Optimal Stabilization Policy in a Model with Endogenous Sudden Stops

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What are sudden stops?

- Sudden and large reversals in private international capital flows to emerging economies have been labeled "sudden stops" by Calvo (1998).
- Episodes associated with collapses in output, consumption, relative prices, and asset prices.

Sudden stops are important

- Perhaps defining feature of EMs' recent experience:
  - Durdu, Mendoza and Terrones (2007) document 18 recent episodes
  - Jeanne and Ranciere (2009) estimates the unconditional probability of SS of about 10% on a yearly basis for their sample of countries.
- Not necessarily defining feature of EMs' business cycles (Mendoza, 2008)

How to model sudden stops?

- Mendoza (2002, 2008) models sudden stops with:
  - Flexible prices
  - Occasionally binding international borrowing constraint
  - Liability dollarization
    - Sudden stops correspond to the case in which constraints is binding.

What should stabilization policy do about sudden stops?

- Much progress has been made on the optimal policy response to a sudden stop:
  - Devereux and Poon (2004), Christiano, Gust, and Roldos (2004), Braggion, Christiano, Roldos (2007), Caballero and Krishnamurthy (2005), Caballero and Panageas (2007), Cúrdia (2007)
- The current literature takes a common starting point:
  - You are in a sudden stop (i.e., the financial friction is binding)
  - Now what are you going to do about it?

How should stabilization policy be designed in an economy subject to sudden stops?

- Sudden Stops *are* a possibility for EMs
  - How should policy be set outside the crises period? Is there a precautionary motive to optimal policy in normal times?
  - How does the commitment to optimal policy affect private sector behavior? And what are the welfare consequences of such policies?

Main results

- Optimal policy is nonlinear
  - Optimal policy outside crisis period is non-interventionist
  - Optimal policy in the crisis period subsidizes nontraded goods purchases
- Optimal policy results in welfare gains even if the crisis never occurs:
  - Lower precautionary saving and higher consumption
- Technical Contribution: Solving models with occasionally binding endogenous borrowing constraint

Outline

1. Nature of the policy problem: 2 period example.
2. Model
3. Calibration
4. Solution
5. Competitive Equilibrium and Optimal policy
6. Welfare analysis
7. Sensitivity analysis
8. Extensions
9. Conclusions

Nature of the policy problem

2 period- **1 good** small open economy:

- Consumer's preferences:

$$u(c_1, c_2, h_1) = \log c_1 - \frac{h_1^d}{d} + \beta \log c_2$$

- Period-specific budget constraints:

$$w_1 h_1 + \pi + b_1 - T = (1 - \tau) c_1 + b_2$$

$$c_2 = b_2 (1 + r) + Y_2$$

- Borrowing limit:

$$b_2 \geq -\frac{1 - \varphi}{\varphi} (w_1 h_1 + \pi) .$$

Nature of the policy problem

- Firm technology:

$$Y_1 = z l_1^{\alpha}$$

- Firm's problem:

$$\max \pi = z l_1^{\alpha} - w_1 l_1.$$

- Government budget constraint:

$$T = \tau c_1$$

Competitive equilibrium combines agents' FOC and market clearing conditions.

Nature of the policy problem (Planner Problem)

- Objective function:

$$u(c_1, c_2, h_1) = \log c_1 - \frac{h_1^d}{d} + \beta \log c_2$$

- Resource constraints:

$$zh_1^\alpha + b_1 = c_1 + b_2,$$

$$c_2 = b_2(1 + r) + Y_2.$$

- Borrowing constraint:

$$b_2 \geq -\frac{1 - \varphi}{\varphi} zh_1^\alpha.$$

- Planner chooses $\{c_1, c_2, b_2, h_1\}$

Nature of the policy problem (comparison of the CE and SP solution)

- Competitive equilibrium solution:

$$h_1^{d-1} = \left[\frac{1}{c_1(1-\tau)} + \frac{1-\varphi}{\varphi} \left(\frac{1}{c_1(1-\tau)} - \frac{1}{c_2}\beta(1+r) \right) \right] z\alpha h_1^{\alpha-1}$$

- Social planner solution:

$$h_1^{d-1} = \left[\frac{1}{c_1} + \frac{1-\varphi}{\varphi} \left(\frac{1}{c_1} - \frac{1}{c_2}\beta(1+r) \right) \right] z\alpha h_1^{\alpha-1}$$

- Equivalence between the two equilibria is obtained by setting $\tau = 0$ in all states of the world.
- In this case our design of the policy problem implies that there is no role for policy despite the presence of the borrowing constraint

