Revisiting Macroprudential Policy in Open-Economy Models with Financial Frictions

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June 23, 2016

• Open-economy models with collateral constraints typically display a pecuniary externality.

• The externality originates in the fact that the price of pledgable objects is endogenous to the model but exogenous to individual agents.

• The existing literature has stressed three consequences of the pecuniary externality:
— **Overborrowing** (agents borrow more than if they internalized the pecuniary externality).
— **Amplification** (business cycles are more volatile than they would be if agents internalized the pecuniary externality).
— Optimal policy is **macroprudential**.

(ex: Auernheimer and García-Saltos (2000), Benigno et al. (2013, 2014), Bianchi (2011), Jeanne and Korinek (2010), Korinek (2011), Lorenzoni (2008), Mendoza (2002, 2010) among several others)

This Paper

- draws attention to the fact that overborrowing in existing quantitative studies is small.

- shows that there is only modest amplification.

- shows that optimal capital control policy is not countercyclical and hence not macroprudential in that sense.

- **Intuition:** Optimal capital control taxes are used to avoid a binding collateral constraint. Avoiding a binding collateral constraint requires taxing borrowing in a recession when the economy is about to hit the borrowing constraint. Hence optimal capital controls taxes are high in deep recessions but not in expansions.

The Model (Bianchi, 2011)

Household problem

$$\max_{\{c_t, c_t^T, c_t^N, d_{t+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma} - 1}{1-\sigma}$$

subject to

$$c_t = \left[a {c_t^T}^{1-1/\xi} + (1-a) {c_t^N}^{1-1/\xi} \right]^{1/(1-1/\xi)}$$

$$c_t^T + p_t c_t^N + d_t = y_t^T + p_t y_t^N + \frac{d_{t+1}}{1+r_t}$$

$$d_{t+1} \leq \kappa (y_t^T + p_t y_t^N)$$

Equilibrium: $\{c_t,\ c_t^T,\ c_t^N,\ d_{t+1},\ \lambda_t,\ \mu_t,\ p_t\}$ satisfying

$$c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1+r_t} \tag{1}$$

$$c_t = \left[a {c_t^T}^{1-\frac{1}{\xi}} + (1-a){c_t^N}^{1-\frac{1}{\xi}}\right]^{\frac{1}{1-\frac{1}{\xi}}} \tag{2}$$

$$\lambda_t = a c_t^{-\sigma}\left(\frac{c_t^T}{c_t}\right)^{-1/\xi} \tag{3}$$

$$\lambda_t\left[\frac{1}{1+r_t} - \mu_t\right] = \beta \mathbb{E}_t \lambda_{t+1} \tag{4}$$

$$p_t = \frac{1-a}{a}\left(\frac{c_t^T}{c_t^N}\right)^{1/\xi} \tag{5}$$

$$c_t^N = y_t^N \tag{6}$$

$$d_{t+1} \leq \kappa\left[y_t^T + p_t y_t^N\right], \quad \mu_t\left[\kappa\left(y_t^T + p_t y_t^N\right) - d_{t+1}\right] = 0, \quad \mu_t \geq 0 \tag{7}$$

given exogenous $\{y_t^T, y_t^N, r_t\}$ and d_0.

Calibration: exactly as in Bianchi (2011)

The natural logarithms of the traded and nontraded endowments follow a bivariate AR(1), which is estimated on annual HP-filtered Argentine data spanning the period 1965 to 2007. Traded GDP: Manufacturing and primary products. Nontraded GDP: remaining components.

$$\begin{bmatrix} \ln y_t^T \\ \ln y_t^N \end{bmatrix} = \begin{bmatrix} 0.901 & -0.453 \\ 0.495 & 0.225 \end{bmatrix} \begin{bmatrix} \ln y_{t-1}^T \\ \ln y_{t-1}^N \end{bmatrix} + \epsilon_t, \tag{8}$$

where $\epsilon_t \sim N(\emptyset, \Omega_\epsilon)$, with $\Omega_\epsilon = \begin{bmatrix} 0.00219 & 0.00162 \\ 0.00162 & 0.00167 \end{bmatrix}$.

Some Unconditional Summary Statistics of the Driving Process

Statistic	$\ln y^T$	$\ln y^N$
Std. Dev.	6%	6%
Serial Corr.	0.53	0.62
Corr($\ln y_t^T, \ln y_t^N$)	0.83	

Comments:

(1) High volatility of tradable and nontradable endowment;

(2) Strong positive correlation between y_t^T and y_t^N;

Discretization of the State Space

There are 4 distinct grid points for $ln(y^T)$,

$$\begin{bmatrix} -0.1093 \\ -0.0347 \\ 0.0347 \\ 0.1093 \end{bmatrix}$$

and 16 distinct pairs (y^T, y^N).

There are 800 grid points for d_t.

The total grid has $16 \times 800 = 12,800$ points.

Summary of the Calibration

Time unit is one year.

Parameter	Value	Description
κ	$0.32(1+r)$	Parameter of collateral constraint
σ	2	Inverse of intertemporal elasticity of consumption
β	0.91	Subjective discount factor
r	0.04	Interest rate (annual)
ξ	0.83	Elasticity of substitution between tradables and nontradables
a	0.31	Weight on tradables in CES aggregator
y^N	1	Steady-state nontradable output
y^T	1	Steady-state tradable output
n_y	16	Number of grid points for $(\ln y_t^T, \ln y_t^N)$
n_d	800	Number of grid points for d_t, equally spaced
$\left[\ln \underline{y}^T, \ln \overline{y}^T\right]$	[-0.1093,-0.1093]	Range for tradable output
$\left[\ln \underline{y}^N, \ln \overline{y}^N\right]$	[-0.1328,0.1328]	Range for nontradable output
$[\underline{d}/(1+r), \overline{d}/(1+r)]$	[0.4 1.02]	Range for debt

Some comments:

