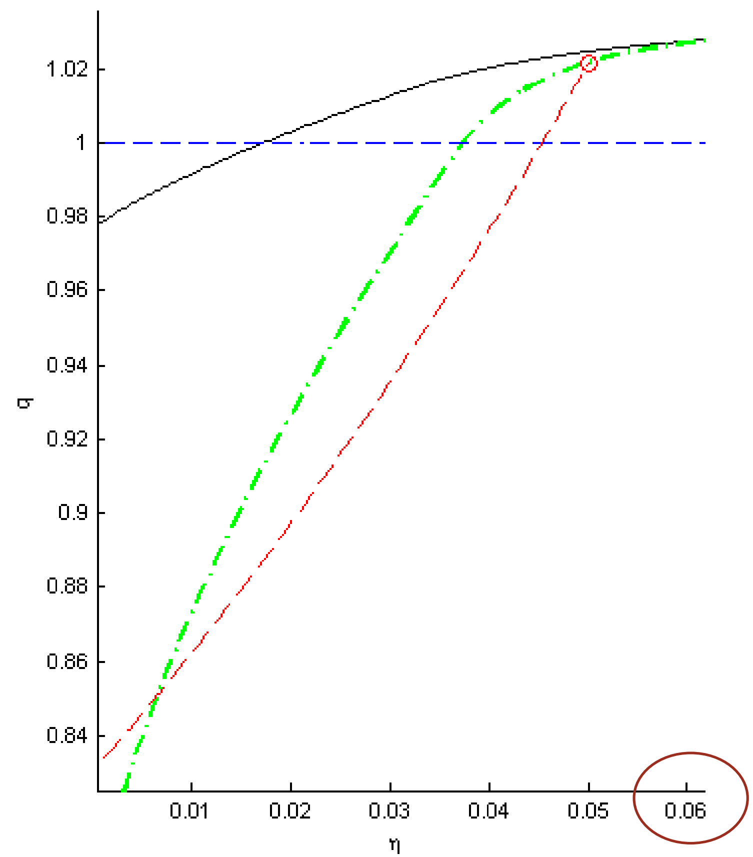
Sudden stop due to sunspot



Sudden stop due to sunspot: Zoomed in





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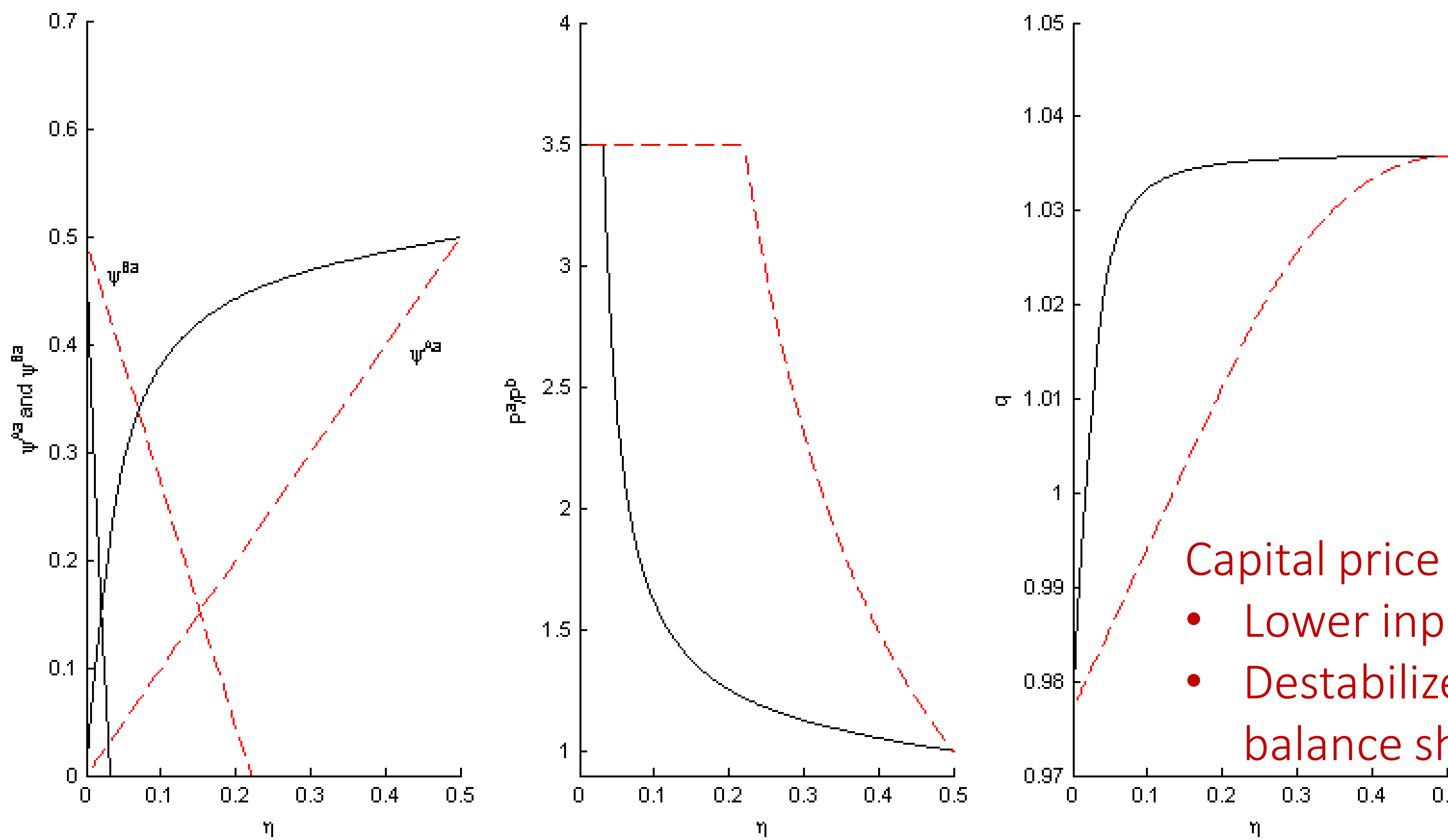
3. Credit account: open vs. closed