Nature of the policy problem

2 period, **2-good** small open economy:

- Consumer's preferences:

$$u(c_1^T, c_1^N, c_2^T, h_1) = \gamma \log c_1^T + (1-\gamma)\log c_1^N - \frac{h_1^d}{d} + \frac{1}{2}\beta \log c_2^T$$

- Period budget constraints:

$$w_1 h_1 + \pi + b_1 - T = (1-\tau) p_1^N c_1^N + c_1^T + b_2$$

$$c_2^T = b_2(1+r) + Y_2,$$

- Borrowing constraint:

$$b_2 \geq -\frac{1-\varphi}{\varphi}\left(w_1 h_1 + \pi\right).$$

Nature of the policy problem

- Firm technology:

$$Y_1 = zh_1^{\alpha}$$

- Firm's problem:

$$\max \pi = Y_1 + p_1^N zh_1^{\alpha} - w_1 h_1$$

- Government budget constraint:

$$T = \tau p_1^N c_1^N$$

Competitive equilibrium combines agents' FOC and market clearing conditions.

Nature of the policy problem (Planner Problem)

- Objective function:

$$u(c_1^T, c_1^N, c_2^T, h_1) = \gamma \log c_1^T + (1-\gamma) \log c_1^N - \frac{h_1^d}{d} + \frac{1}{2}\beta \log c_2^T$$

- Resource constraints:

$$c_1^T + b_2 = Y_1 + b_1$$

$$c_2 = b_2(1+r) + Y_2.$$

- Borrowing constraint:

$$b_2 \geq -\frac{1-\varphi}{\varphi}\left(Y_1 + p_1^N z \left(l_1^N\right)^{\alpha}\right),$$

in which we substitute $\frac{(1-\gamma)}{\gamma}\left(\frac{c^T}{c^N}\right)\frac{1}{(1-\tau)} = p_1^N$

Nature of the policy problem

- Competitive equilibrium allocation:

$$\frac{(1-\gamma)}{\gamma}\frac{c_1^T}{c_1^N} = \frac{(1-\tau)h^{d-\alpha}}{z\alpha\left(\frac{\gamma}{c_1^T} + \frac{1-\varphi}{\varphi}\left(\frac{\gamma}{c_1^T} - \frac{\beta(1+r)}{c_2}\right)\right)} \quad (1)$$

- Social planner allocation:

$$\frac{(1-\gamma)}{\gamma}\frac{c^T}{c^N} = \frac{h^{d-\alpha}}{\left(\frac{\gamma}{c_1^T}\right)\alpha z}. \quad (2)$$

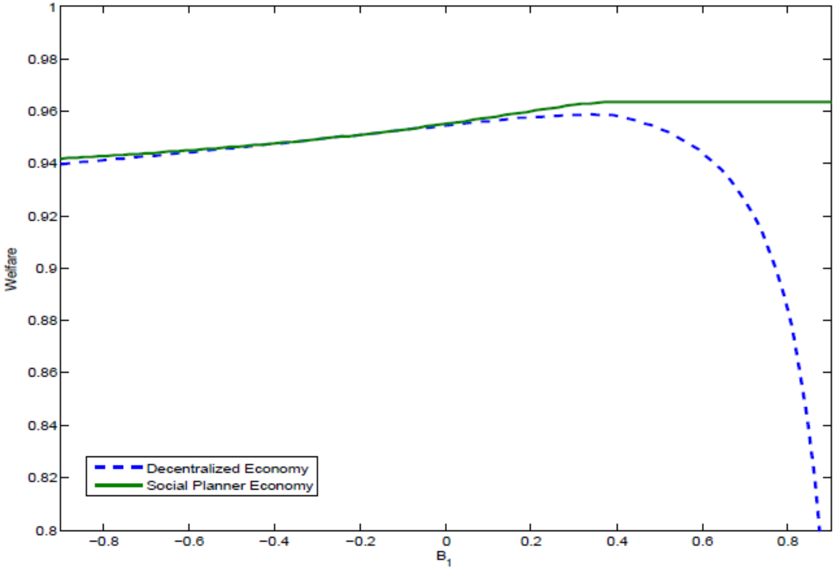
- Optimal $\tau = 0$ in this case when the constraint is not binding.
- When the constraint is binding $1-\tau = 1 + \frac{1-\varphi}{\varphi}\left(\frac{\gamma}{c_1^T} - \frac{\beta(1+r)}{c_2}\right)$ would be needed in order to make the two allocation equivalent.