Agents are quite impatient

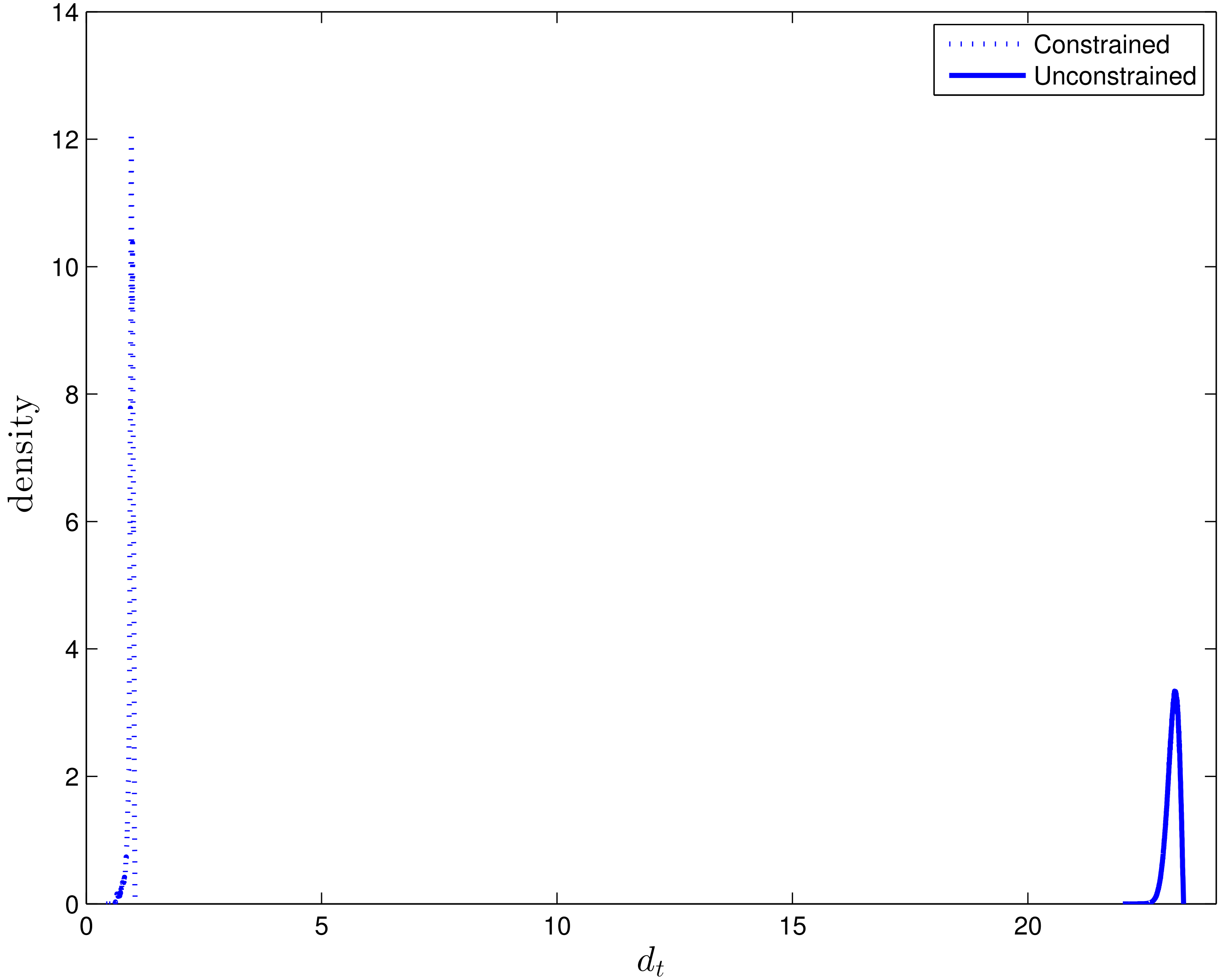
$r = 0.04$;

$\beta = 0.91$;

$\beta(1 + r) = 0.9464$

The high degree of impatience influences how far apart the debt densities are between the CC and the no CC economy. See the next figure

Debt Densities



Collateral constraint shifts mean of debt from 23.1 to 0.9.

The natural debt limit is 23.3.

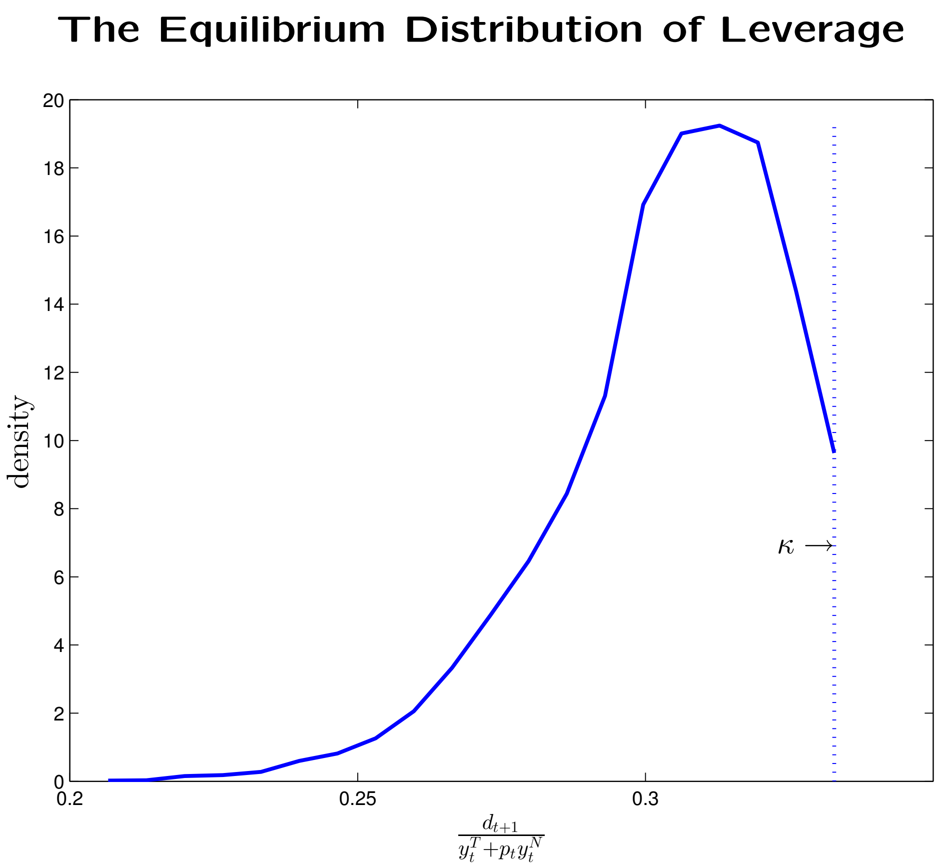
With collateral constraint:

$$E\left(\frac{d_{t+1}}{(1+r)y_t}\right) = 29.2\%$$

Without collateral constraint:

$$E\left(\frac{d_{t+1}}{(1+r)y_t}\right) = 1,993\%!!$$

How often does the constraint bind?



$$\text{leverage} = \frac{d_{t+1}}{y_t^T + p_t y_t^N}$$

- Probability of a crisis (i.e., a binding collateral constraint) is **8.5** percent.

