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# Optimal Monetary Policy in a ‘Sudden Stop’

Fabio Braggion (Tilburg), Lawrence Christiano, Jorge Roldos (IMF)

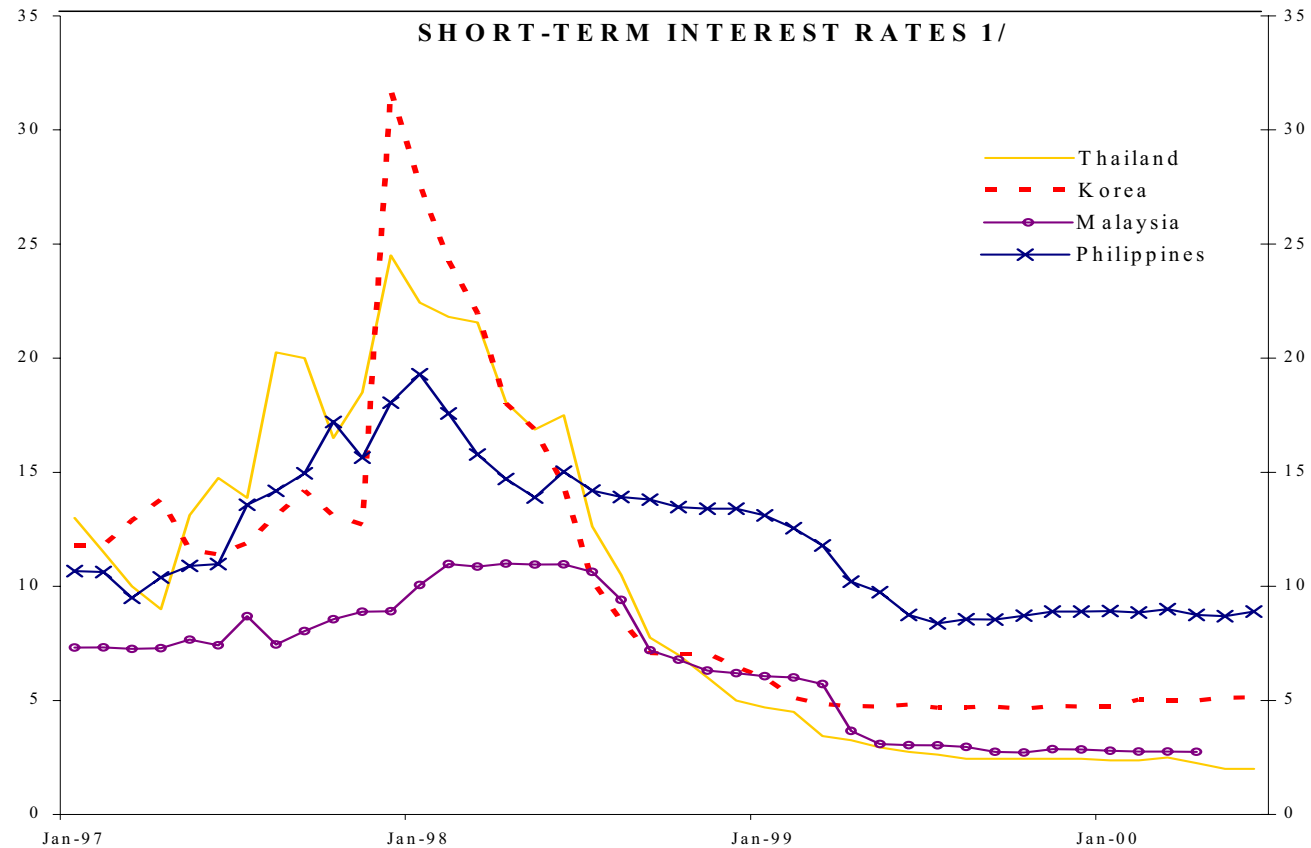
# Motivation

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- Asian Financial Crisis: ‘Sudden Stop’
  - Current Account Swings Negative to Positive by 15 Percentage Points of GDP
  - Output Drops 12 Percent, Consumption a Little More, Employment a Little Less
  - Asset Prices and Exchange Rates Drop by Over 40 Percent
- Controversy: How Should the Domestic Monetary Authority Respond?
- Two Responses:
  - Krugman-Stiglitz:
    - \* A Crisis is a Time When Economies are Slipping Into Recession.
    - \* Medicine Appropriate for US: Interest Rate Cut.
  - IMF: A Crisis is a Time When Foreign Investors are Rushing for the Exits. Need High Rates to Stop Them.

## Motivation ...

- What *Did* They Do? Both!

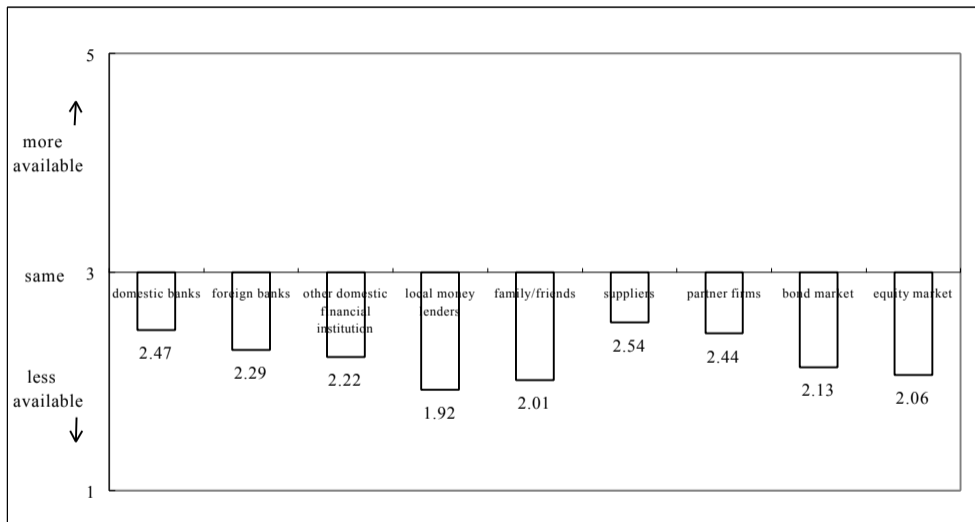


- Was Policy Erratic, Responding to Different Advice at Different Times?
- Our Argument: this Policy May have been Roughly *Optimal*.

## Motivation ...

- Analysis: Compute Optimal Monetary Policy in a Variant on Model in Christiano, Gust, Roldos (2004)
- Model Highlights Key Features of Crisis Economies:
  - General Evidence From Surveys of ‘Credit Crunch’

**Fig.9. Availability of Credit after the Crisis**



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### Syndicated Loans to Emerging Markets (in billions of U.S. dollars)

Year	Total	Secured	Secured as % of Total
1993	47.5	7.9	16.5
1994	64.9	11.5	17.7
1995	93.0	16.1	17.3
1996	104.3	22.0	21.1
1997	143.7	61.4	42.7
1998	77.3	25.9	33.5
1999	73.1	26.3	35.9

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    - \* Thailand: banks loaned 70-80% of collateral pre-crisis, 50-60% after crisis (Edison, Luangaram and Miller (2000))

