Discussion of Hills, Nakata and Schmidt

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Inflation: Drivers and Dynamics
Federal Reserve Bank of Cleveland

What is RSS and Why / When Should We Care

- Nonlinear models typically "live" away from their steady state.
- A local approximation around the steady state becomes less accurate.
- Iterating between finding the "right" point around which to approximate and the approximation itself computationally intensive and convergence not guaranteed.
- Coeurdacier, Rey and Winant (2012) develop risky steady state (RSS) where they show one can simultaneously solve for the point and the approximation. This is useful.
- Does RSS have any use outside local approximations?
- I will argue "no".
- I will demonstrate that **the mean of the ergodic distribution** (sometimes called the stochastic steady state) is the right concept to use (to understand where the model lives) and RSS can be misleading.

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Stochastic Growth Model with Irreversible Investment

$$\max_{\{c_t,k_{t+1}\}} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

$$c_t + x_t = y_t$$

$$y_t = exp(z_t)f(k_t)$$

$$x_t = k_{t+1} - (1-\delta)k_t$$

$$z_{t+1} = \rho z_t + \epsilon_{t+1} \text{ with } \epsilon_{t+1} \sim N(0, \sigma_\epsilon^2)$$

$$x_t \geq 0$$

- Solve globally using Parametrized Expectations Approach (PEA)
- $\sigma_\epsilon = 0.01$ and $\sigma = 1$ [risk aversion of $u(.)$]
- Normalize steady state of capital to 1.

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Definition of Concepts

Equilibrium decision rules: $c(k, z; \sigma_\epsilon)$ and $k'(k, z; \sigma_\epsilon)$.

- **Steady State**: (c^{SS}, k^{SS}) such that

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\begin{aligned}
c^{SS} &= c(k^{SS}, 0; 0) \\
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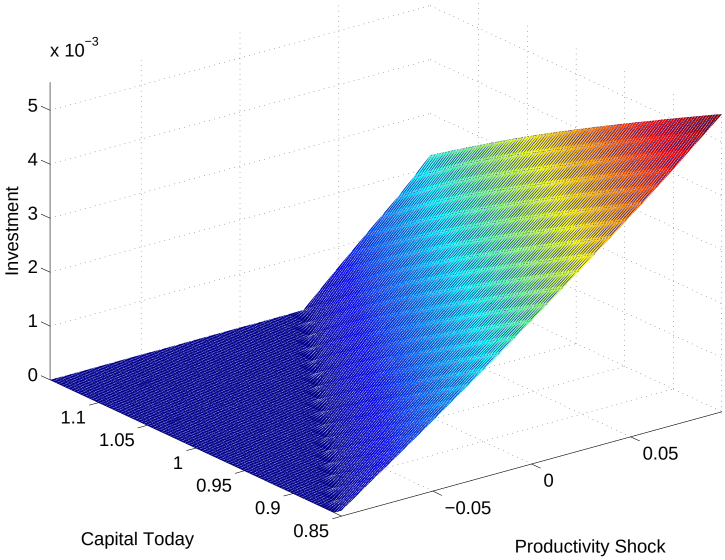
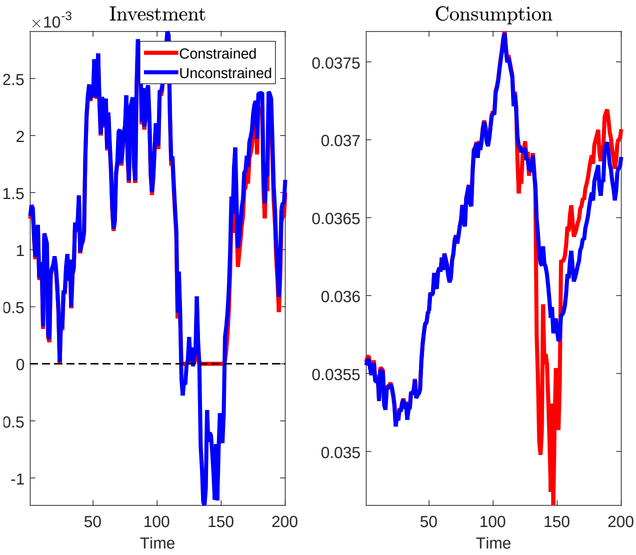
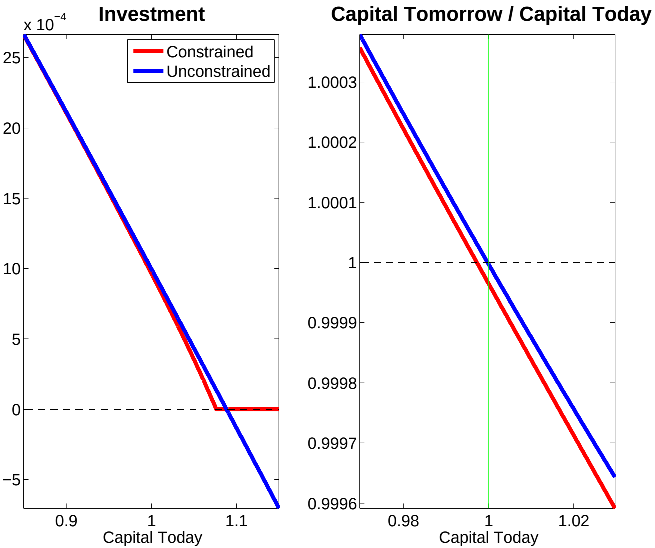
Investment Decision Rule