- $r = 5\%, \overline{a} = 14\%, \underline{a} = 4\%, \delta = 5\%, \kappa = 2, \sigma^A = \sigma^B = 10\%,\ s = 1$



Capital price lower

- Lower input price
- Destabilizes balance sheet

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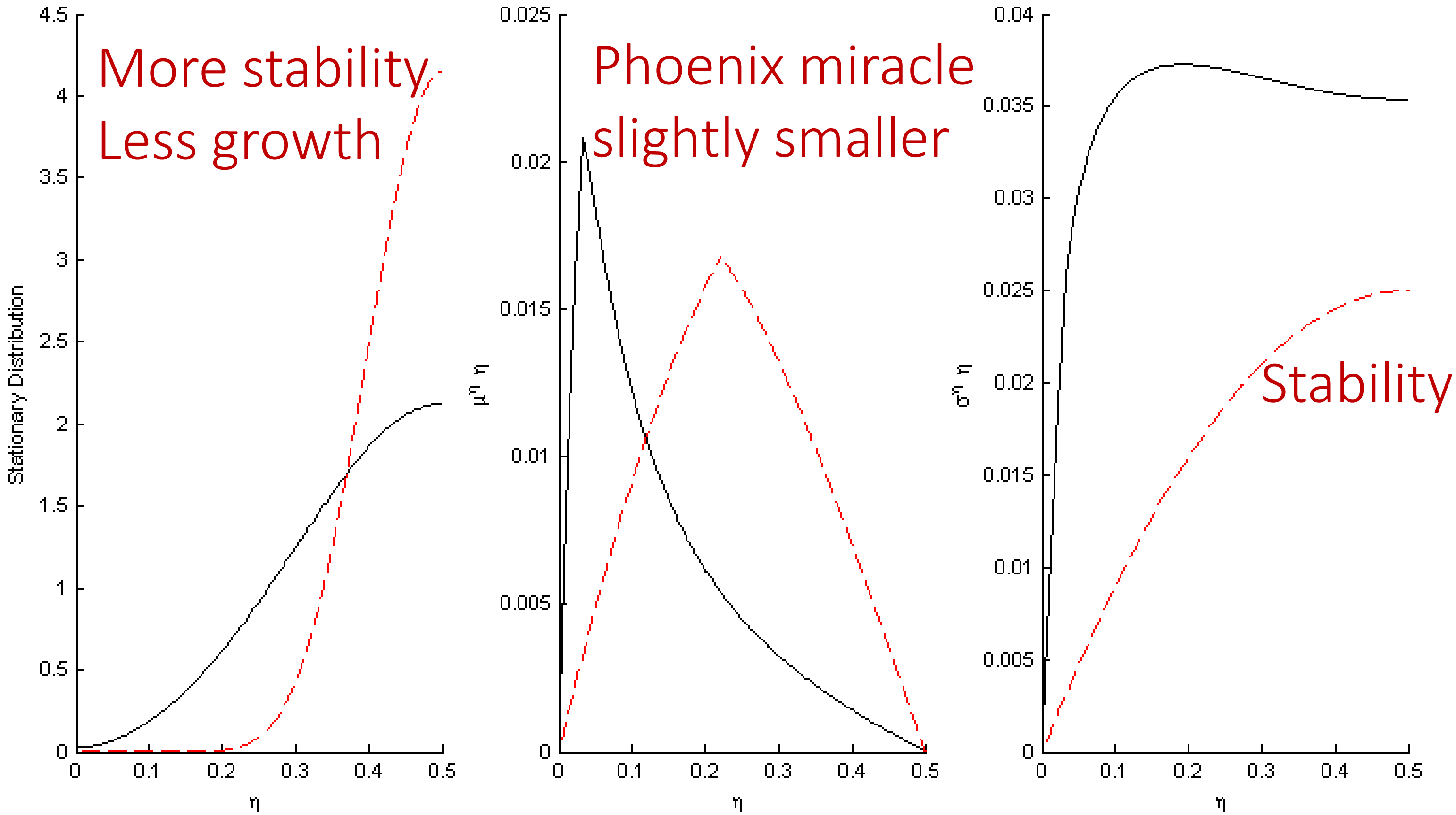