## Motivation ...

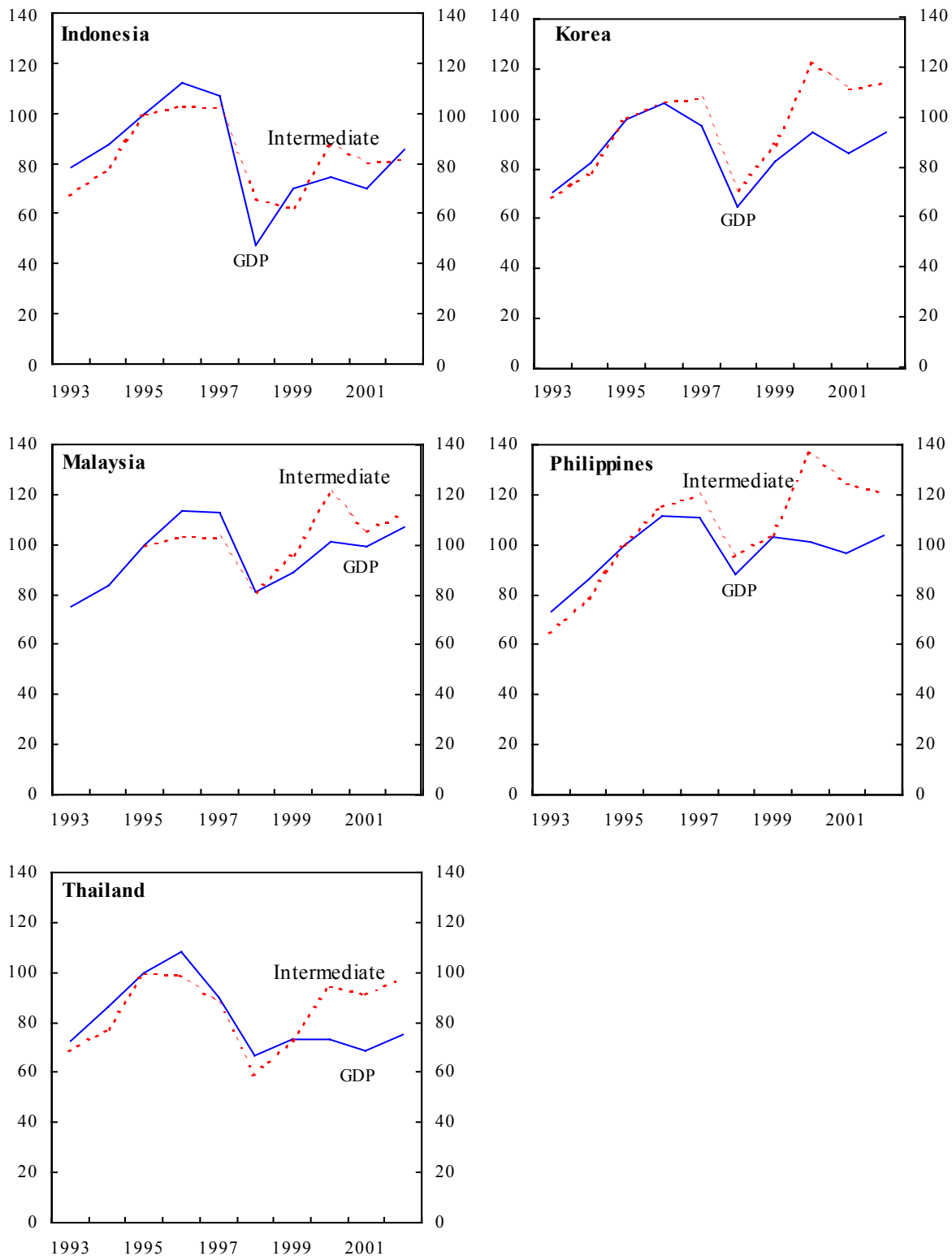
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  - Intermediate Inputs are an Important Component of Imports

Year	<b>Malaysia</b>			<b>Korea</b>		
	Total	Intermediate	% of Total	Total	Intermediate	% of Total
<b>1995</b>	77,601	50,447	65%	135,119	64,611	48%
<b>1996</b>	78,426	52,201	67%	150,339	68,556	46%
<b>1997</b>	79,036	51,922	66%	144,616	69,361	48%
<b>1998</b>	58,293	40,901	70%	93,282	45,593	49%
<b>1999</b>	65,389	48,321	74%	119,752	57,253	48%
<b>2000</b>	81,963	61,233	75%	160,481	78,975	49%
<b>2001</b>	73,856	53,271	72%	141,098	71,929	51%
<b>2002</b>	79,881	56,939	71%	152,126	73,891	49%

## Intermediate Goods Import vs. GDP (Index 1995 = 100)



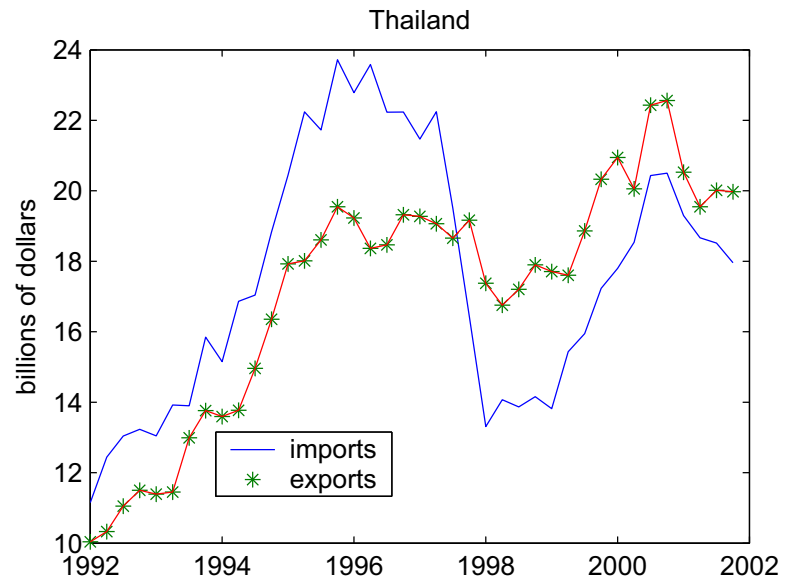
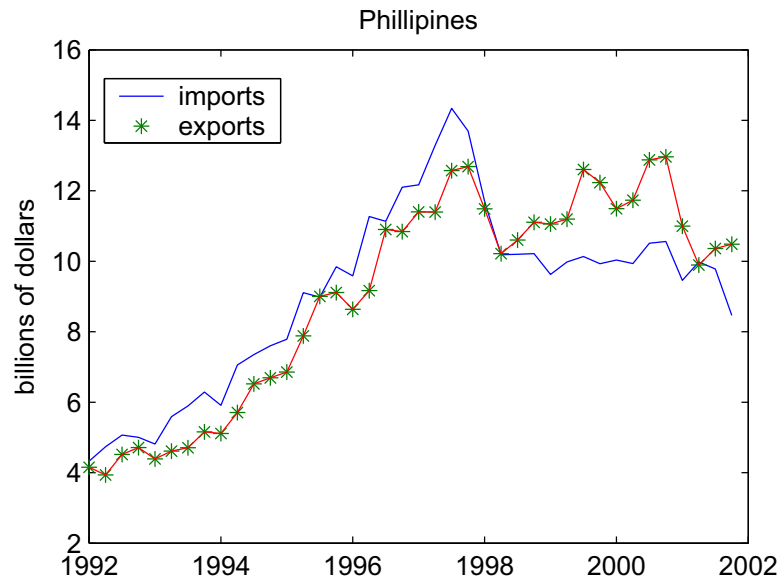
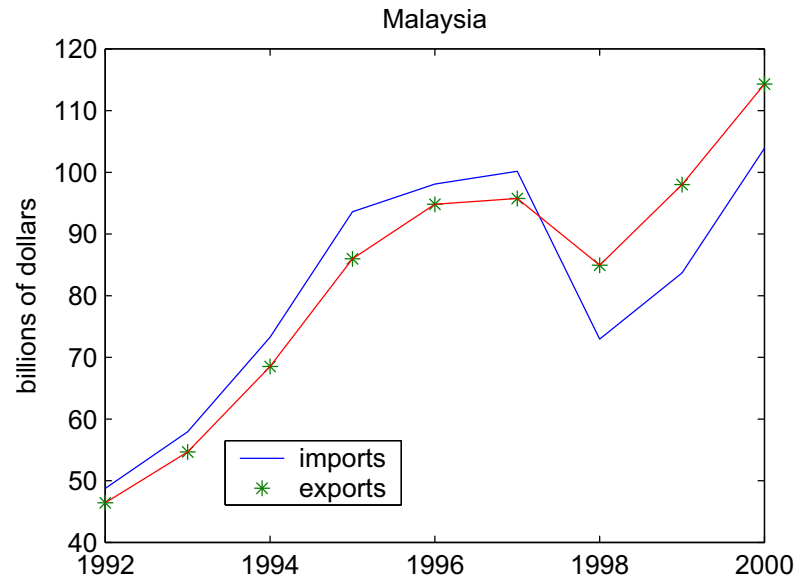
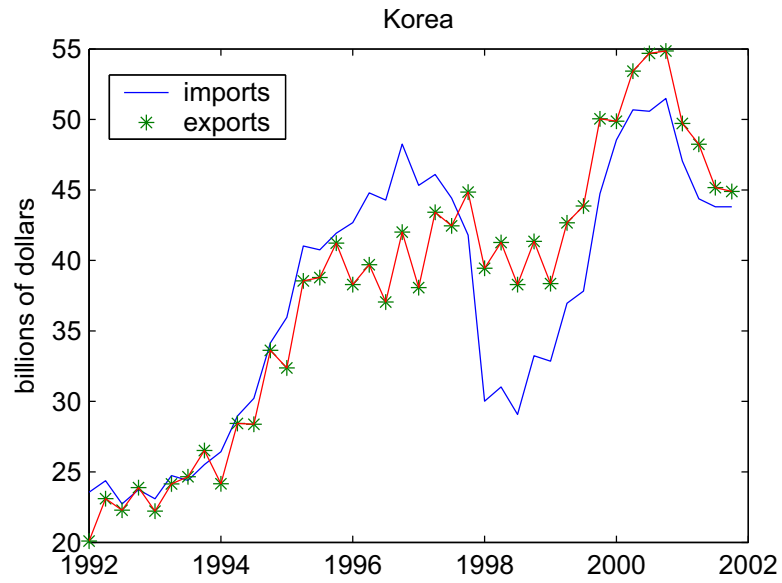
Sources: CEIC; and WEO.