Nature of the policy problem

Why is there a role for a policy intervention?

- In a two-good model the agents do not internalize the effects of their decisions on relative prices.
  - With no borrowing constraint this would be irrelevant.
  - With a borrowing constraint the planner can relax this constraint.
- In the Ramsey allocation, in which the planner chooses the optimal τ to maximize household utility subject to the competitive equilibrium conditions, the planner will manipulate p^N by varying τ so as to relax the borrowing constraint.

Ramsey planner versus social planner



Model: Main features

- The model follows with some simplifications Mendoza (2002, 2008)
- The model is a small, open, production economy with traded and nontraded goods
- Asset markets are incomplete and access is imperfect:
  - One bond economy with endogenous borrowing constraint
- The model can potentially match many of the quantitative features of emerging market business cycles, inside and outside sudden stop periods

Model: Preferences

- Households maximize:

$$U^j \equiv E_0 \left\{ \sum_{t=0}^{\infty} \exp\left(-\theta_t\right) \frac{1}{1-\rho} \left(C_t - \frac{H_t^{\delta}}{\delta} \right)^{1-\rho} \right\},$$

- Consumption basket C is a composite of tradable and non-tradables goods:

$$C_t \equiv \left[\omega^{\frac{1}{\kappa}} \left(C_t^T \right)^{\frac{\kappa-1}{\kappa}} + (1-\omega)^{\frac{1}{\kappa}} \left(C_t^N \right)^{\frac{\kappa-1}{\kappa}} \right]^{\frac{\kappa}{\kappa-1}}.$$

- Aggregate price index increasing in relative price of non-tradables

$$P_t = \left[\omega + (1-\omega) \left(P_t^N \right)^{1-\kappa} \right]^{\frac{1}{1-\kappa}};$$

Model: Budget and Credit Constraint

- Access to international capital markets is not only incomplete:

$$C_t^T + \left(1 + \tau_t^N\right) P_t^N C_t^N = \pi_t + W_t H_t - B_{t+1} \\ - (1 + i) B_t - P_t^N T^N,$$

- But also imperfect:

$$B_{t+1} \geqslant -\frac{1 - \phi}{\phi} \left[\pi_t + W_t H_t\right]$$

- The constraint limits B to a fraction of current income. Note that debt is denominated in units of tradeable but part of income on which debt is leveraged originates in the non-tradeable sector. (captures the effects of "liability dollarization").
- Constraint binds only occasionally, with the binding state endogenously determined: shock lowers tradable output, non-tradable output, wages, relative price, react endogenously.

Model: Household FOCs

- Marginal utility of current consumption is higher when constraint is binding (time profile of relative price affects time profile of consumption)

$$\mu_t + \lambda_t = \exp\left(-\theta_t\right)\left(1+i\right) E_t\left[\mu_{t+1}\right]$$

- Labor supply higher if constraint is binding (labor supply decreases when relative price of non-tradable, or the tax rate, increases):

$$z_H\left(H_t\right) = \frac{W_t}{\left(1+\tau_t^N\right) P_t}\left[1 + \frac{\lambda_t}{\mu_t}\frac{1-\phi}{\phi}\right],$$

- Non-tradable consumption falls when its relative price or the tax rate increases:

$$\frac{C_{C_t^N}}{C_{C_t^T}} = \left(1+\tau_t^N\right) P_t^N,$$

- Marginal utility of tradable consumption determines multiplier

$$\mu_t = u_{C_t} C_{C_t^T}.$$

Model: Firms

- Traded goods are endowed to firm stochastically.
- Nontraded goods are produced with variable labor input:

$$Y_t^N = AK^\alpha H_t^{1-\alpha},$$

- The firm (owned by the consumer) chooses labor to maximize profits:

$$\pi_t = \exp\left(\varepsilon_t^T\right) Y^T + P_t^N AK^\alpha H_t^{1-\alpha} - W_t H_t.$$

- Labor demand schedule:

$$W_t = (1-\alpha)\, P_t^N AK^\alpha H_t^{-\alpha},$$

Model: Government

- The government runs a balanced budget

$$0 = \tau_t^N P_t^N C_t^N + P_t^N T_t^N.$$

- Stabilization policy is implemented with a distortionary tax on non-tradable consumption
- Budget is balanced with lump sum taxation (nondistortionary financing)
- Interpretation of Policy Intervention: Policy aims to affect the real exchange rate. We model this intervention explicitly as a tariff or subsidy on non-traded goods

