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:

- 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:
  \[ b_2 \geq -\frac{1 - \phi}{\phi} (w_1 h_1 + \pi) \]
Nature of the policy problem

- Firm technology:
  \[ Y_1 = zl_1^\alpha \]

- Firm’s problem:
  \[ \max \pi = zl_1^\alpha - w_1 l_1. \]

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

- Consumer's preferences:

\[ u(c^T_1, c^N_1, c^T_2, h_1) = \gamma \log c^T_1 + (1 - \gamma) \log c^N_1 - \frac{h^d_1}{d} + \frac{1}{2} \beta \log c^T_2 \]

- Period budget constraints:

\[ w_1 h_1 + \pi + b_1 - T = (1 - \tau)p^N_1 c^N_1 + c^T_1 + b_2 \]

\[ c^T_2 = b_2 (1 + r) + Y_2, \]

- Borrowing constraint:

\[ b_2 \geq -\frac{1 - \varphi}{\varphi} (w_1 h_1 + \pi). \]
Nature of the policy problem

- Firm technology:
  \[ Y_1 = z h_1^\alpha \]

- Firm’s problem:
  \[ \max \pi = Y_1 + p_1^N z h_1^\alpha - w_1 h_1 \]

- Government budget constraint:
  \[ T = \tau p_1^N c_1^N \]

Competitive equilibrium combines agents’ FOC and market clearing conditions.
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:

\[ b_2 \geq -\frac{1 - \varphi}{\varphi} \left( Y_1 + \rho_1 z \left( l_1^N \right)^\alpha \right), \]

in which we substitute \( \frac{(1-\gamma)}{\gamma} \left( \frac{c_1^T}{c_1^N} \right) \frac{1}{(1-\tau)} = \rho_1^N \).
Nature of the policy problem

- Competitive equilibrium allocation:

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

(1)

- Social planner allocation:

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

(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.
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 $\tau$ to maximize household utility subject to the competitive equilibrium conditions, the planner will manipulate $p^N$ by varying $\tau$ so as to relax the borrowing constraint.
Ramsey planner versus social planner

The graph compares welfare in two different economic scenarios: a Decentralized Economy (dashed blue line) and a Social Planner Economy (solid green line) as a function of $B_1$. The welfare values are displayed on the y-axis, ranging from approximately 0.8 to 1.0, while $B_1$ values range from -0.8 to 0.8 on the x-axis.
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:

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

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

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

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

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

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

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)

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

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

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

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

\[ \frac{C_{Ct}^N}{C_{Ct}^T} = (1 + \tau^N_t) P_t^N, \]

- Marginal utility of tradable consumption determines multiplier

\[ \mu_t = u_{Ct} C_{Ct}^T. \]
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:

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

- Labor demand schedule:

\[ W_t = (1 - \alpha) P_t^N AK^\alpha H_t^{-\alpha}, \]
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.
Upon aggregation the borrowing constraint can be written as

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

- Shocks to tradeable output lower income (firm profits)
- Wages and nontraded output react endogenously
- Wages fall with negative traded goods shock
The shocks to the endowment of traded goods follows an AR(1) process

\[ \varepsilon_t = \rho \varepsilon_{t-1} + \sigma_n n_t, \]

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 $\tau^N = 0.0793$
To solve for the CE we solve a planner problem that satisfies the Bellman equation

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

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 $B' = G^n_B(B, \varepsilon^T)$
  - Recursive pricing functions: $P = G^P_B(B, \varepsilon^T), H = G^H_B(B, \varepsilon^T)$

- 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 $\tau$, that we suppress in the notation.
Pn with and without constraint
Wages with and without constraint

![Graph showing wages with and without constraint](image)
Labor with and without constraint
Consumption with and without constraint
The solution algorithm works as described for the CE
Optimal policy is the $\tau^N_t$ 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 $\tau^N_t$ is moved
Transfer function: \( T = G_T(B, \varepsilon^T, \tau) \)
- transfer function depends on \( \tau \);
- 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 $\tau$. 
Policy function for tax
Policy function for transfers
Wages with and without optimal policy

![Graph showing wages with and without optimal policy](image-url)
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
Sensitivity Analysis: Pn
Sensitivity Analysis: Labor

![Graph showing sensitivity analysis for labor with various parameters and their effects on $H_t$ and $B_t$.]
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 (~ 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