- Or, equivalently, the collateral constraint binds every 12 years on average.

- Calibration of $\beta(1+r) = 0.9564$, picked to obtain match observed frequency of crisis. If less impatience, (say 0.9880, then frequency of crisis falls to 2.95 percent)

Observation:

Definition of crisis in Bianchi is different: binding collateral constraint and current account 1 std above mean. Empirical studies (Eichengreen et al 2006: current account surplus and 1 std increase in outflows.)

And when the constraint binds, then ...

- there is a Fisherian debt deflation
- the value of collateral collapses
- the economy deleverages
- consumption of tradables contracts sharply
- the trade balance spikes up ... and the crisis is over after just one period

The Pecuniary Externality

This model has a pecuniary externality. In equilibrium the value of collateral depends on the level of borrowing. Individual agents understand this mechanism but also understand that individually they are too small to affect the equilibrium price of nontradables. Hence they take the price of nontradables, p_t, as given.

The existing related literature has argued that the pecuniary externality induces

- **overborrowing**
- **amplification**
- **and that macroprudential policy is desirable**

What is the point of comparison? An economy in which the externality is internalized. In this case the household problem becomes

$$\max_{\{c_t, c_t^T, c_t^N, d_{t+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma} - 1}{1-\sigma}$$

subject to

$$c_t = A(c_t^T, c_t^N) \equiv \left[a {c_t^T}^{1-1/\xi} + (1-a) {c_t^N}^{1-1/\xi}\right]^{1/(1-1/\xi)}$$

$$c_t^T + p_t c_t^N + d_t = y_t^T + p_t y_t^N + \frac{d_{t+1}}{1+r_t}$$

$$d_{t+1} \leq \kappa(y_t^T + p_t y_t^N)$$

$$\boxed{p_t = \frac{A_2(c_t^T, c_t^N)}{A_1(c_t^T, c_t^N)} = \frac{1-a}{a}\left(\frac{c_t^T}{c_t^N}\right)^{\frac{1}{\xi}}}$$

One can show (but not done in these slides) that the competitive equilibrium of that economy is the same as the solution to

$$v(y^T, y^N, d) = \max_{c^T, d'} \left\{ U(A(c^T, y^N)) + \beta \mathbb{E} \left[v(y^{T\prime}, y^{N\prime}, d') \middle| y^T, y^N \right] \right\}$$

subject to

$$\begin{aligned} c^T + d &= y^T + \frac{d'}{1+r} \\ d' &\leq \kappa \left[y^T + \frac{A_2(c^T, y^N)}{A_1(c^T, y^N)} y^N \right] \end{aligned}$$

where a prime superscript denotes next-period values.

Observation: Although the constraints of this control problem may not represent a convex set in tradable consumption and debt, the fact that the Ramsey allocation is the result of a utility maximization problem, implies that its solution is generically unique.

How could one make private households internalize the externality? One way is to introduce **capital controls** and set them in a Ramsey optimal fashion.

τ_t = proportional tax on debt assumed in period t; $\tau_t > 0$ capital control tax , $\tau_t < 0$ borrowing subsidy

Financed with lump sum taxes: ℓ_t = lump-sum taxes in period t

Tax revenue: $\tau_t \frac{d_{t+1}}{1+r_t}$

Government budget constraint in period t: $\tau_t \frac{d_{t+1}}{1+r_t} = \ell_t$

The Household budget now is constraint:

$$c_t^T + p_t c_t^N + d_t = y_t^T + p_t y_t^N + (1 - \tau_t) \frac{d_{t+1}}{1 + r_t} + \ell_t$$

Interest rate on foreign borrowing was

$$(1 + r_t)$$

and now is

$$\frac{1 + r_t}{1 - \tau_t} > 1 + r_t, \quad \text{if } \tau_t > 0$$

Competitive equilibrium in the economy with capital control taxes are processes c_t^T, d_{t+1}, λ_t, μ_t, and p_t satisfying

$$c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1+r_t} \tag{9}$$

$$\lambda_t = U'(A(c_t^T, y_t^N))A_1(c_t^T, y_t^N) \tag{10}$$

$$\left(\frac{1-\tau_t}{1+r_t} - \mu_t\right)\lambda_t = \beta \mathbb{E}_t \lambda_{t+1} \tag{11}$$

$$p_t = \frac{A_2(c_t^T, y_t^N)}{A_1(c_t^T, y_t^N)} \tag{12}$$

$$d_{t+1} \leq \kappa\left[y_t^T + p_t y_t^N\right] \tag{13}$$

$$\mu_t[\kappa(y_t^T + p_t y_t^N) - d_{t+1}] = 0 \tag{14}$$

$$\mu_t \geq 0 \tag{15}$$

given $\{\tau_t\}$, $\{y_t^T\}$ and $\{r_t\}$, and d_0.

How to pick τ_t? To maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(A(c_t^T, y_t^N))$$

subject to (9)-(15).

Claim: $\{c_t^T\}$ and $\{d_{t+1}\}$ satisfy (9)-(15) if and only if they satisfy (9) and

$$d_{t+1} \leq \kappa \left[y_t^T + \frac{A_2(c_t^T, y_t^N)}{A_1(c_t^T, y_t^N)} y_t^N \right]. \tag{16}$$

Proof: Suppose $\{c_t^T\}$ and $\{d_{t+1}\}$ satisfy (9) and (16). Show that they also satisfy (9)-(15). (To show the reverse is also needed, but as it is trivial not shown here.)