Model: Aggregation and Borrowing constraint

- Upon aggregation the borrowing constraint can be written as

$$B_{t+1} \geqslant -\frac{1-\phi}{\phi}\left[\exp\left(\varepsilon_t^T\right) Y^T + P_t^N Y^N\right].$$

- Shocks to tradeable output lower income (firm profits)
- Wages and nontraded output react endogenously
- Wages fall with negative traded goods shock

Model: Shocks

- The shocks to the endowment of traded goods follows an AR(1) process

$$\varepsilon_t = \rho_\varepsilon \varepsilon_{t-1} + \sigma_n n_t,$$

- We include no other sources of macroeconomic risk
- Shocks to nontraded technology, world interest rates, and government spending may be considered

Calibration: key parameter values

- Elast. of sub. (tradable and non-tradable goods) $\kappa = 0.76$
- Weight of tradable and non-tradable goods $\omega = 0.344$
- Utility curvature $\rho = 2$
- Labor supply elasticity $\delta = 2$
- Labor share in production $\alpha = 0.364$
- Credit constraint parameter $\phi = 0.74$
- Persistence/volatility shock: $\rho_\varepsilon = 0.553, \sigma_n = 0.028$

Calibration: steady state values of key variables

- Home real interest rate $i = 0.0159$
- Per capita home GDP $Y = 2.54$
- Per capita tradable endowment $Y_T = 1$
- Per capita consumption $C = 1.698$
- Per capita tradable consumption $C^T = 0.607$
- Per capita non-tradable consumption $C^N = 1.093$
- Relative price of non-tradable $P^N = 1$
- Per capita NFA $B = -3.56$
- Tax rate on non-tradable consumption $\tau^N = 0.0793$

Solution of Competitive Equilibrium

- To solve for the CE we solve a planner problem that satisfies the Bellman equation

$$V(b_t, B_t, \varepsilon_t^T) = \max_{B_{t+1}} \left\{ \begin{array}{c} u\left(C_t - z\left(H_t\right)\right) + \\ \exp\left(-\theta_t\right) E\left[V(b_{t+1}, B_{t+1}, \varepsilon_{t+1}^T)\right] \end{array} \right\}.$$

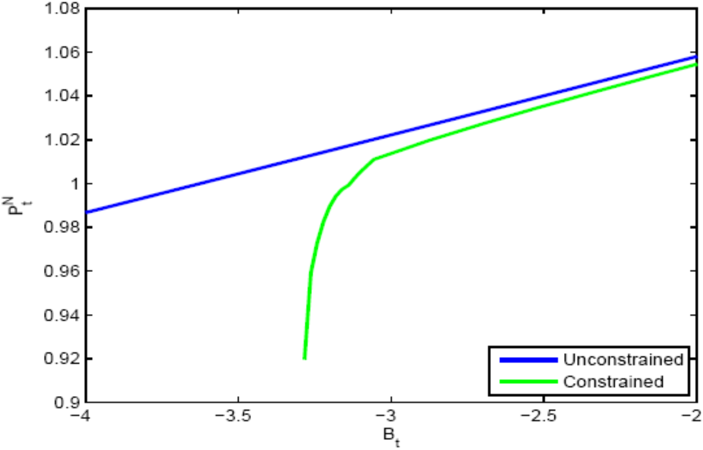
  in which:

  - the credit constraint is taken from an individual perspective;
  - markets clear.

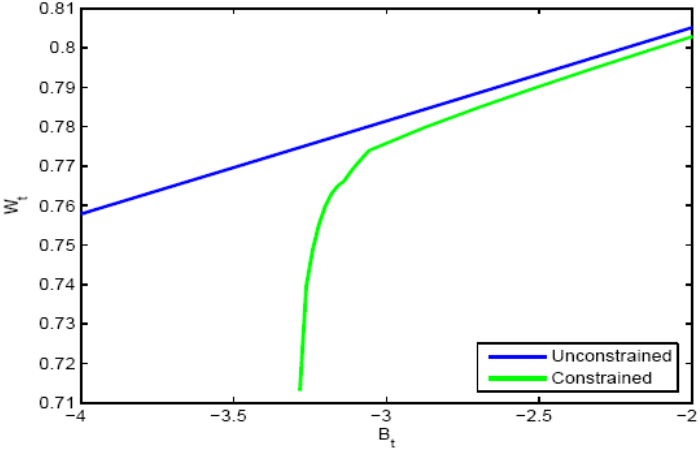
Algorithm is a standard policy function iteration