**Figure 2**

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- Model Highlights Key Features of Crisis Economies:
  - General Evidence From Surveys of ‘Credit Crunch’
  - Collateral Constraints on Loans in Crisis Economies Tightened
  - Intermediate Inputs are an Important Component of Imports
  - Imports Fell a Lot, Exports Fell too, but by Less
    - \* Consistent with notion that international credit supporting imports was reduced, and this interfered with ability to produce and export.

Figure 3: Exports and Imports



# Structure of Model

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- Small, Open Economy with Traded and Nontraded Goods
- Imported Intermediate Inputs and Labor Must be Financed in Advance
  - Trigger of Crisis: Sudden Tightening of Binding Collateral Constraints.
    - \* We Ask: How should the domestic central bank respond?
- Key Labor Market Friction:
  - Short Run: Firms Cannot adjust labor quickly in tradable sector
  - Longer Run: Labor Everywhere Flexible
- Interpretation of Labor Market Friction:
  - Labor market regulations enforced in traded good sector.
  - Traded good sector easier to monitor: higher wages, higher capital per worker, higher value-added, more plants per firm, etc. (US data: Melitz).

## Structure of Model ...

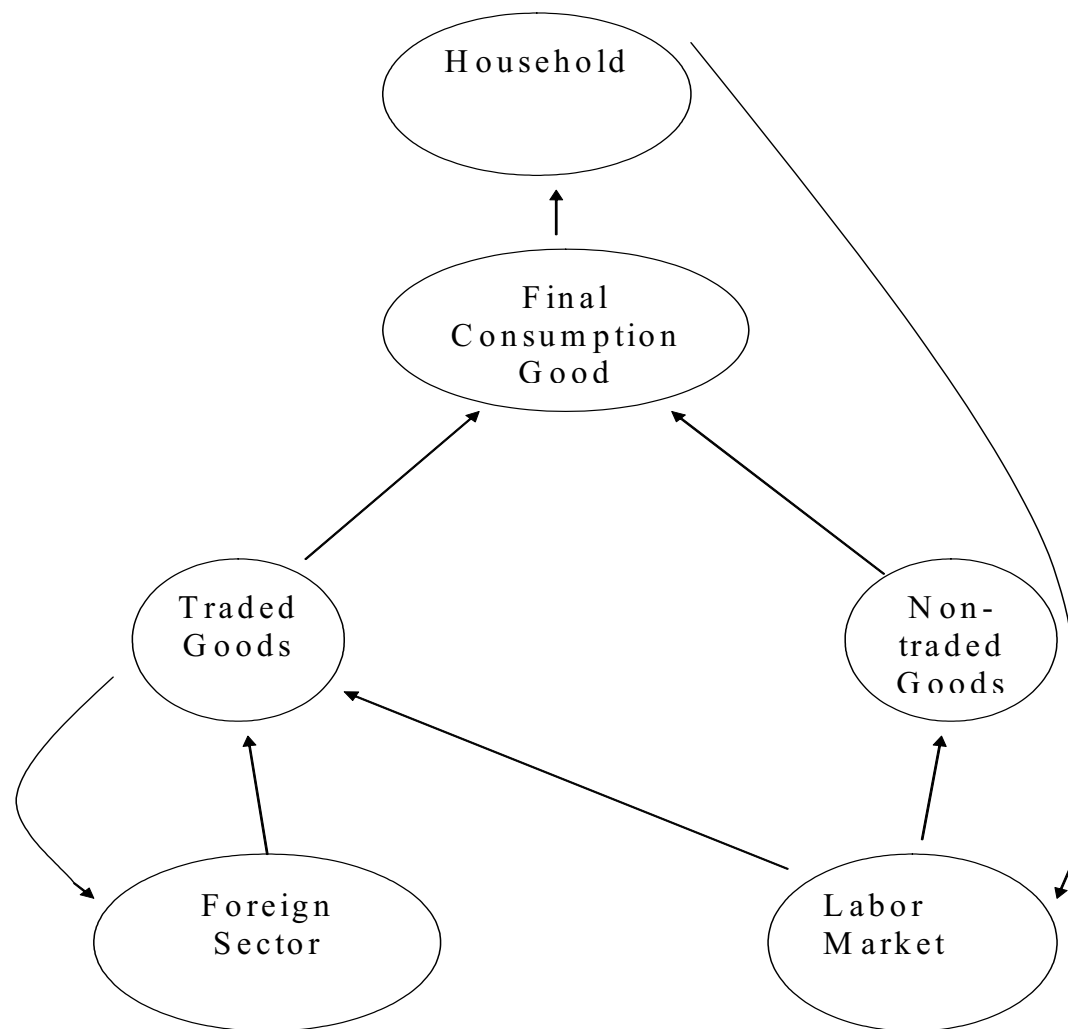
- Aggregation of Assets and Liabilities
  - All assets and liabilities concentrated in hands of single representative firm.
  - Borrowers have access to all collateral in economy (rule out mismatches as in Caballero-Krishnamurthy)
  - Motivation:
    - \* Claessens, Djankov, Fan, and Lang (1999): 75 percent of firms belong to a group of firms in Southeast Asia in 1991-1996.
    - \* Shin and Park (1999): firms in Korean chaebols guarantee bank loans taken by other firms in the same chaebol.
    - \* Groups of firms often span traded and nontraded sectors.
- Non-neutrality of money: Limited Participation Assumption.

# Outline

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- Simulate Optimal Monetary Policy in Response to Collateral Shock in Full Dynamic Model
- Draw Attention to Unusual Feature of Optimal Policy.
  - Welfare and Output Increased in First Period with Increase in Domestic Interest Rate
- Carefully Go Through A Highly Simplified (Non-Monetary, Static) Version of the Model to Understand Monetary Transmission Mechanism.

## Flow of Goods and Labor in the Model



# Model

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Agents: Households, Final Good Firms, Intermediate Good Firms, Foreign Sector

- Households

$$\max_{c_t, L_t, D_t} \sum_{t=0}^{\infty} \beta^t \frac{\left[ c_t - \frac{\psi_0}{1+\psi} L_t^{1+\psi} \right]^{1-\sigma}}{1-\sigma}$$

$$P_t c_t \leq W_t L_t + \tilde{M}_t - D_t$$

$$\tilde{M}_{t+1} = R_t (D_t + X_t) + P_t^T \pi_t + W_t L_t + \tilde{M}_t - D_t - P_t c_t$$

$\tilde{M}_{t+1} \sim$  money chosen by household

$R_t \sim$  gross domestic nominal rate

$X_t \sim$  money injection by central bank

$\pi_t \sim$  profits

$D_t \sim$  deposits of cash with intermediary

## Model ...

- Final Good Firms ('Retailers'):

$$c = \min \{ (1 - \gamma) c^T, \gamma c^N \}$$

- Domestic Intermediate Good Firms:

- Technology, traded goods:

$$y^T = \left\{ \theta [\mu_1 V]^{\frac{\xi-1}{\xi}} + (1 - \theta) [\mu_2 z]^{\frac{\xi-1}{\xi}} \right\}^{\frac{\xi}{\xi-1}},$$

$$V = A (K^T)^\nu (L^T)^{1-\nu},$$

$\xi \sim$  elasticity of substitution between  $V$  and  $z$

$z \sim$  foreign intermediate good

- Technology, non-traded goods:

$$y^N = (K^N)^\alpha (L^N)^{1-\alpha}$$

## Model ...

- Representative Intermediate Good Firms:

$$\max \sum_{t=0}^{\infty} \beta^t \Lambda_{t+1} \pi_t,$$

$$\pi_t = p_t^N y_t^N + y_t^T - R_t [w_t^T L_t^T + w_t^N L_t^N] - R^* z_t - r^* B_t + (B_{t+1} - B_t)$$

- Collateral Constraint:

$$\tau q_t^N K^N + \tau q_t^T K^T \geq R^* z_t + (1 + r^*) B_t + \zeta R_t (w_t^T L_t^T + w_t^N L_t^N)$$