Pick $\{p_t\}$ to satisfy (12). Then by (16), (13) holds.
Pick $\{\mu_t\} = 0 \ \forall t$, then (14) and (15) hold
Pick λ_t to satisfy(10).
Pick τ_t to satisfy (11) ■

[**Note** that τ_t is **not unique**. Ie, $\exists$ other picks for μ_t and τ_t that are consistent with the same allocation. This is the case in periods in which the collateral constraint binds in the Ramsey equilibrium.]

Thus, we have shown that the Ramsey Optimal Capital Control Tax Problem can be stated as:

$$\max_{\{c_t^T, d_{t+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(A(c_t^T, y_t^N))$$

subject to

$$c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1+r_t} \tag{9}$$

$$d_{t+1} \leq \kappa \left[y_t^T + \frac{A_2(c_t^T, y_t^N)}{A_1(c_t^T, y_t^N)} y_t^N \right] \tag{16}$$

which says that with a capital control tax instrument the Ramsey planner fully internalizes the pecuniary externality. And that the solution to the Ramsey problem in an economy with a capital control tax is the same as the solution to a competitive economy in which individual households internalize the pecuniary externality.

Therefore, like the related literature, we pick the Ramsey optimal allocation under capital control taxes as the point of comparison (that is, the case when the pecuniary externality is internalized) and we will compare the allocation in the unregulated economy to that of the Ramsey economy.

To which extend the unregulated economy displays:

- **overborrowing**

- **amplification**

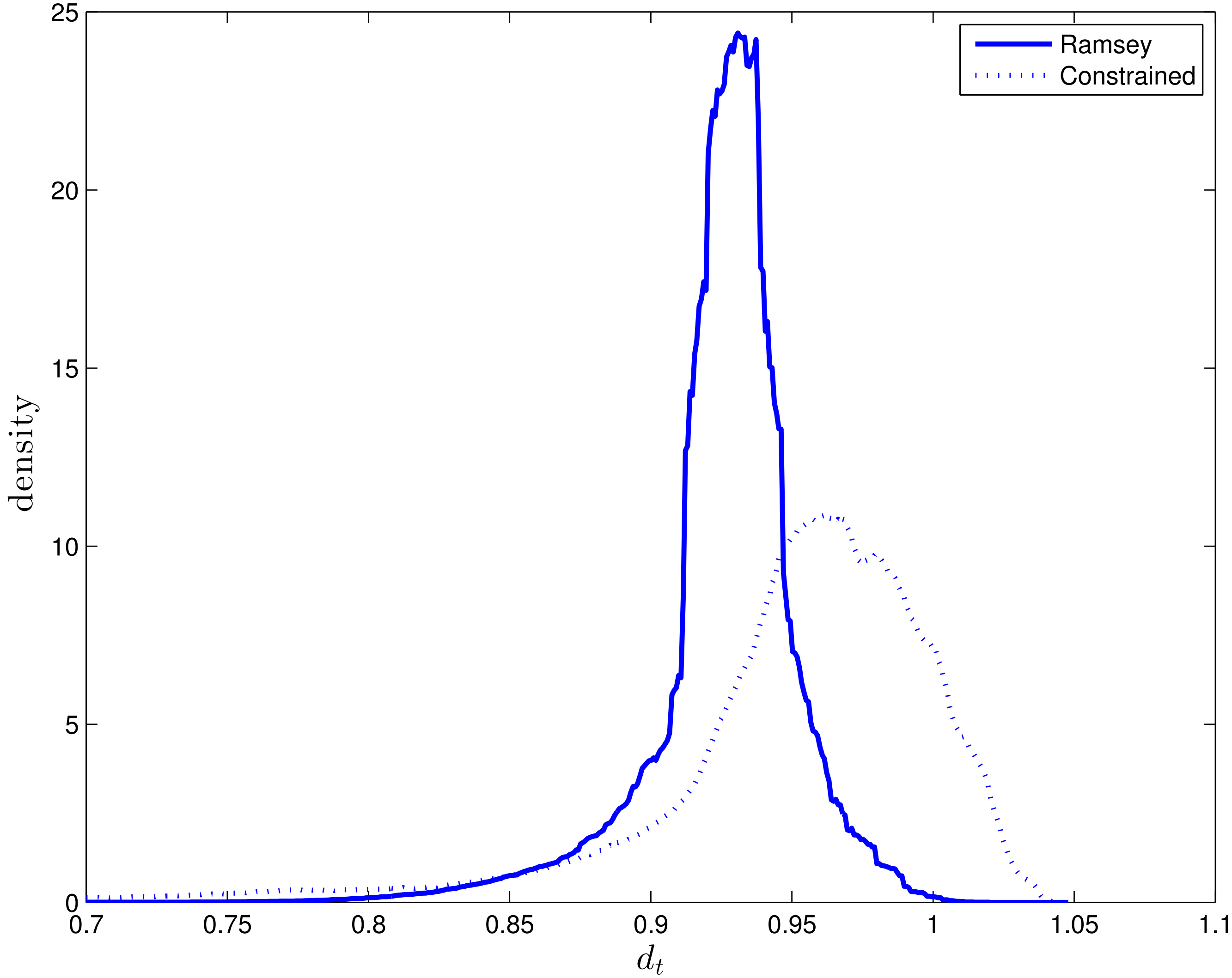
- **and whether the optimal capital control policy is indeed macroprudential**

Overborrowing

Definition: the unregulated economy is said to **overborrow** if its average level of external debt is **higher** than that of the Ramsey economy.

Comment: To our knowledge there does not exist an analytical proof that economies with a flow collateral constraint of the type analyzed here **must** display overborrowing. Overborrowing seems to be calibration dependent. [We have shown elsewhere (Schmitt-Grohé and Uribe, 2016) that economies of the type studied here may display underborrowing. Our analytical proof was for an economy without uncertainty and with $\beta(1+r) = 1$. There we also show underborrowing in a calibrated stochastic economy with $\beta(1+r) < 1$.]