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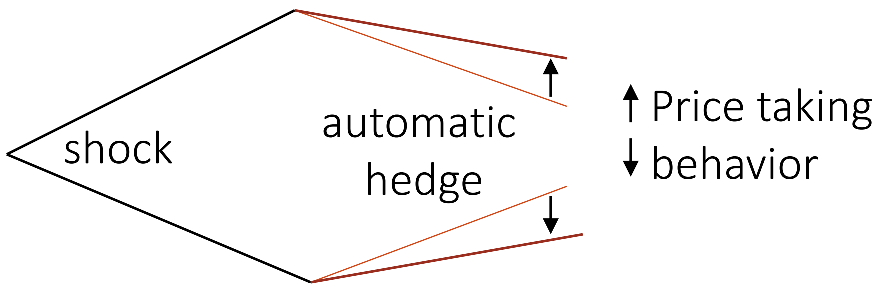
   - Pecuniary externalities
   - Welfare calculations + Pareto improving redistributions

4. When are credit flows excessive?

- Constrained inefficiency (in incomplete market setting) due to pecuniary externalities
  - Price of capital: fire sale externality if leverage is high
  - Price of output good: "terms of trade hedge" restrained competition
    - Price taking behavior undermined this hedge



4. When are credit flows excessive?

- Constrained inefficiency (in incomplete market setting) due to pecuniary externalities
  - Price of capital: fire sale externality if leverage is high
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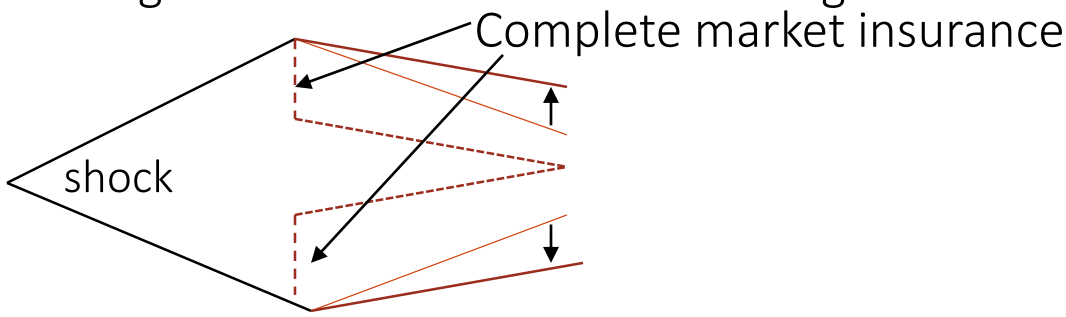