- Start by guessing some needed functions:
  - A value function (vector of numbers for a fixed set of nodes in the space $\left(b, B, \varepsilon^T\right)$
  - Law of motion for aggregate bond holdings $B' = G_B^n(B, \varepsilon^T)$
  - Recursive pricing functions: $P = G_P(B, \varepsilon^T)$, $H = G_H(B, \varepsilon^T)$
- The value function is then extended to the real line using a cubic spline;
- Given the guessed value function we compute the recursive competitive equilibrium
  - The solution ensures that the borrowing constraint is respected
- We iterate until the value function converges
- Decisions also depend on τ, that we supress in the notation.

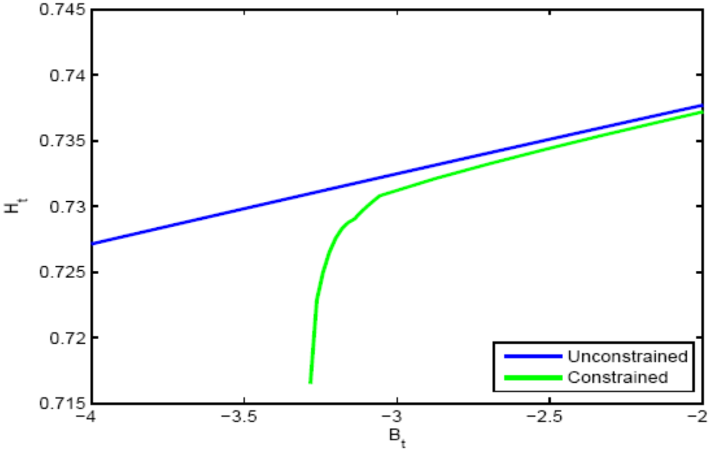
Pn with and without constraint



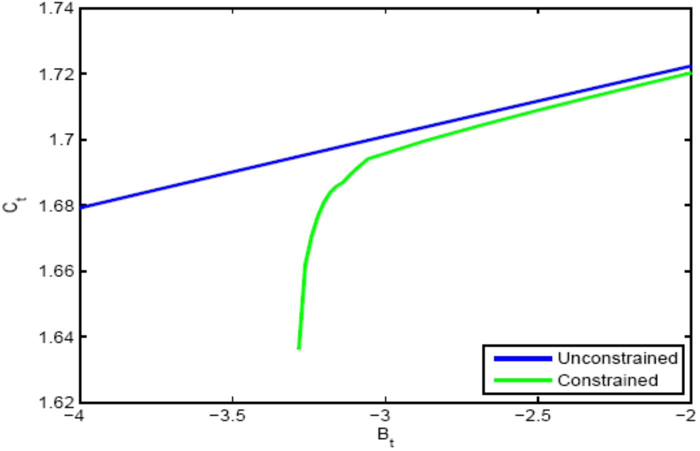
Wages with and without constraint



Labor with and without constraint



Consumption with and without constraint



Optimal Policy

- The solution algorithm works as described for the CE
- Optimal policy is the τ_t^N that maximizes utility (Ramsey problem).
- Agents in the economy are aware that the government will intervene in a crisis.
- There is no issue of commitment.
- Lump sum transfers balance the government budget constraint if τ_t^N is moved

Optimal Policy

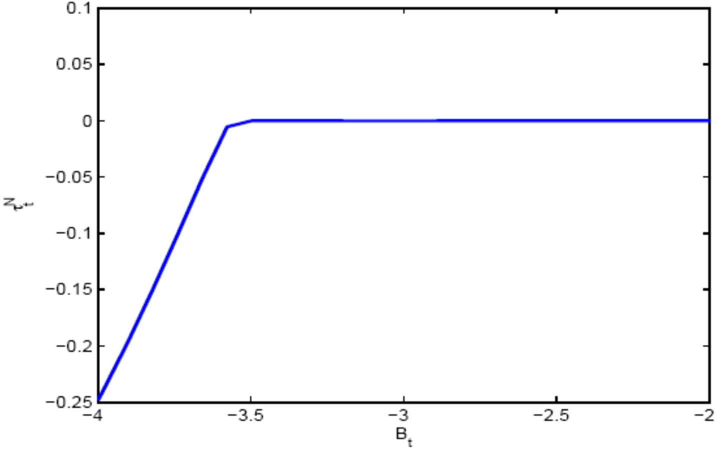
- Transfer function : $T = G_T(B, \varepsilon^T, \tau)$
  - transfer function depends on τ;
  - this is true for B, N and P functions;
  - taxes are not a state variable.
- Optimal policy is given by solving:

$$\tau\left(B, \varepsilon^T\right) = \arg\max_{\tau}\left\{V(B, \varepsilon^T, \tau)\right\}$$