Investment and Consumption



Benchmark – Cross-Section When $z = 0$



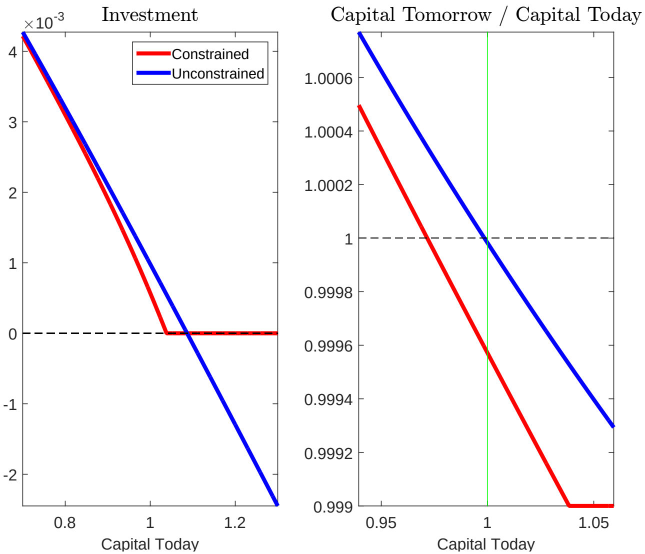
Risky steady state: Unconstrained: 0.9998, Constrained: 0.9972

RSS vs. $\mathbb{E}(k)$ in the Irreversible Investment Model

	Constraint	Benchmark
$\mathbb{P}(x = 0)$		14%
k^{RSS}	No	0.9998
k^{RSS}	Yes	0.9972
$\mathbb{E}(k)$	No	1.0003
$\mathbb{E}(k)$	Yes	1.0021

Remember that $k^{SS} = 1$.

High σ_ϵ – Cross-Section When $z = 0$



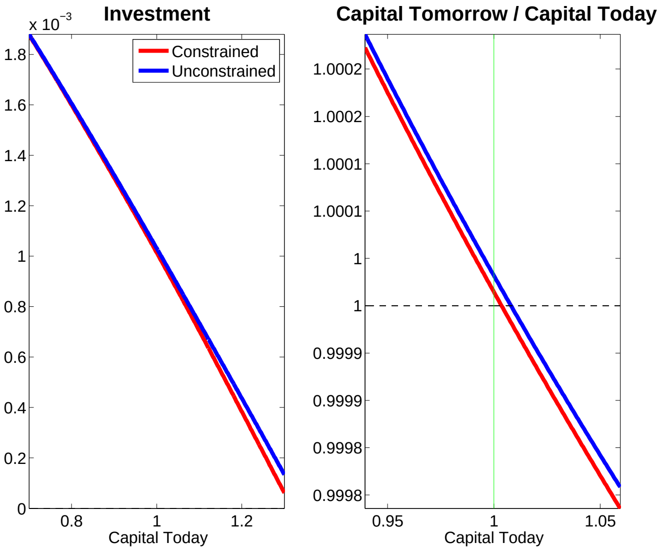
Risky steady state: Unconstrained: 0.9986, Constrained: 0.9716