Modest Amount of Overborrowing under the Bianchi Calibration



Under Ramsey Optimal Capital Controls:

$$E\left(\frac{d_{t+1}}{(1+r)y_t}\right) = 28.5\%$$

With collateral constraint:

$$E\left(\frac{d_{t+1}}{(1+r)y_t}\right) = 29.2\%$$

$\Rightarrow$ Pecuniary externality leads to overborrowing of 0.7 percentage points of output

(These results are our replication of those reported in Bianchi. He reports, 28.6 and 29.2)

Amplification

- of regular business cycles

— Mendoza (2002): No.
— Bianchi (2011): Somewhat.

- of boom-bust episodes

Amplification of Regular Business Cycles

	Std. Dev.		Serial Corr.		Corr. w. Output	
Indicator	CC	R	CC	R	CC	R
Traded Endowment, y_t^T	0.06	0.06	0.53	0.53	0.72	0.95
Nontraded Endowment, y_t^N	0.06	0.06	0.62	0.62	0.50	0.71
Value, $p_t y_t^N$	0.12	0.06	$\boxed{-0.07}$	0.35	0.99	0.99
Output, $y_t^T + p_t y_t^N$	0.09	0.06	$\boxed{0.05}$	0.43	1.00	1.00
Consumption, c_t	$\boxed{0.06}$	$\boxed{0.05}$	0.41	0.60	0.85	0.86
Trade Balance, tb_t	0.06	0.02	-0.25	-0.03	-0.71	-0.02
Current Account, ca_t	0.06	0.02	-0.25	-0.03	-0.72	-0.01

Note. CC=unregulated economy; R=Ramsey economy. Table reports unconditional second moments.

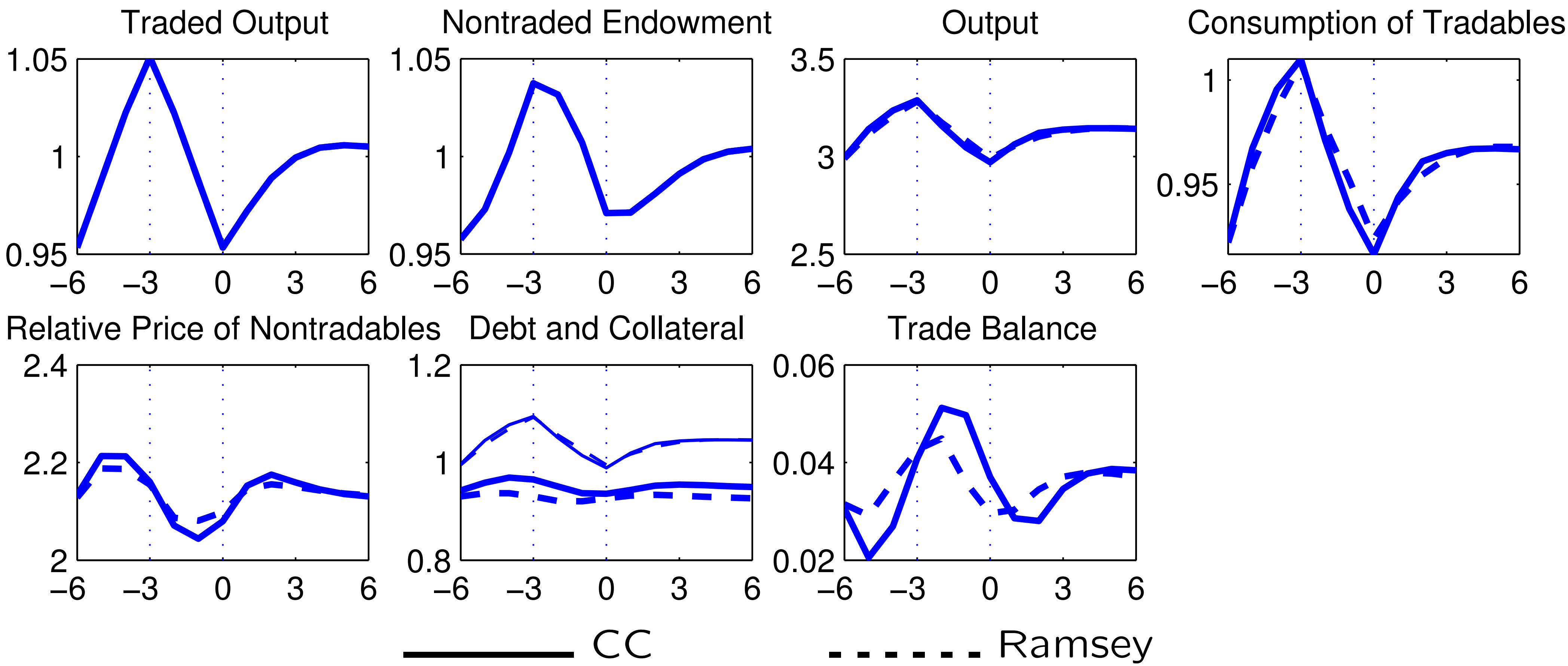
Consumption is more volatile in the CC economy and so is output.

Bianchi reports for consumption 0.059 and 0.053, respectively.

Comment:

In the CC economy: total output and output in the nontraded sector are both predicted to be serially uncorrelated.

No Amplification of Boom-Bust Episodes



Definition of boom-bust episode: $y^T_{-6} < 1$ and $y^T_{-3} > 1$ and $y^T_0 < 1$; given grid this implies that during a typical boom bust episode output falls from 5% above mean to 5% below mean over 3 years. Frequency, 12.3%

Is Optimal Capital Control Policy Macroprudential?

Properties of the optimal capital control tax

• Capital Control Taxes are positive on average

$$\text{Mean}(\tau_t) = 0.042; \qquad \text{Median}(\tau_t) = 0.0258$$

• Effective interest rate twice as high

$$\mathbb{E}\frac{1+r}{1-\tau_t} = 1.088$$

• yet, recall that debt is not much smaller in the Ramsey economy, with a mean of 0.926 (or 28.5%) as opposed to 0.9483 (or 29.2%)

So what is the role of Ramsey optimal capital control taxes? They make the economy stay clear of a binding constraint:

• Frequency of binding constraint in Ramsey 3.9% (or every 26 years and in CC economy 8.5% (or every 12 years).