- Resource Constraints:

$$y^N = c^N$$

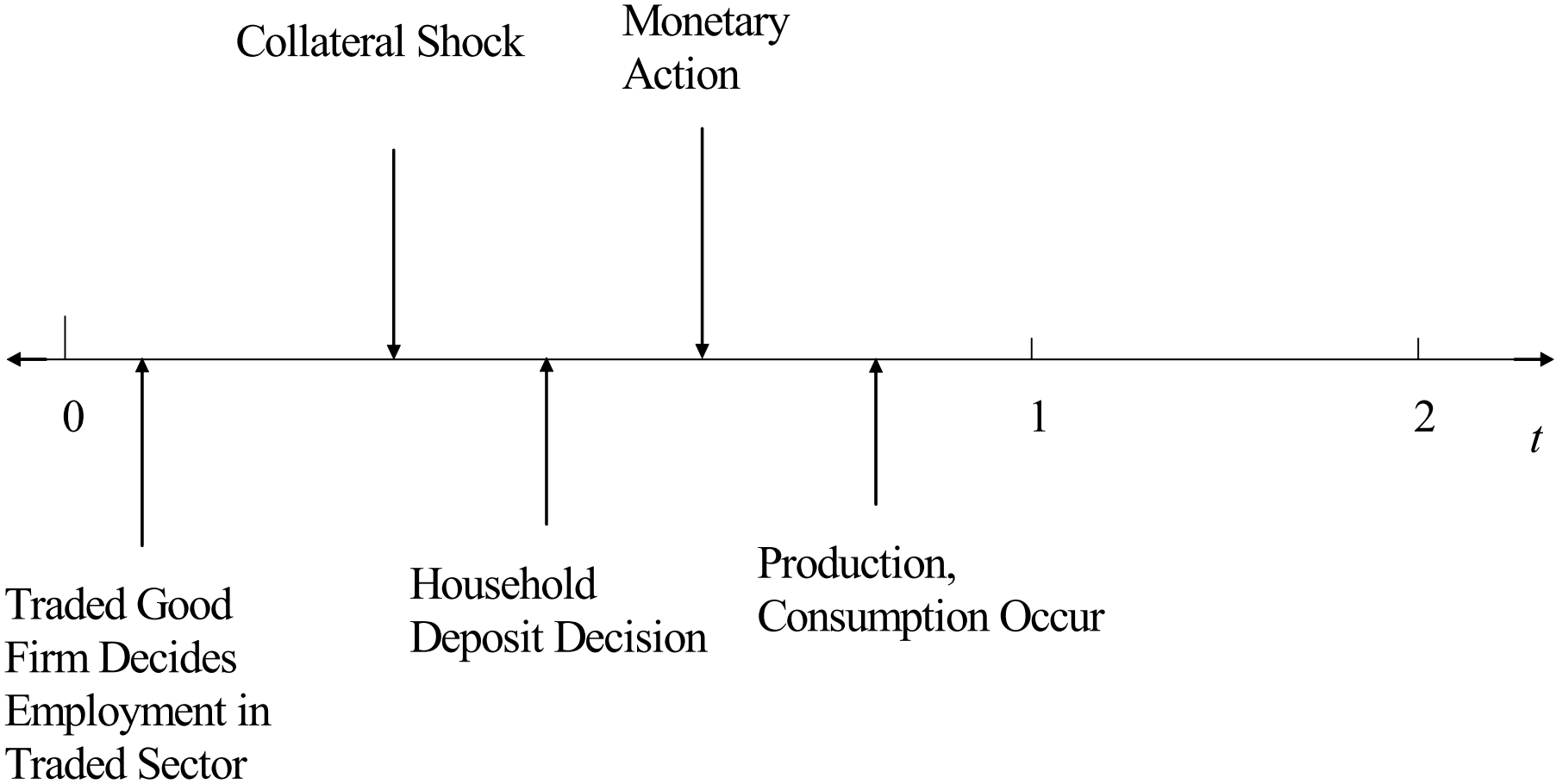
$$y^T = c^T + R^* z + r^* B - (B' - B)$$

- Money Market Clearing:

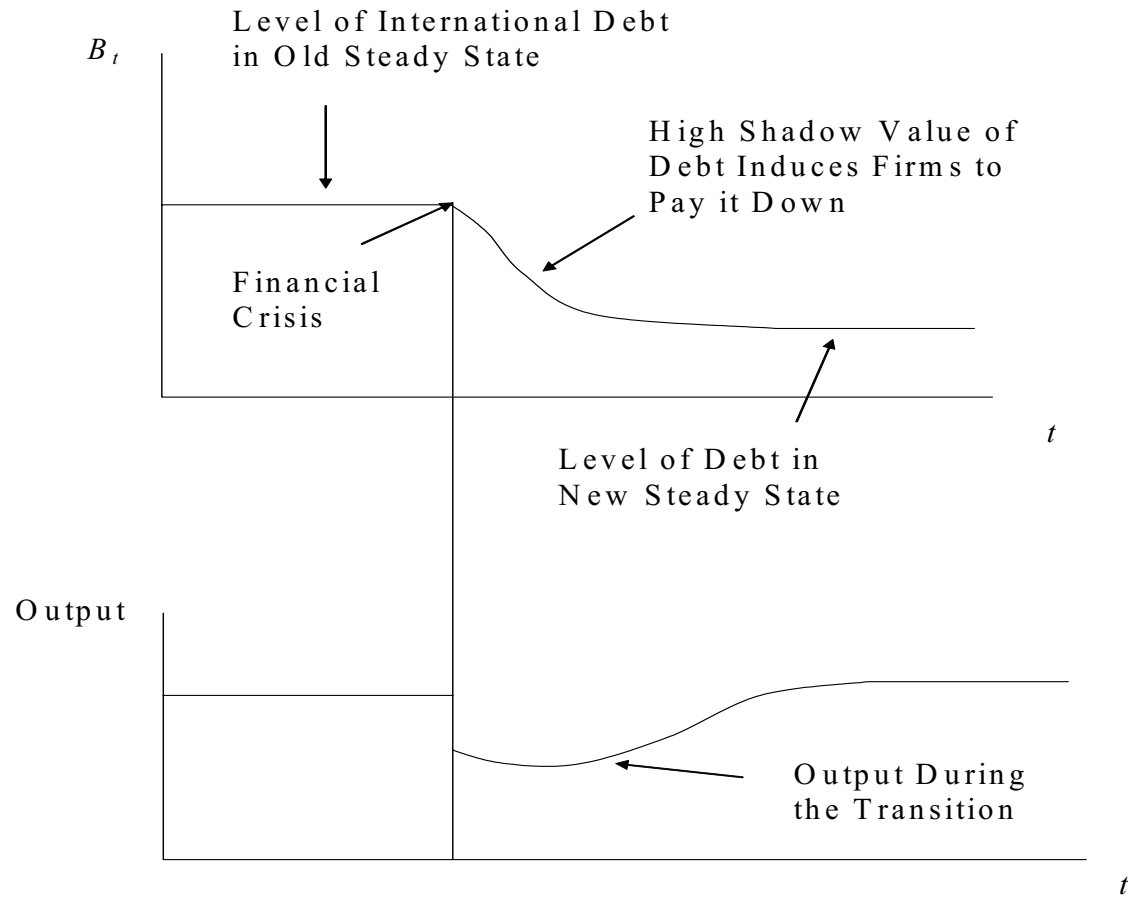
$$D_t + X_t = W_t L_t$$

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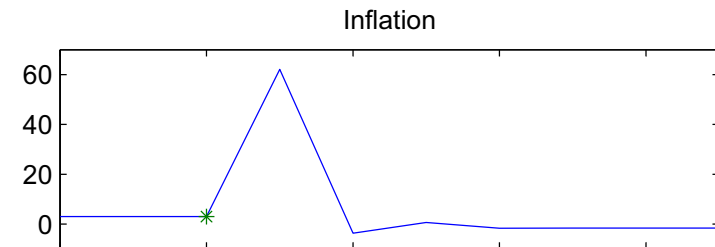
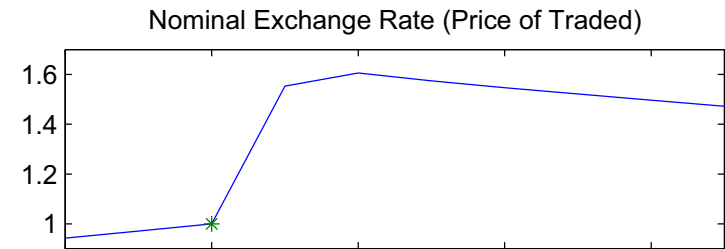
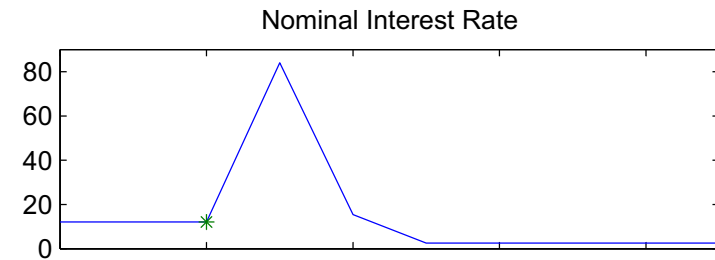
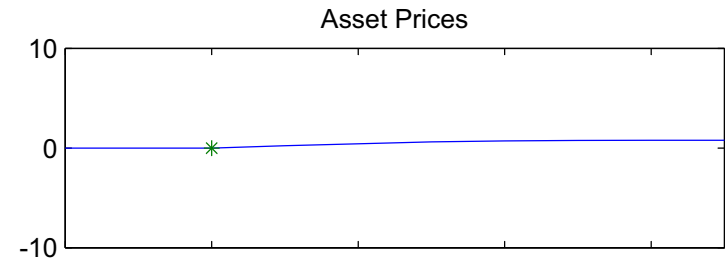
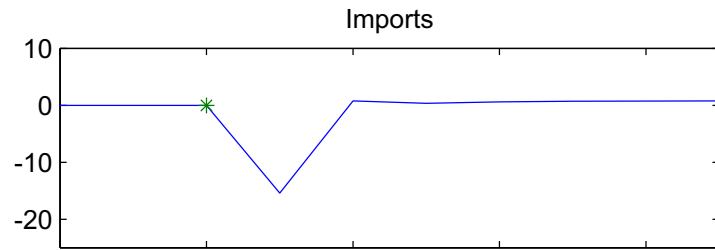
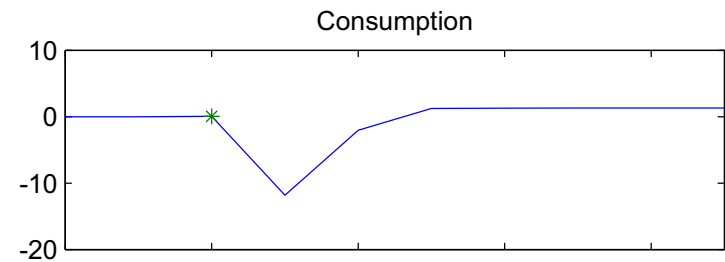
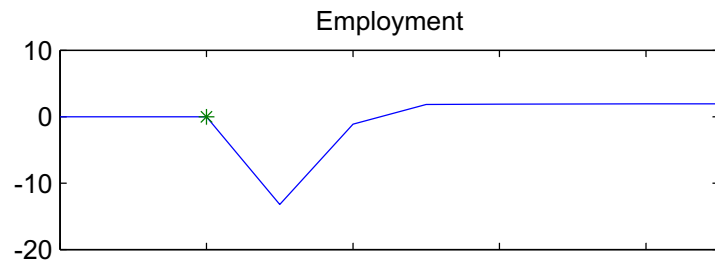
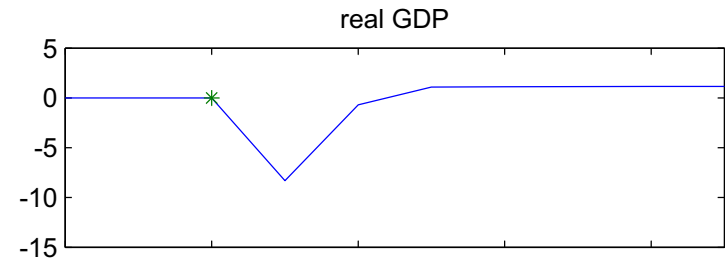
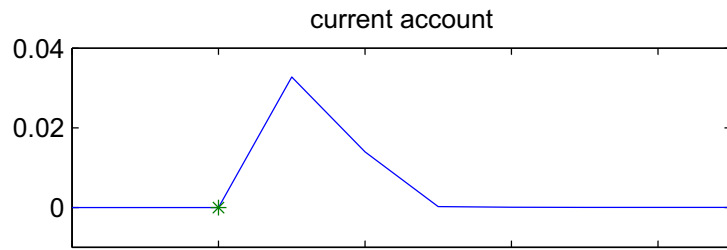
Timing



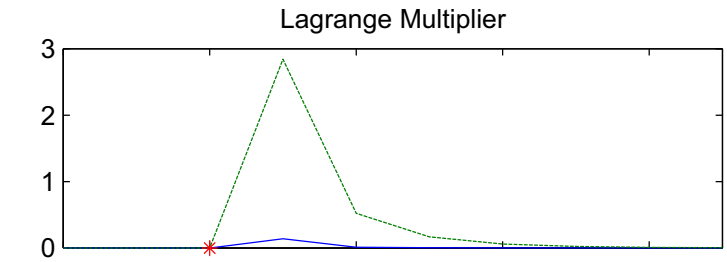
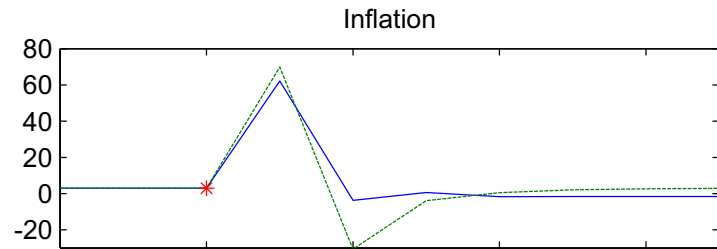
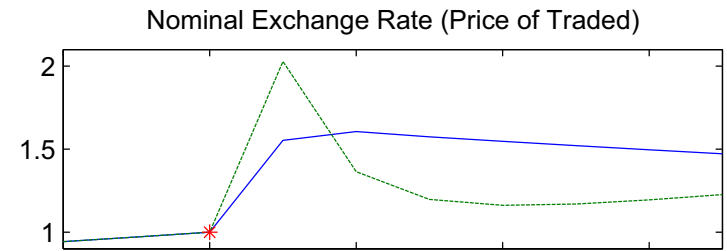
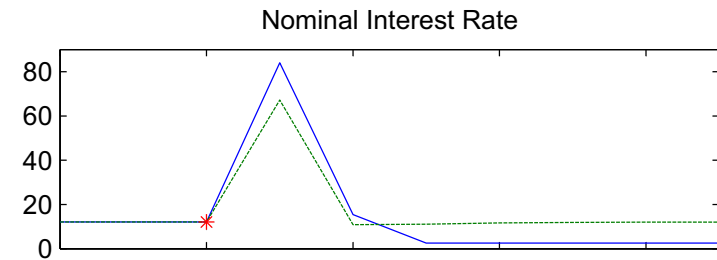
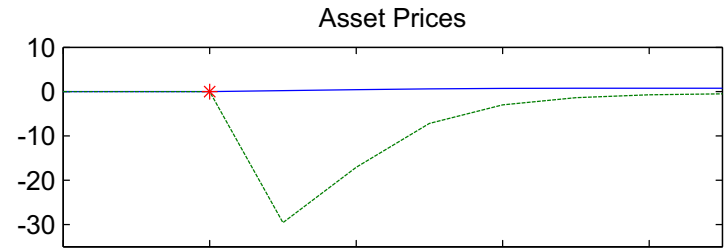
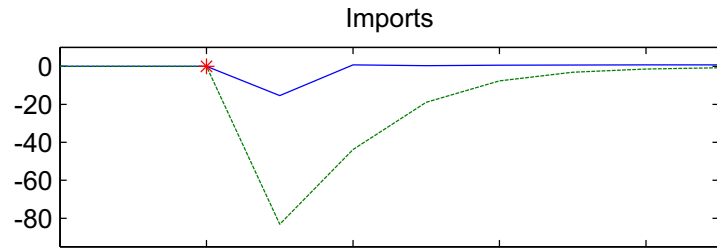
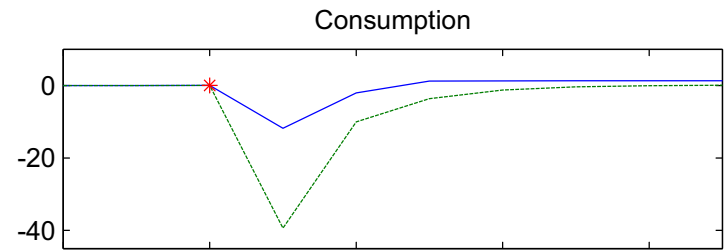
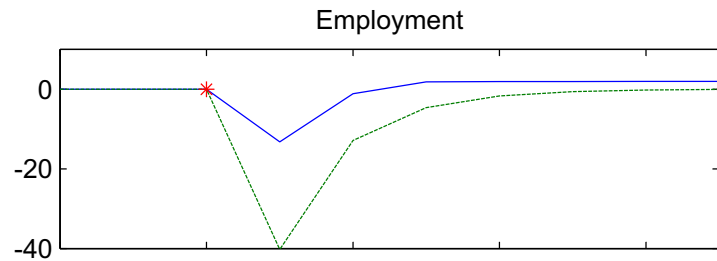
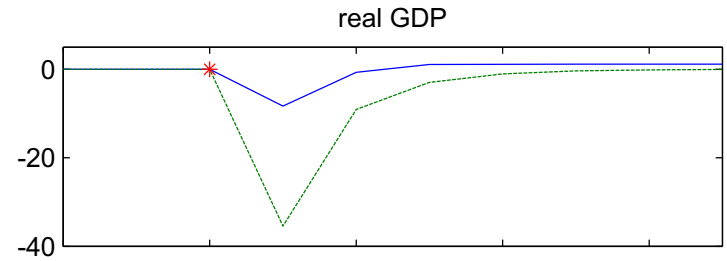
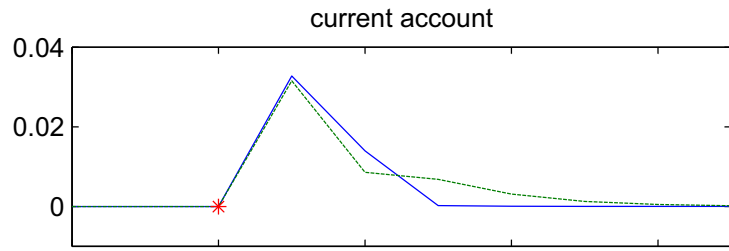
Response of Debt and Output to Collateral Shock In  
the Absence of Monetary Policy Response (Fixed  
Money Growth)