RSS vs. $\mathbb{E}(k)$ in the Irreversible Investment Model

	Constraint	**Benchmark**	**High σ_ϵ**
$\mathbb{P}(x=0)$		14%	65%
k^{RSS}	No	0.9998	0.9986
k^{RSS}	Yes	0.9972	0.9716
$\mathbb{E}(k)$	No	1.0003	1.0060
$\mathbb{E}(k)$	Yes	1.0021	1.0302

Remember that $k^{SS} = 1$.

High σ – Cross-Section When $z = 0$



Risky steady state: Unconstrained: 1.0081, Constrained: 1.0036

RSS vs. $\mathbb{E}(k)$ in the Irreversible Investment Model

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$\mathbb{P}(x=0)$		14%	65%	14%
k^{RSS}	No	0.9998	0.9986	1.0081
k^{RSS}	Yes	0.9972	0.9716	1.0036
$\mathbb{E}(k)$	No	1.0003	1.0060	1.0101
$\mathbb{E}(k)$	Yes	1.0021	1.0302	1.0208

Remember that $k^{SS}=1$.

Back to the ZLB / ELB Model

- Paper argues that the presence of the ELB causes inflation to be below steady state (also the central bank's target) and this may be why the Fed may be undershooting its target for years.
    - If the interest cannot go down further to a desired level, inflation will remain lower than it otherwise would be.
    - Relies on the idea that the probability the public places on ELB has increased once we hit it in 2009. Seems reasonable.
- I do not think we need the RSS to make the case.
- As long as you are solving the model globally, the same argument can be made by $\mathbb{E}(\pi)$ in a more reliable way.
- Use the models in Aruoba, Cuba-Borda and Schorfheide (2012-2016) to demonstrate this.

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Aruoba, Cuba-Borda and Schorfheide (2012-2016)

- New Keynesian model with sticky prices (no internal habits or sticky wages)
- A sunspot variable moves the economy between a “targeted inflation regime” and a “deflation” regime. (Benhabib et al., 2001)
- Structural shocks: technology, discount factor, government spending, monetary policy
- Estimated using pre-ZLB data for U.S. and Japan.
- Solve **targeted-inflation equilibrium** or **sunspot equilibrium** using a global approximation (and a full bag of tricks).
- Extract shocks, including the sunspot variable to explain the ZLB episode.
  - U.S. likely stayed in the targeted-inflation regime
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RSS vs. $\mathbb{E}(\pi)$ in the NK Model with ZLB

	Linear	Targeted-Inflation Eq'm		Sunspot Equilibrium	
		Benchmark	High σ_d	Benchmark	Low p_{11}
$\mathbb{E}(\pi \mid s=1)$	2.45	2.40	2.63	2.36	1.79
π^{RSS}	2.46	2.37	2.00	2.28	1.81
$\mathbb{P}(ZLB)$	1%	1%	13%	0.01%	0.33%

1. ZLB is an unlikely event in this estimated model.
2. It causes $\mathbb{E}(\pi)$ to be below π^*, but not by much.
3. With higher σ_d, $\mathbb{P}(ZLB)$ is higher but as is $\mathbb{E}(\pi)$ and $var(\pi)$.
4. Aside: Empirical frequency of ZLB of 36% in the data? (Why start counting in 1995?)
5. Possibility of sunspots is a bigger deal, especially if we now fear of "being Japan".
6. **Important:** All this assumes public takes ZLB in to account but Fed does not! Fed can set (higher) π^* such that $\mathbb{E}(\pi)$ hits the target. (divorce the "target" from π^*)

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		Benchmark	High σ_d	Benchmark	Low p_{11}
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π^{RSS}	2.46	2.37	2.00	2.28	1.81
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