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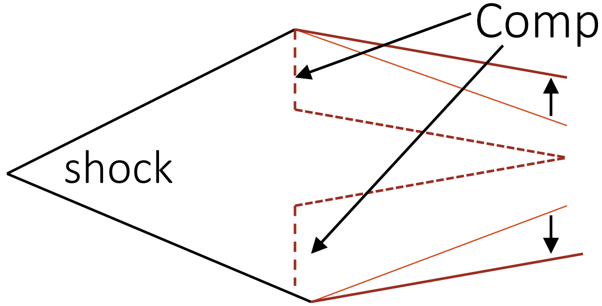
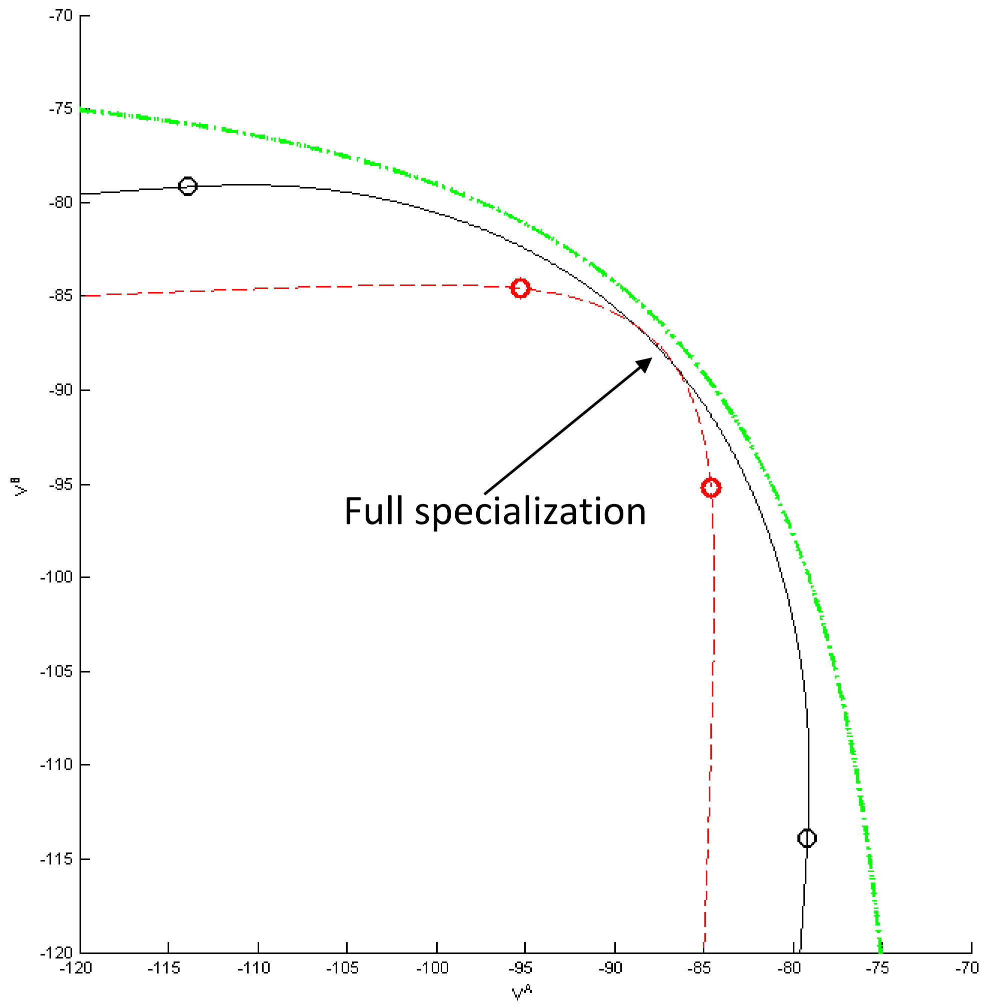


Brunnermeier & Sannikov

Price	Intention	Depends on
Capital price (input)	Buy cheaper but capital losses on existing k_t	Adjustment cost, $\Phi(\iota)$, κ
Output price	Sell output more expensive	Elasticity of substitution, s
Interest rate	Borrow cheaper	Intertemporal preference