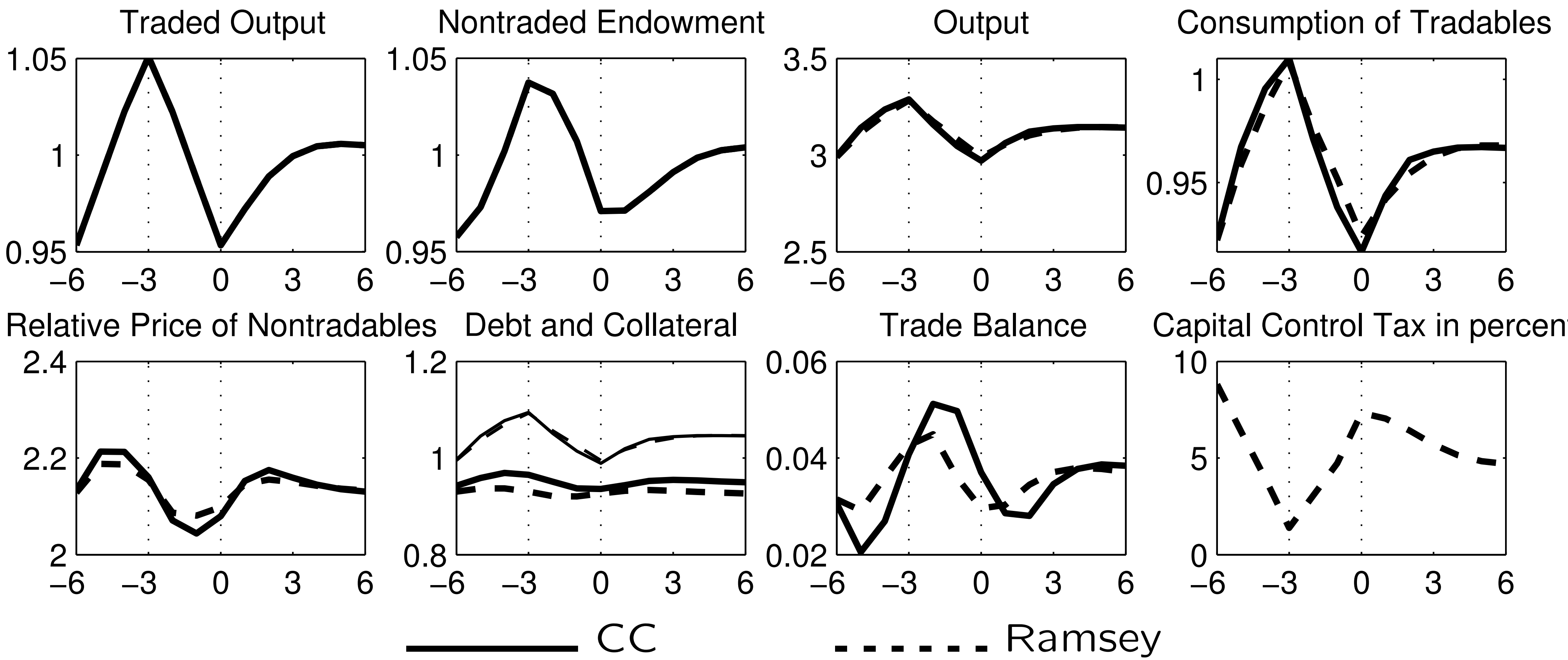
• Standard Deviation of optimal capital control tax is high, 4.2%.

Are Optimal Capital Control Taxes Macroprudential?

By which definition?

Let's look at the behavior of the optimal capital control tax over a boom-bust cycle

Optimal Capital Controls During Boom-Bust Episodes



Tax is lowered during boom and raised during bust, this is, it is not macroprudential in that sense.

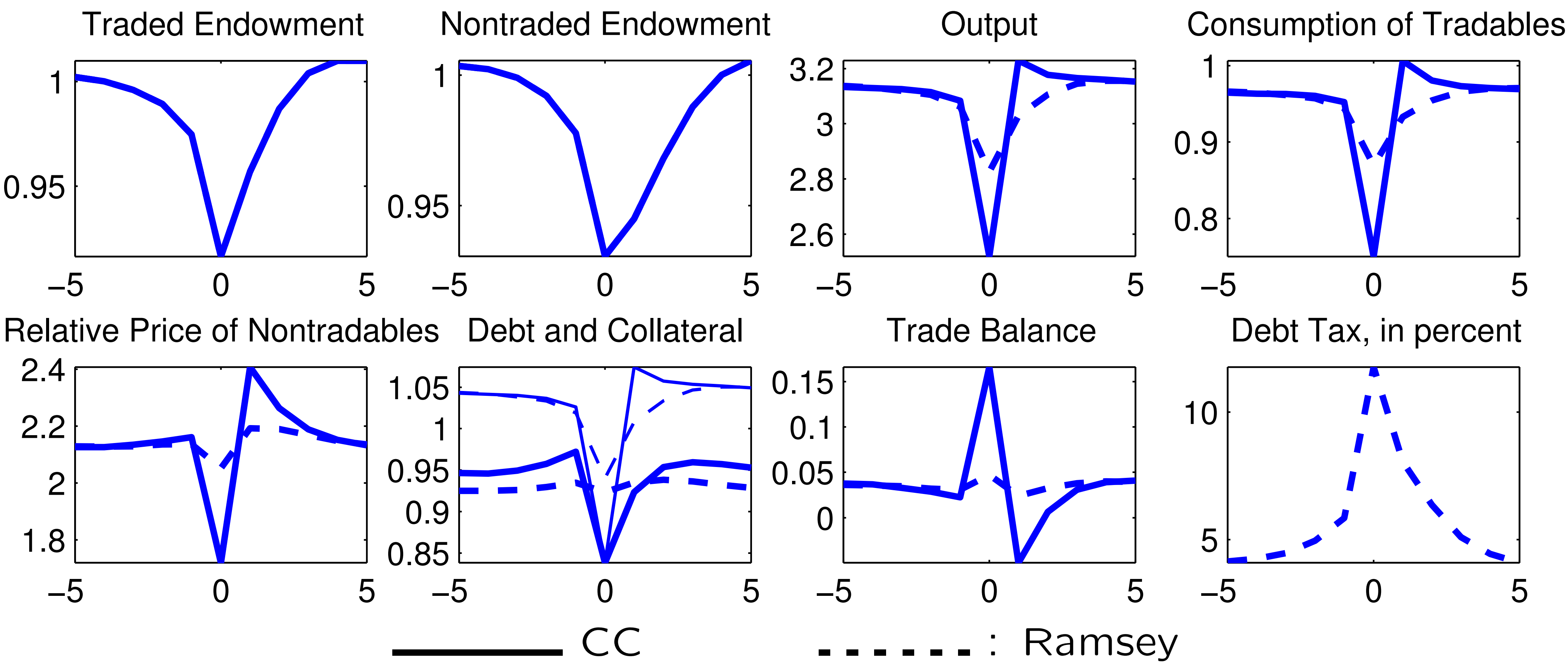
What about unconditionally?