# Optimal Money Growth

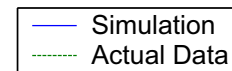
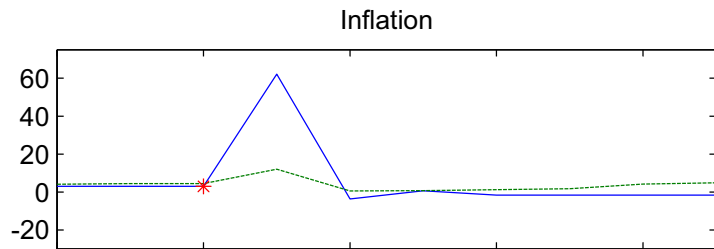
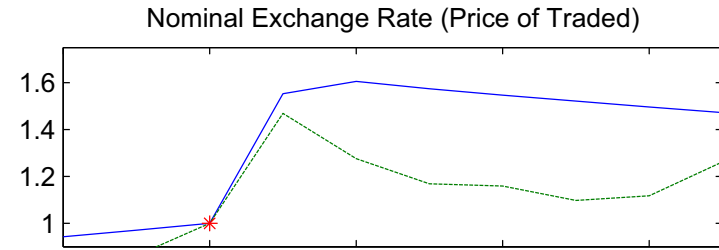
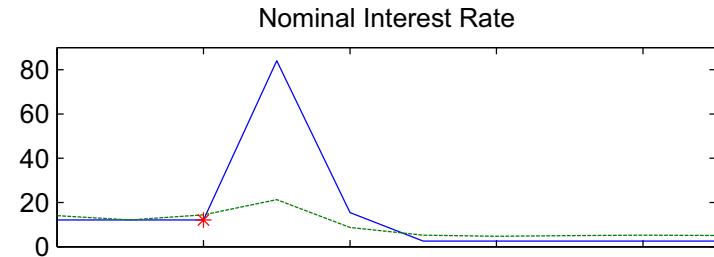
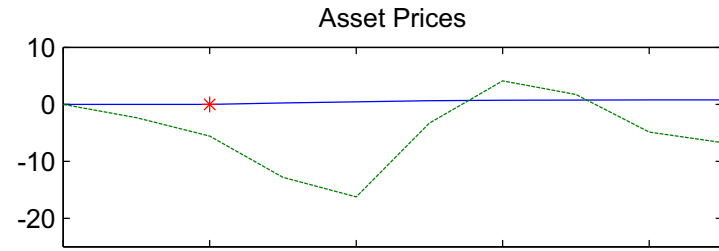
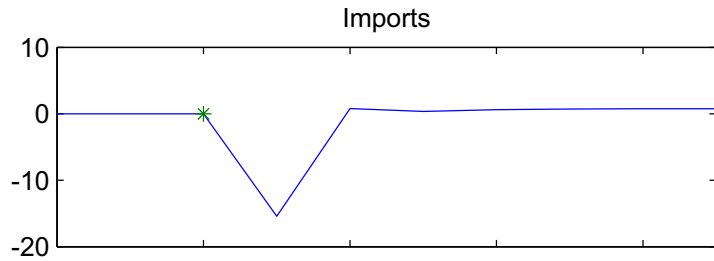
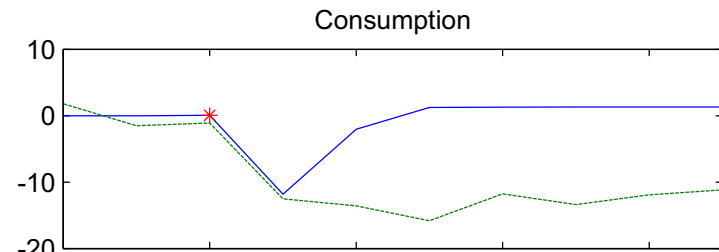
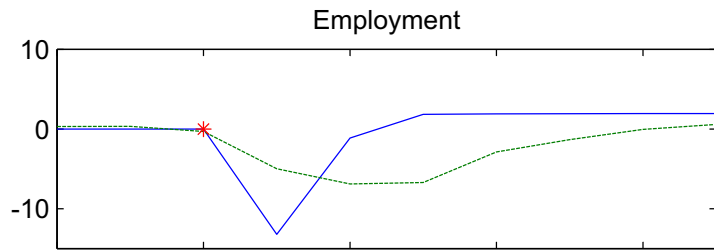
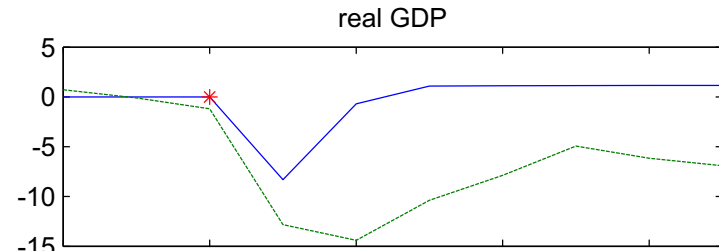
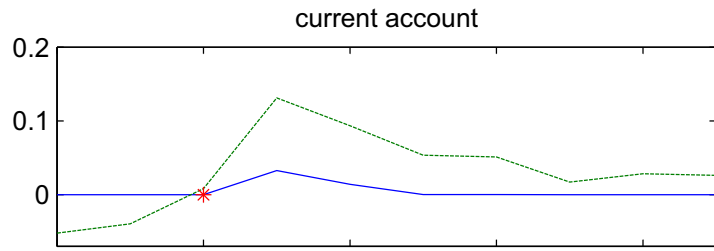


# Optimal and Constant Money Growth



— Optimal Money Growth  
- - - Constant Money Growth

# Optimal Money Growth and Korean Data



# Heart of Analysis

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- Raising Interest Rate Leads to Higher Employment, Asset Prices and Welfare
- Puzzle:
  - Interest Rate is Like Tax on Labor
    - \* Why Does Raising Tax on Labor Lead to More Employment and Higher Welfare?
  - Asset Values Correspond to Inputs that *Complement* Labor
    - \* Why Does Raising Tax on Labor Raise Value of Complementary Inputs?
- Answer: Higher Wedge on Labor Permits Reduction in Another Wedge, Collateral Constraint
- Will Work Through a Simple Example, Where Analytic Result is Possible

# Simplified Model Economy

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- Households
  - Maximize

$$u(c, L) = c - \frac{\psi_0}{1 + \psi} L^{1+\psi}$$

- subject to:

$$pc \leq wL + \pi + T$$

- Firms:

- Final Good Technology:

$$c = \min \{ (1 - \gamma)c^T, \gamma c^N \}$$

## Simplified Model Economy ...

– Traded and Non-Traded Good Technology:

$$y^T = V^\theta z^{1-\theta}, \quad V = A (K^T)^\nu (L^T)^{1-\nu}$$

$$y^N = (K^N)^\alpha (L^N)^{1-\alpha}.$$

– Market Clearing

$$\begin{aligned} y^T &= c^T + R^* z, \\ y^N &= c^N. \end{aligned}$$

– Intermediate Good Firm Problem: maximize

$$\pi = p^N y^N + y^T - w(1 + \tau)L - R^* z - q^N (K^N - K_0^N) - q^T (K^T - K_0^T),$$

$$\text{s.t. } R^* z \leq q^N K^N + q^T K^T.$$

## Simplified Model Economy ...

- Timing

1. Labor Tax Rate,  $\tau$ , Selected

2. Price of Capital in Non-traded Good Sector:

$$q^N = \frac{\alpha p^N (K^N)^{\alpha-1} (L^N)^{1-\alpha}}{1 - \lambda \tau^N}$$

3. Price of Capital in Non-traded Good Sector:

$$q^T = \frac{MP_{K^T}}{1 - \lambda \tau^T}$$

4. Markets Meet and Clear

# Results

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- Proposition: If there is a unique equilibrium in which the collateral constraint binds, then an increase in  $\tau$  leads to an increase in Real Exchange Rate ( $p^N$ ), Asset Values ( $q^N K^N + q^T K^T$ ), Imports ( $z$ ), Employment ( $L^N$ ), Welfare

# Proof Strategy

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- Eight variables to determine in equilibrium:

$$w, p, p^N, q^N, q^T, L^N, z, \lambda$$

- What we want to determine: how these variables change with change in parameter of model (labor tax rate).
- Direct attack on problem not wise: too much simultaneity.
- Can simplify the problem:
  - make  $\lambda$  exogenous and temporarily ignore collateral constraint
  - compute ‘equilibrium’  $w, p, p^N, q^N, q^T, L^N, z$ .
  - move  $\lambda$  around until  $\lambda \geq 0$ ,  $\lambda^*$ , is found which satisfies collateral constraint.
  - easy to determine how  $\lambda^*$  varies with  $\tau$ .

$$f(\lambda; \tau) = \tau^N q^N(\lambda; \tau) K^N + \tau^T q^T(\lambda) K^T - z(\lambda)$$