4. Welfare comparison

- $r = 5\%, \overline{a} = 14\%, a = 4\%, \delta = 5\%, \kappa = 2, \sigma^A = \sigma^B = 10\%,$



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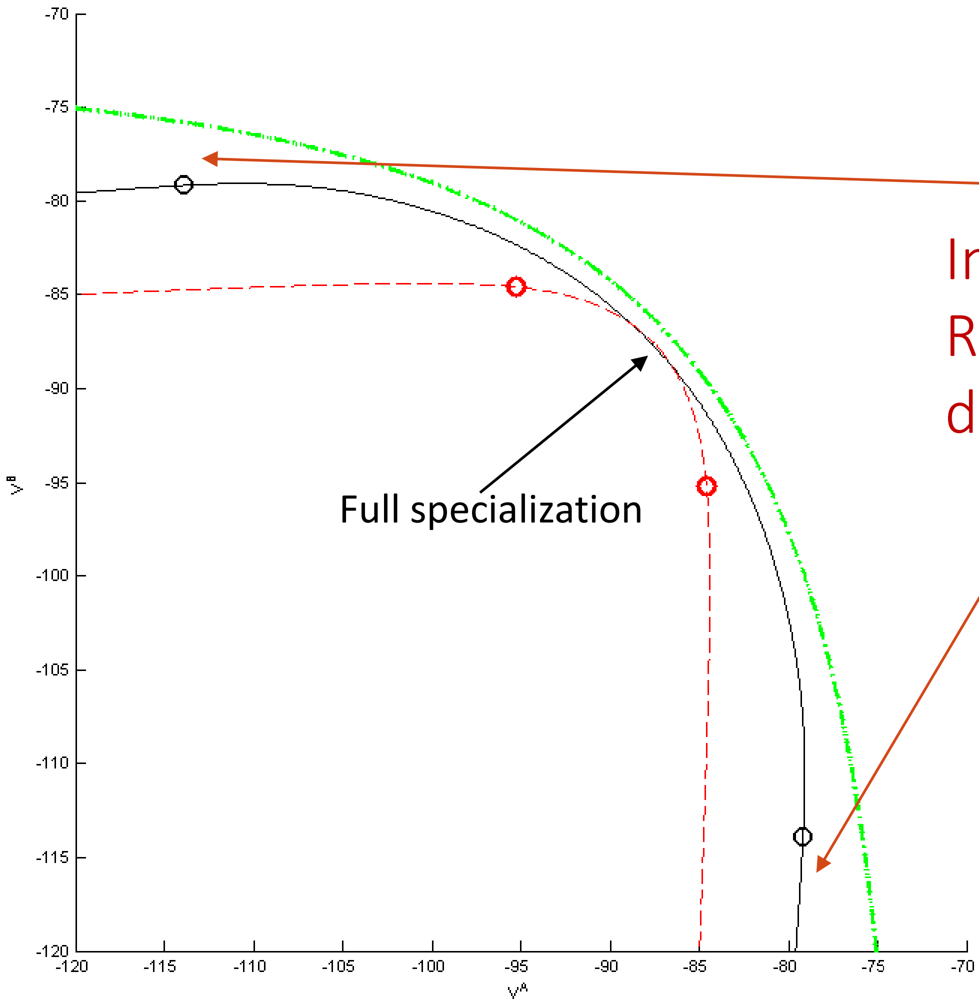

Inefficiency at the extremes:
Role for redistributive Policy
default/bail-out/debt-relief