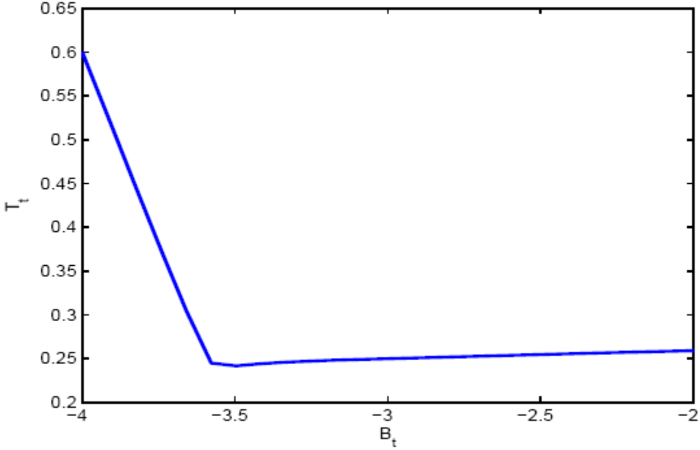
Roles of Policy

- To relax the occasionally binding borrowing constraint (sudden stop)
  - This has the effect of reducing the incentive for private sector saving
- Minimize the distortions associated with the use of τ.

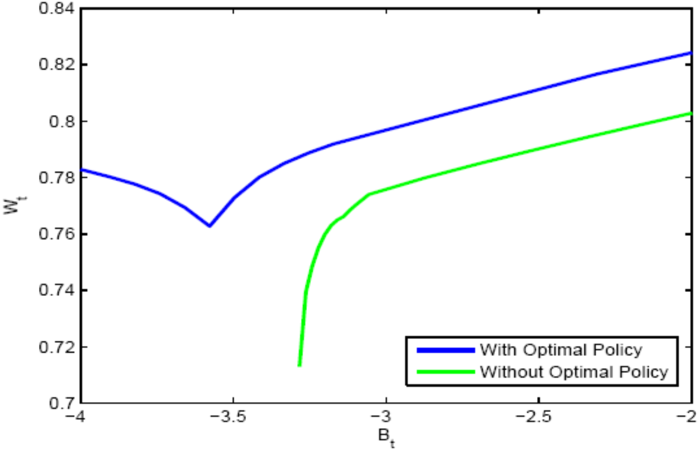
Policy function for tax



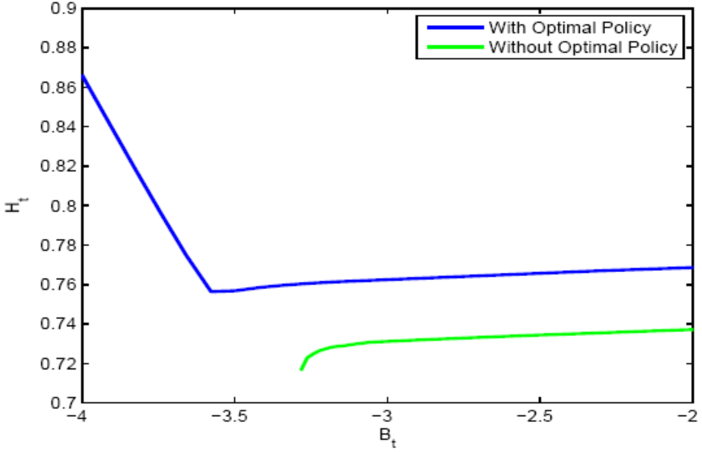
Policy function for transfers