$\text{corr}(\tau_t, \ln y_t) =$ **-0.84**,

$\text{corr}(\tau_t, \ln c_t^T) =$ **-0.88**

$\Rightarrow$ optimal capital controls are **not** macroprudential in that sense either.

Procyclical Optimal Capital Controls During Typical Financial Crises



The dynamics are conditional on a financial crisis (i.e., a binding collateral constraint) in the CC economy.

CC: 85,242 years with a binding constraint in 1 million years. Of those Ramsey economy also has a binding collateral constraint in 30,517 episodes, or 36% of the crisis in the CC economy are also a crisis in the Ramsey economy.

Ramsey planner **raises** capital control taxes in run up to crisis and lowers them once crisis is over. ⇒ optimal capital controls are **not** countercyclical and thus not macroprudential in that sense.

Conclusion

In quantitative models with a pecuniary externality due to a flow collateral constraint:

- only modest overborrowing
- no amplification of boom bust cycles
- Ramsey optimal capital control taxes are raised during recessions and lowered during booms and not macroprudential in that sense.

EXTRAS

Alternative Calibration: Traded Endowment and Interst Rate Shocks:

Calibration from Schmitt-Grohé and Uribe (2016)

Annualize the quarterly process estimated in Schmitt-Grohé and Uribe (2016). There we use Argentine quarterly data over the period 1983:Q1 to 2001:Q4. The resulting annual process is

$$\begin{bmatrix} \ln y_t^T \\ \ln \frac{1+r_t}{1+r} \end{bmatrix} = A \begin{bmatrix} \ln y_{t-1}^T \\ \ln \frac{1+r_{t-1}}{1+r} \end{bmatrix} + \epsilon_t, \tag{17}$$

where $\epsilon_t \sim N(\emptyset, \Sigma_\epsilon)$, with

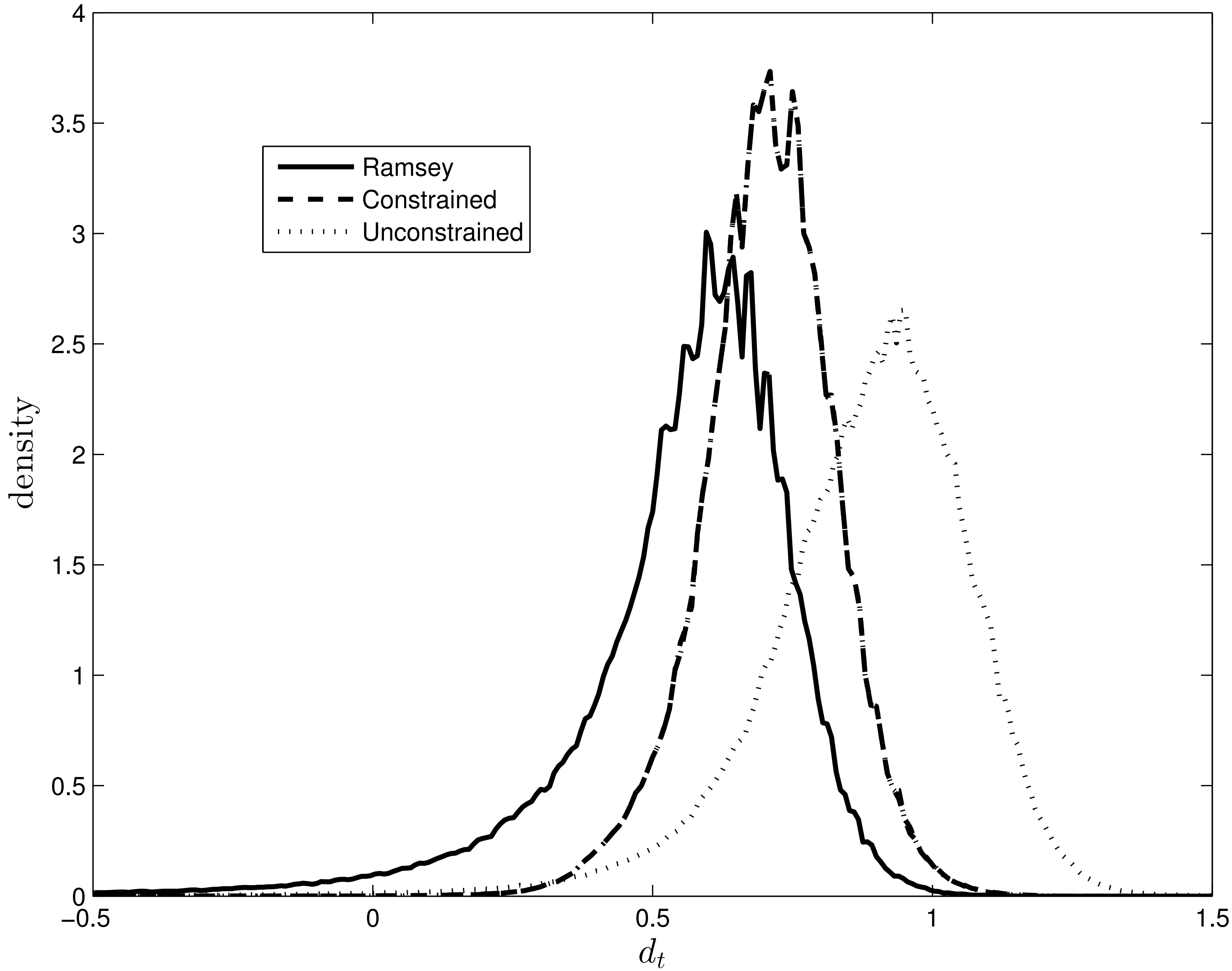
$$A = \begin{bmatrix} 0.48 & -0.77 \\ -0.08 & 0.68 \end{bmatrix}; \qquad \Sigma_\epsilon = \begin{bmatrix} 0.0031 & -0.0015 \\ -0.0015 & 0.0014 \end{bmatrix}; \qquad r = 0.135.$$

$\kappa = 0.3$, $\beta = 0.9635^4$, $\sigma = 1/\xi = 2$, $a = 0.26$, and $y^N = 1$.