Pareto improving

Intuition:
Other country's output price is high

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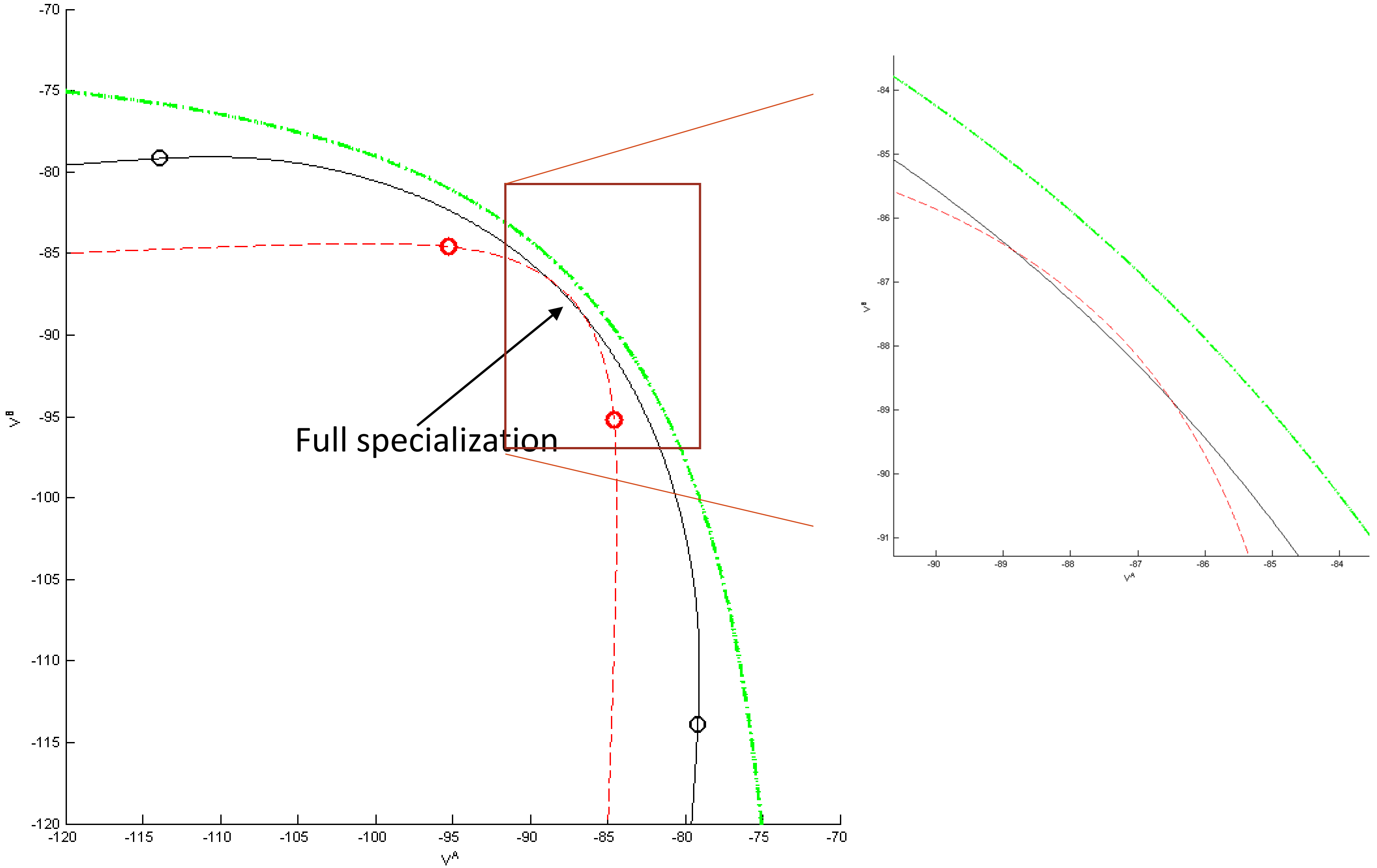
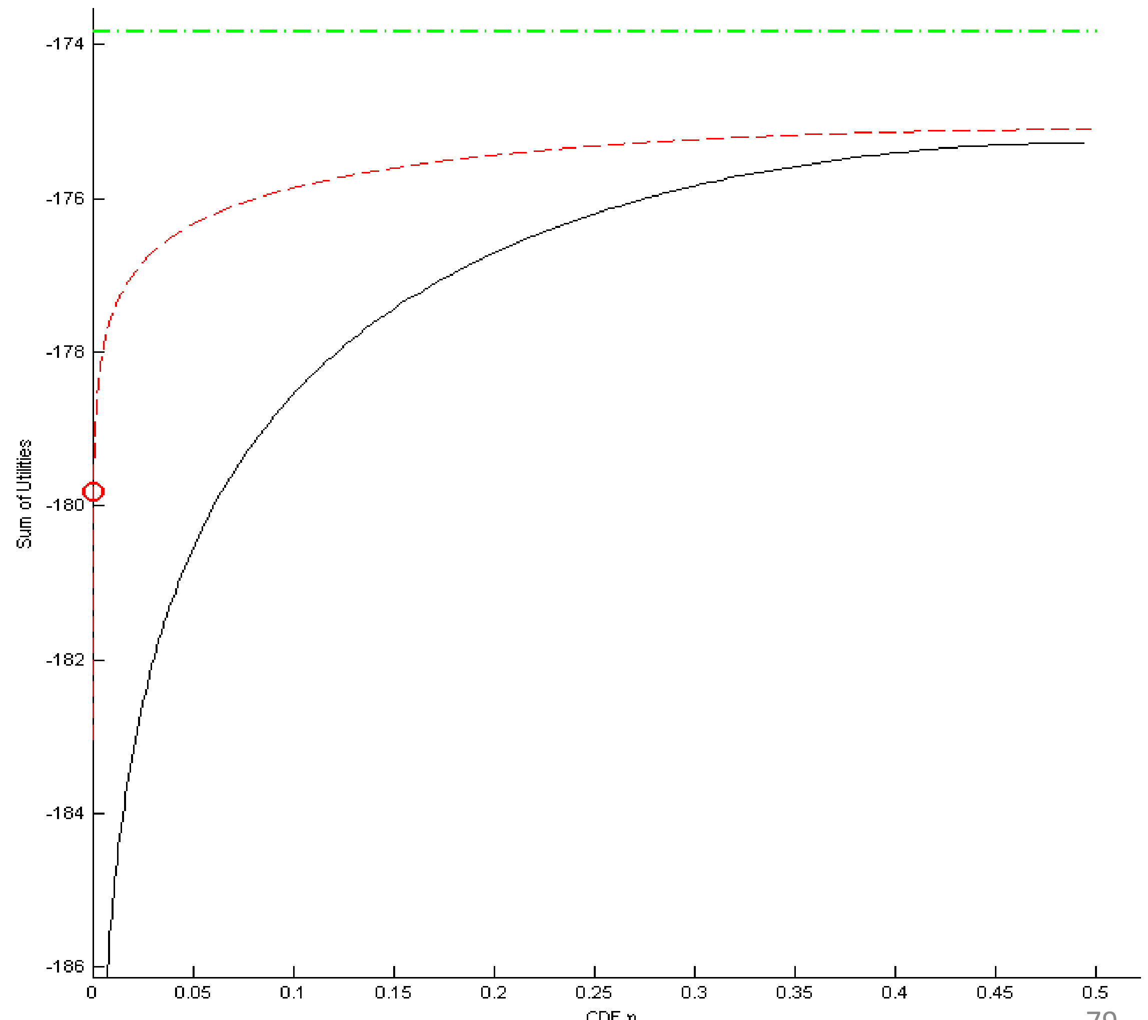