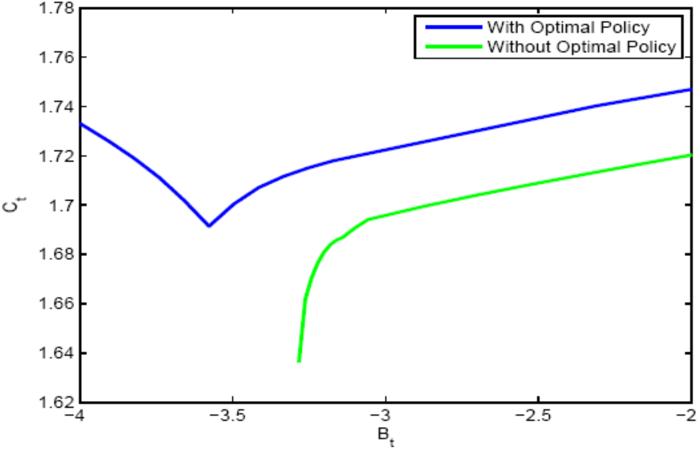
Wages with and without optimal policy



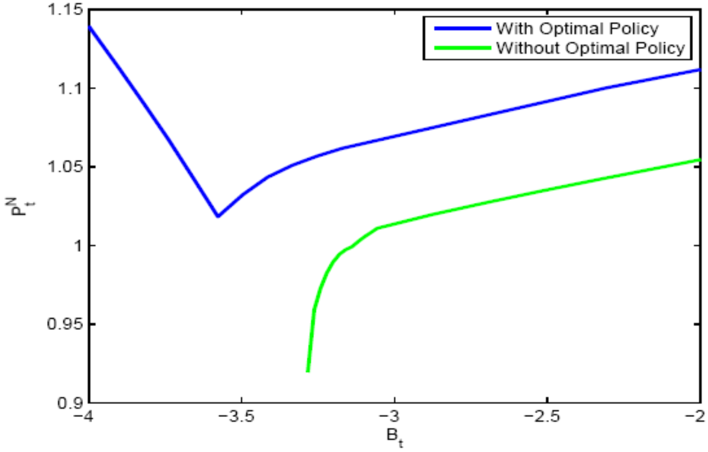
Labor with and without optimal policy



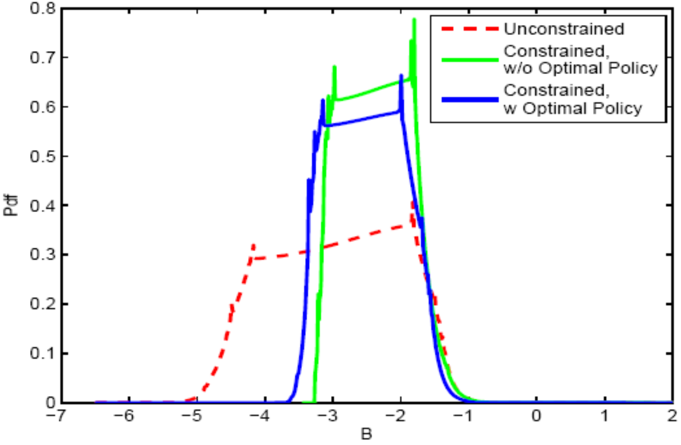
Consumption with and without optimal policy



Pn with and without optimal policy



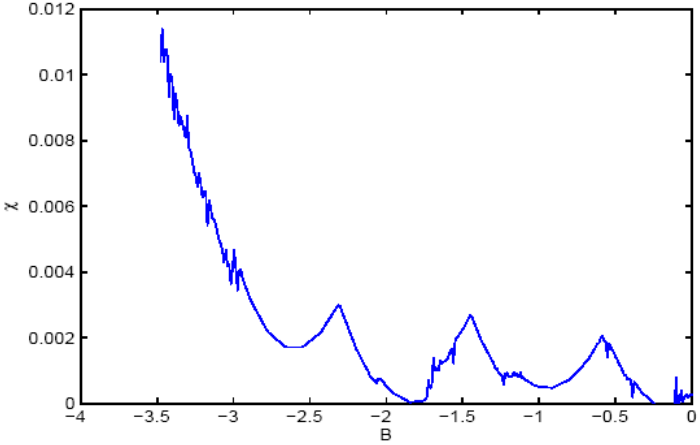
Comparison of ergodic distribution in NFA