Calibration from Schmitt-Grohé and Uribe (2016)

Parameter	Value	Description
κ	0.3	Parameter of collateral constraint
σ	2	Inverse of intertemporal elasticity of consumption
β	0.9635	Quarterly subjective discount factor
r	0.0316	Steady state quarterly country interest rate
ξ	0.5	Elasticity of substitution between tradables and nontradables
a	0.26	Weight on tradables in CES aggregator
y^N	1	Nontradable output
y^T	1	Steady-state tradable output
n_{y^T}	21	Number of grid points for $\ln y_t^T$, equally spaced
n_r	11	Number of grid points for $\ln[(1+r_t)/(1+r)]$, equally spaced
n_d	501	Number of grid points for d_t, equally spaced
$\left[\ln \underline{y}^T, \ln \overline{y}^T\right]$	[-0.3706,0.3706]	Range for tradable output
$\left[\ln\left(\frac{1+\underline{r}}{1+r}\right), \ln\left(\frac{1+\overline{r}}{1+r}\right)\right]$	[-0.2040,0.2040]	Range for interest rate
$[\underline{d}, \overline{d}]$	[-2,2]	Range for debt

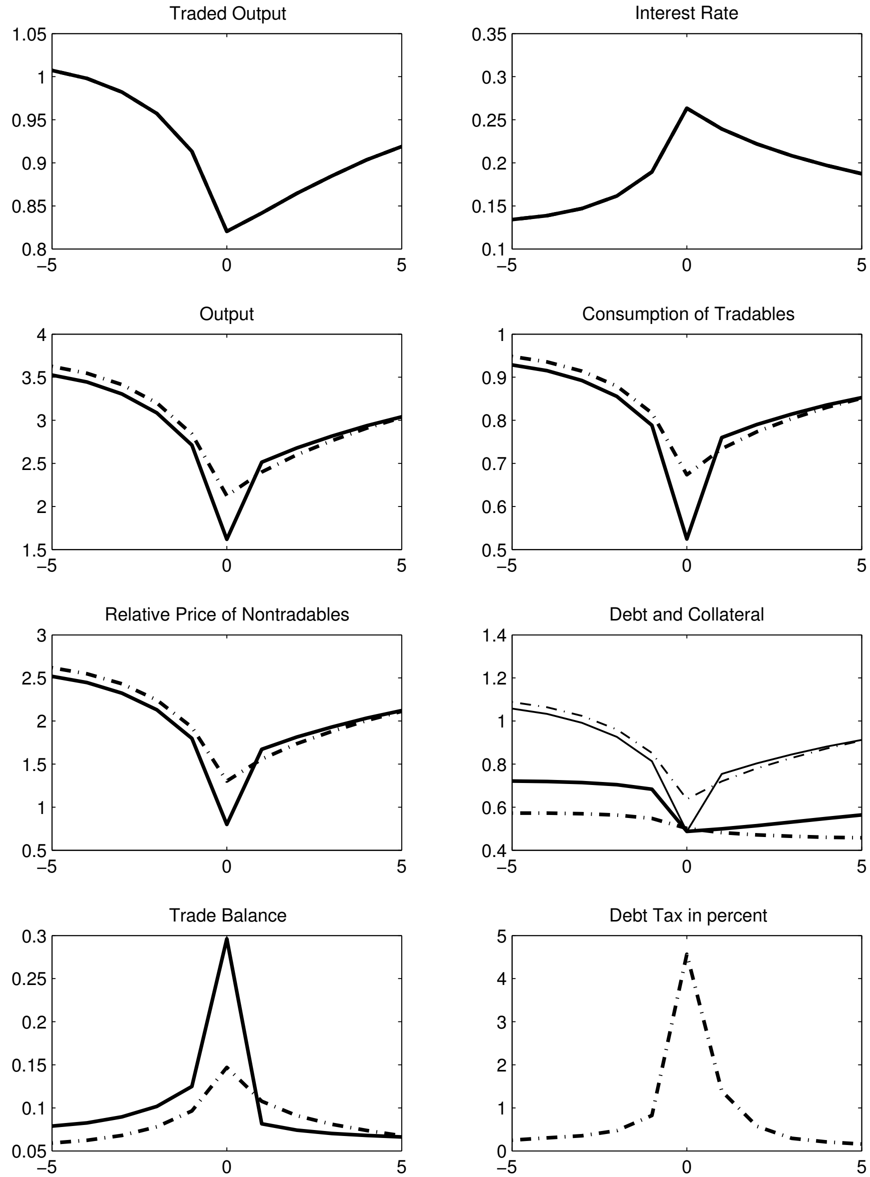
External Debt Densities With And Without Collateral Constraints



The mean debt-to-output ratio is 27.6 percent in the economy without the collateral constraint and 20.8 percent in the economy with the constraint.

Under Ramsey optimal debt taxes the mean debt to output ratio is 15.6. It follows that the unregulated economy displays overborrowing of 5.2 percent of output.

Optimal Capital Control Policy Around Financial Crises: Endowment and Interest Rate Shocks



CC Ramsey

Models with a Pecuniary Externality Due to the Combination of Downward Nominal Wage Rigidity and a Currency Peg (Schmitt-Grohe and Uribe, JPE 2016)

These results stand in contrast to those obtained when the externality arises from the combination of downward nominal wage rigidity and a fixed exchange rate regime. As shown in Schmitt-Grohé and Uribe (JPE, 2016), in that case optimal capital control policy is countercycical, i.e., it discourages capital inflows during booms and encourages them during downturns.

Boom-Bust Cycles
With and Without Optimal Capital Controls