4. Welfare comparison

- Any monotone transformation of η would be equally good state variable
- Normalization: take CDF of η
  - Uniform stationary distribution!



Brunnermeier & Sannikov

5. Why continuous time modeling?

- Characterization for volatility and amplification
  - Discrete: only impulse response functions
    - Only for shocks starting at the steady state
    - Only expected path – fan charts help somewhat
- More analytical steps
  - Return equations
    - Next instant returns are essentially log normal (easy to take expectations)
  - Explicit net worth and state variable dynamics
    - Continuous: only slope of price function determines amplification
    - Discrete: need whole price function (as jump size can vary)
- Numerically simple – solve differential equations
- Discrete: IES/RA within period $= \infty$, across periods $1/\gamma$

5. Cts. time: special features of diffusions

- Continuous path – fast enough delivering
  - Never jumps over a specific point, e.g. insolvency point
- Implicit assumption: can react to small price changes
  - Can continuously delever as wealth goes down
  - Makes them more bold ex-ante

Conclusion

- Sudden stops
  - Amplification of fundamental shock
  - Runs due to sunspots – vulnerability region
- Phoenix miracle
- Tradeoff between capital allocation & risk sharing
  - "Terms of trade hedge"
- When are short-term credit flows excessive?
  - When can capital controls (financial liberalization) be welfare enhancing (reducing)?
  - Pecuniary externality
    - Price of physical capital fire-sales externality – technological illiquidity
    - Price of output goods: "terms of trade hedge" externality
- Bailout/Restructuring
  Redistributive policy can be Pareto improving if one country is sufficiently balance sheet impaired
  - Reduces output good price

positive

normative