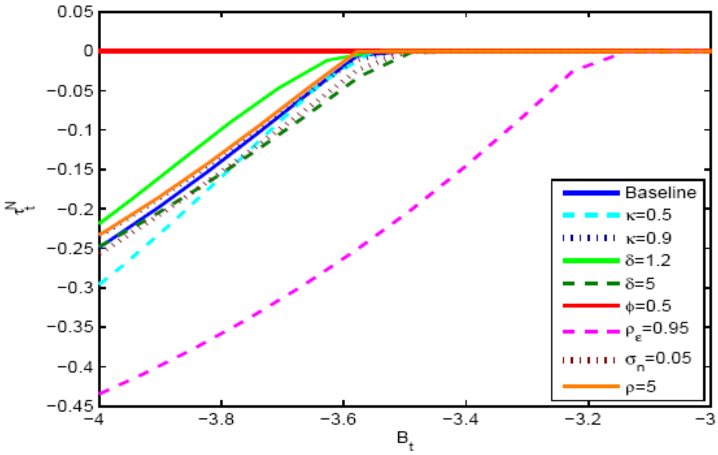
Welfare Gains from Optimal Policy

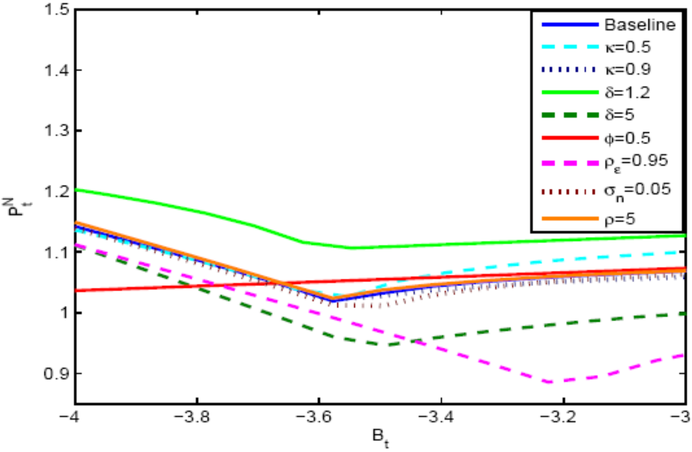
- How much would the agents pay (in percentage change in lifetime consumption) at every state and in every period to be indifferent between optimal and non-optimal policy case.
- The value of eliminating the constraint is about 0.5% consistent with the literature on sudden stop.
- The optimal policy yields about 40% of this gain.

Welfare gains by state

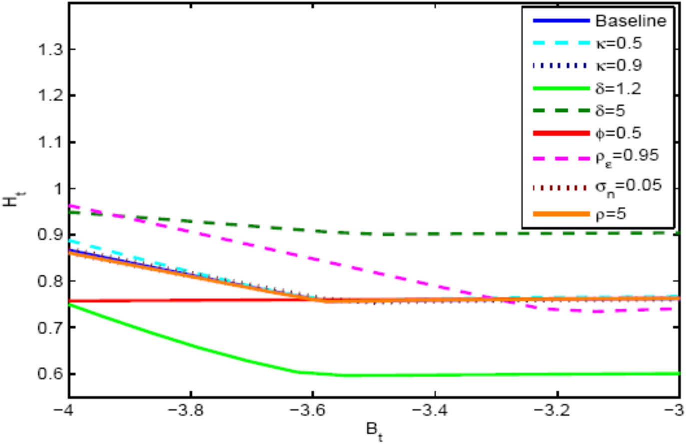


Sensitivity Analysis: Optimal tax




1.5
1.4
1.3
1.2
1.1
1
0.9
−4
−3.8
−3.6
−3.4
−3.2
−3
P^N_t
B_t
Baseline
κ=0.5
κ=0.9
δ=1.2
δ=5
φ=0.5
ρ_ε=0.95
σ_n=0.05
ρ=5

Sensitivity Analysis: Labor



Approximated solution

- We have calculated 3rd order solution around a steady state.
- We use a penalty function to approximate constraint
  - The decision rules are of similar shape near the constraint
  - The optimal is nonzero away from constraint
  - This is due to the fact that the 3rd order solution isn't flexible enough to capture the nonlinearity
  - The 3rd order solution doesn't capture average differences in consumption between model with and without policy

Extensions: Distortionary Financing and Capital

- Funding the optimal policy requires revenue
- Raising revenue is typically distortionary and costly
- Production in both sectors and tax both sectors.

Conclusions

- Optimal stabilization policy is highly non-linear
  - Optimal policy in a sudden stops subsidize non-traded goods ($\sim$ exchange rate policy).
  - No precautionary behavior of policy in tranquil time.
- Policy commitment induces less precautionary saving and lower SS probability
- Welfare gains from optimal policy are non-trivial

What is next?

- Enriching model for more serious empirical evaluation of policy rules
  - Nonlinear estimation methods needed
- Occasionally binding credit constraints apparently affect large economies:
  - Extend to a closed economy two sector case
  - Requires endogeneity of interest rate
  - Consider a housing sector
- Add Nominal Rigidities
  - Tension between nominal rigidity and financial market imperfection