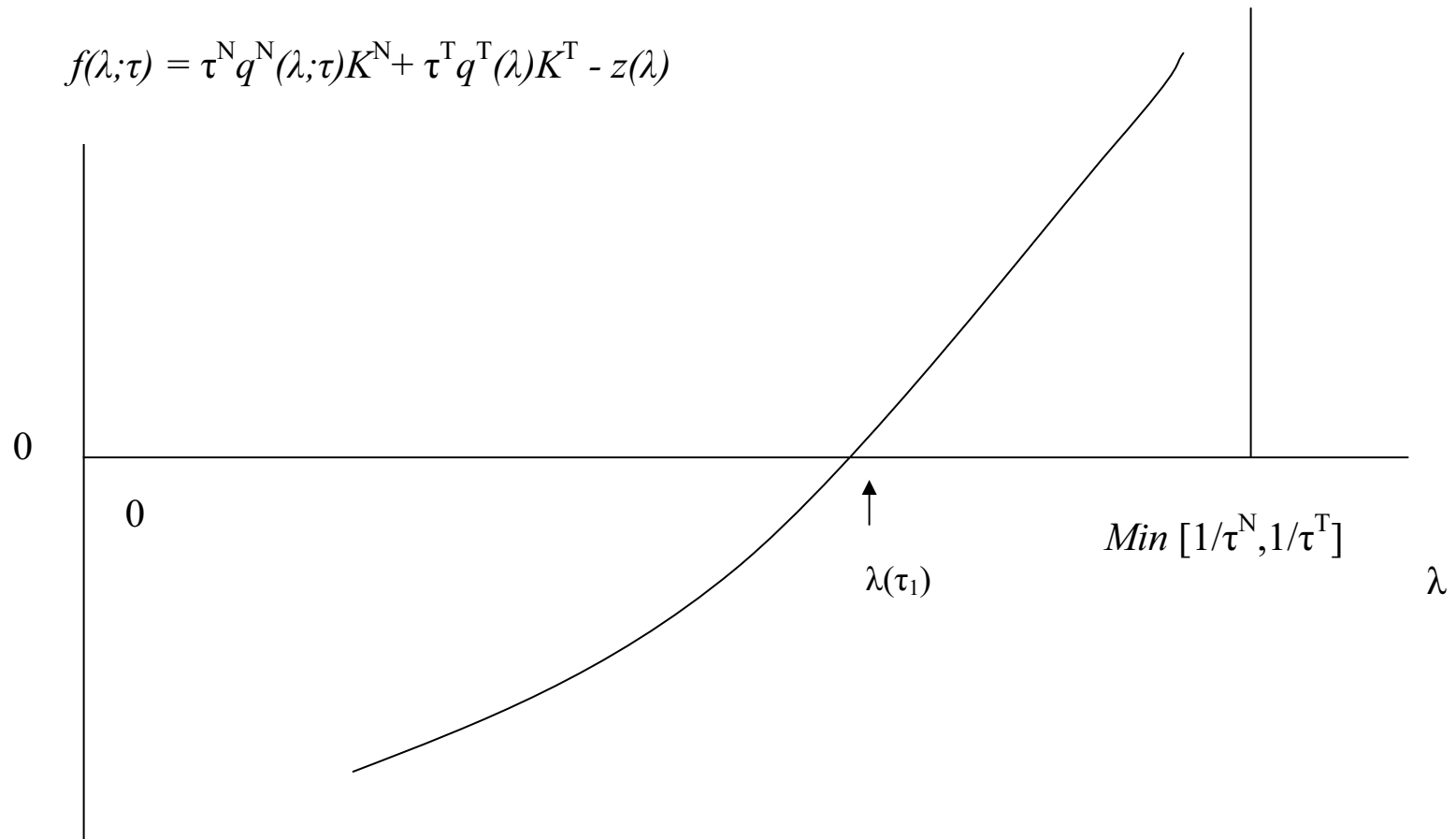


Figure 4: The Effect of An Increase in the Labor Tax Rate

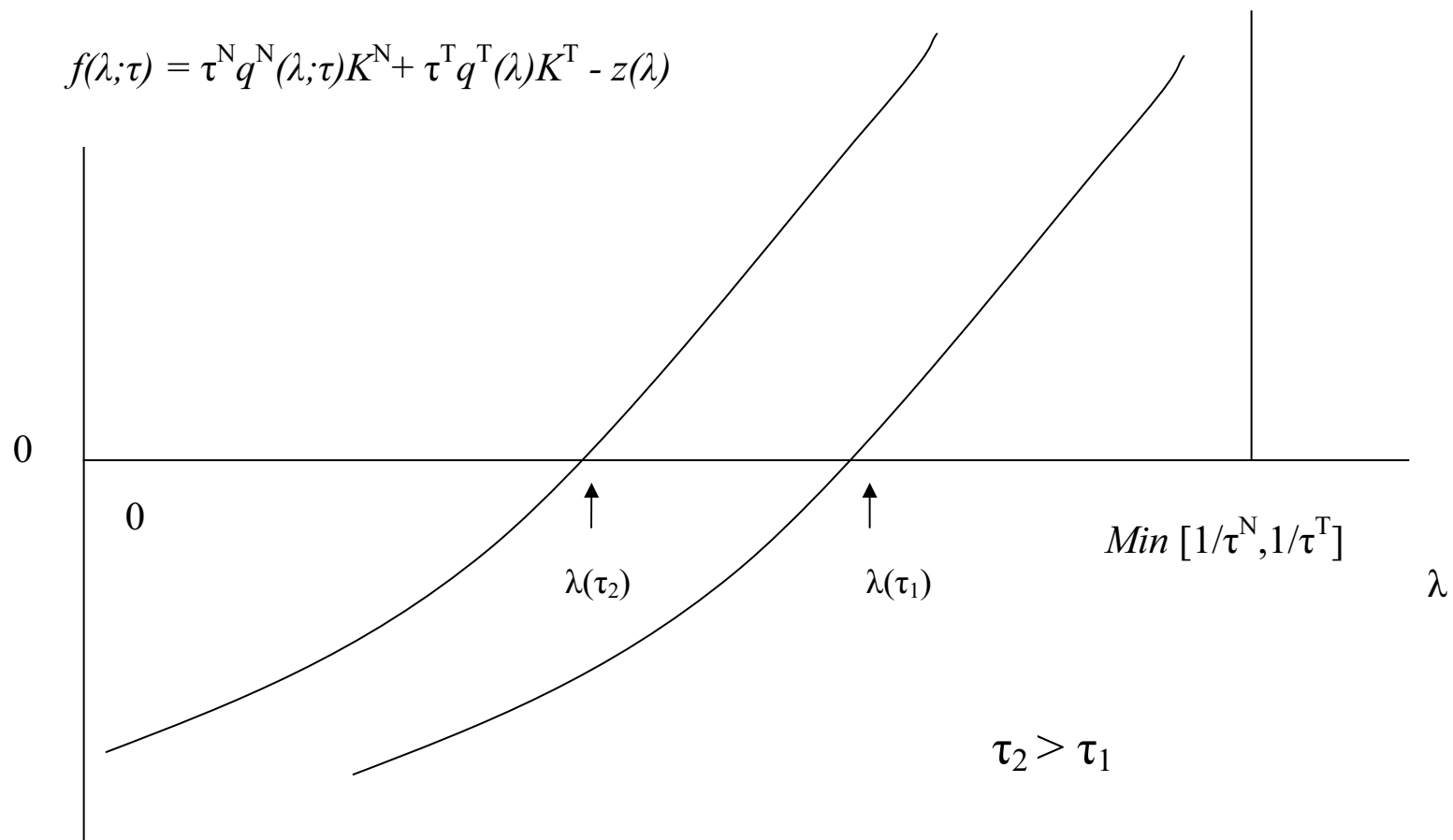


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- Rise in  $\tau$  Increases Marginal Cost of Nontraded Goods
- Relative Price,  $p^N$ , of Non-Traded Goods, Rises
- Value of Assets in Non-Traded Good Sector Increase
- Relaxation of Collateral Constraint ( $\lambda$  decreases):
  - Imports of Intermediate Good Expand
  - Increased Production of Tradeable Good
  - Increased Demand (Leontieff Helps Here!) For Non-Tradable Good
  - Supports Increased Employment in Non-Tradable Sector

Results ...

Figure: Labor Market Equilibrium

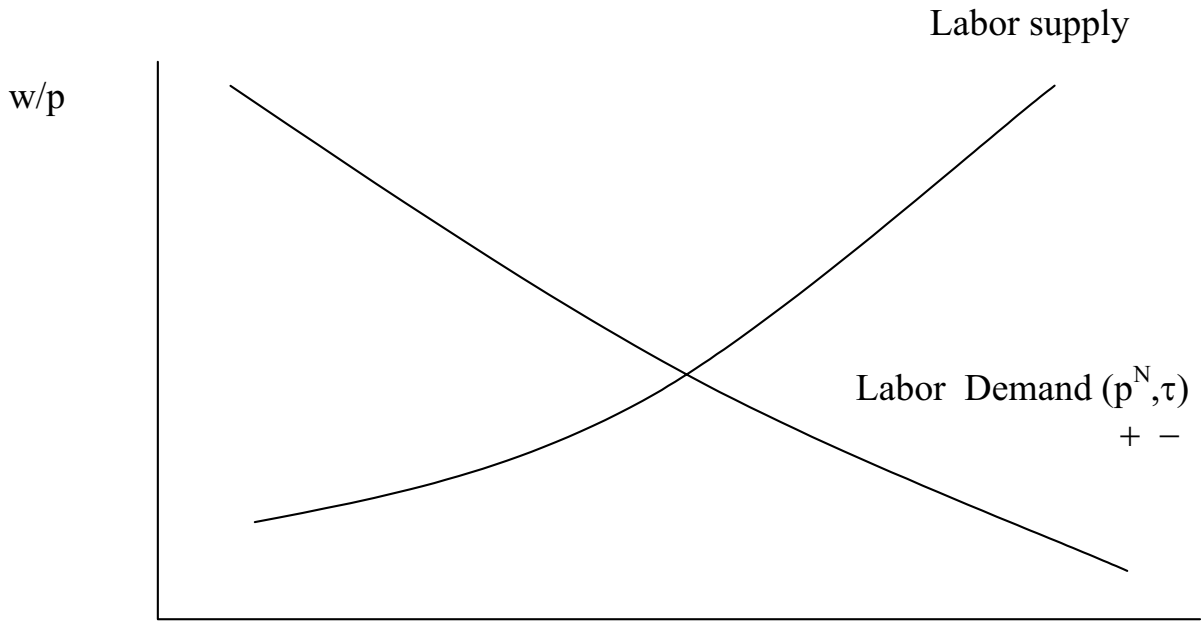
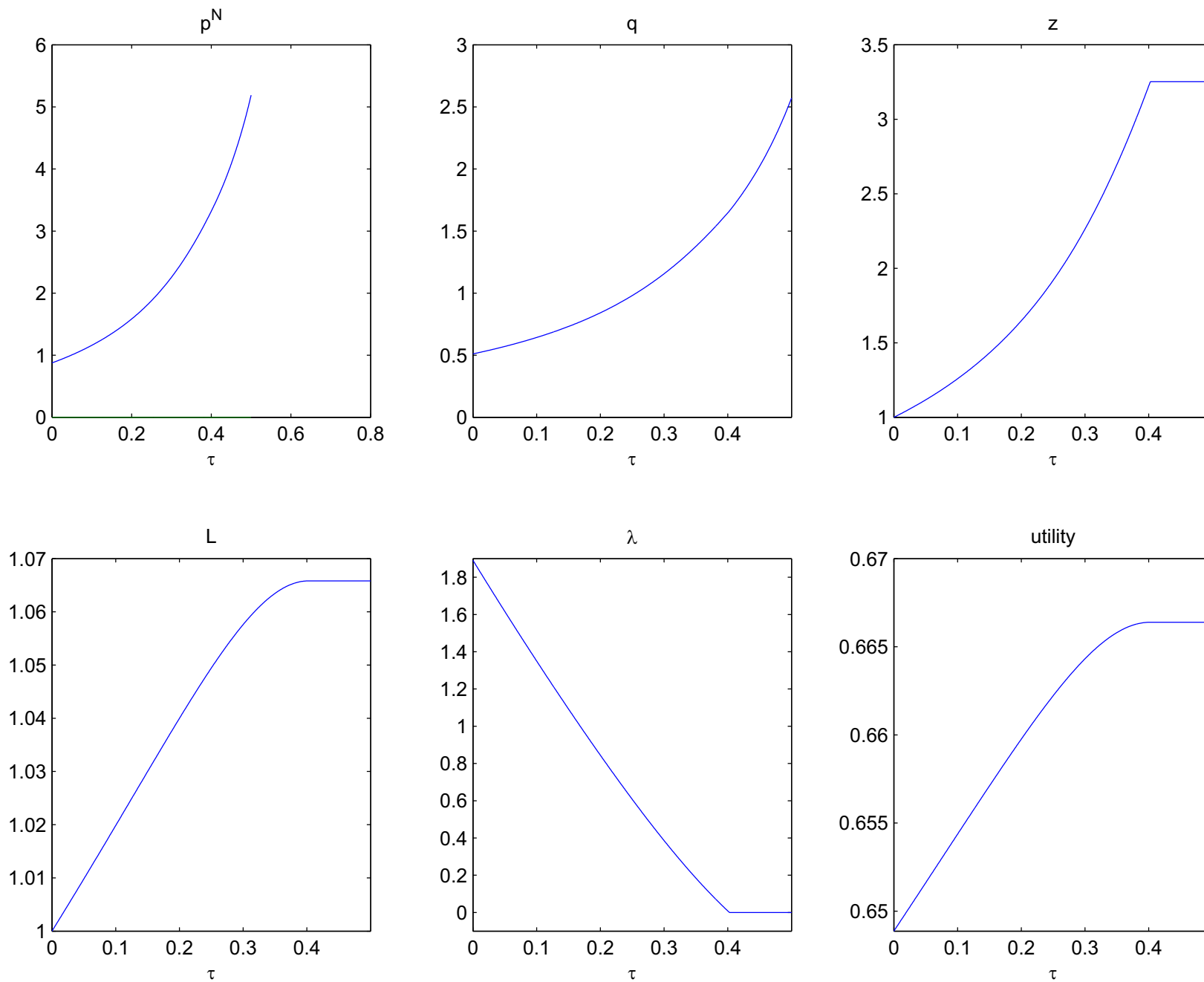


Figure 5: Equilibrium Associated With Various Tax Rates



## Conclusion

- Identified Factors That Make Raising the Interest Rate in Immediate Aftermath of Financial Crisis Optimal
- Simulated a Model With These Properties (Inflexible Factors of Production in Short Run) and Found that Actual Interest Rate Response May Have Been Roughly Optimal
- Broader Implications of Analysis:
  - Monetary Transmission Mechanism May Be Profoundly Different When Collateral Constraints are Binding
- Connections to Related Literature:
  - Empirical: “Non-Keynesian Effects of Fiscal Policy”, “Expansionary Fiscal Consolidations” (Giavazzi-Jappelli-Pagano, Perotti)
  - Theoretical: Financial Frictions Literature Suggest that High Interest Rates May Be a Feature of Optimal Policy (Kocherlakota)