Small Open Economy Model With Sterilized Intervention

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August 22, 2021

Outline

- Do Central Banks have one tool, or two?
  - Failure of UIP introduces the possibility of a second tool.
- What is the impact of sterilized intervention?
  - In standard, simple models sterilized intervention irrelevant. Why?
  - What plausible model changes could make sterilized intervention relevant?
- Here, consider behavior of the economy with and without sterilized intervention policy.
  - How does sterilized intervention affect the transmission of a rise in the foreign interest rate?
  - Does sterilized intervention provide a tool to drive out of a recession when the interest rate cannot be used?

Uncovered Interest Parity (UIP) and MUIP

- r_t and r_t^*: domestic and foreign net nominal rates of interest, respectively:

$$r_t = r_t^* + E_t \log S_{t+1} - \log S_t, \text{(UIP)}$$

  where S_t is exchange rate (higher - depreciation).
  - UIP, equilibrium condition imposed by private markets in standard models.
  - Gov't has only one tool, cannot independently move $\{r_t\}$ and $\{S_t\}$.
  - UIP is like a set of handcuffs on government policy.
- But, there is a lot of evidence against UIP, and in favor of MUIP

$$r_t = \Lambda_t + r_t^* + E_t \log S_{t+1} - \log S_t, \text{(MUIP)}$$

  where Λ_t is an unobserved variable referred to as the 'risk premium'.
  - Evidence suggests that the Λ_t comoves with $r_t - r_t^*$ and in emerging markets, $\Lambda_t > 0$ on average.
- If Λ_t is partly a function of CB policy, then CB has 'two tools': handcuffs off.

Government Sterilized Intervention

- Introduce government assets: F_t^* ~ government dollar assets and B_t ~ government local currency debt.
  - Both are one-period financial instruments.
- Government acquisition of financial assets, $F_t^* - F_{t-1}^*$, is *sterilized*:

$$S_t \left(F_t^* - F_{t-1}^*\right) = B_t - B_{t-1}.$$

  - To see the full government budget constraint, see section 5.3 in document.
  - Any profits/losses experienced by the government because of exchange rate or interest rate fluctuations are financed by a lump-sum tax.
  - (Analysis closely follows Castillo and Medina (2021) and Lama and Medina (2020).)

Sterilized Intervention Strategy

- Government intervention policy:

$$\frac{F_t^*}{\overline{F}_t^*} = \left(\frac{F_{t-1}^*}{\overline{F}_{t-1}^*}\right)^{\rho_{fx}} \left(\frac{R_{d,t}^* - 1}{R_d^* - 1}\right)^{-\theta_{R^*}}, \rho_{fx} = 0.5, \theta_{R^*} = 0.4$$

where $\overline{F}_t^*$ is target level of dollar reserves ('Greenspan-Guidotti rule'):

$$\begin{aligned}\overline{F}_t^* &= \left(\upsilon_t^{cb}\left[\text{gross dollar liabilities}_t\right]\right)^{1-\vartheta}\left(\overline{F}_{t-1}^*\right)^{\vartheta} \\ &= \left(\upsilon_t^{cb}\right)^{1-\vartheta}\left(\overbrace{R_{d,t-1}^* B_{t-1}^{\$}}^{\text{dollar liabilities of banks}} + \overbrace{P_t^m\left(I_{m,t} + C_{m,t}\right)/S_t}^{\text{imports in units of dollars}}\right)^{1-\vartheta}\left(\overline{F}_{t-1}^*\right)^{\vartheta}\end{aligned}$$

- We choose steady state value of υ_t^{cb}, υ^{cb}, so that in non-stochastic steady state,

$$\frac{\overline{F}_t^*}{4GDP_t} = 0.3.$$

Clearing in Financial Markets and Ricardian Irrelevance

- Local currency markets:

$$\overbrace{D_t}^{\text{household local currency assets}} = \overbrace{B_t^{peso}}^{\text{borrowing by banks}} + \overbrace{B_t}^{\text{gov't borrowing}}$$

- Dollar markets:

$$\overbrace{D_t^*}^{\text{dollar assets of households}} + \overbrace{F_t^*}^{\text{dollar assets of gov't}} + \overbrace{F_t^o}^{\text{dollar assets of foreigners}} = \overbrace{B_t^{\$}}^{\text{borrowing by banks}}$$

- Absent suitable frictions, Ricardian irrelevance result:

$$\frac{d\left(F_t^* + D_t^*\right)}{dF_t^*} = 0.$$

- We avoid irrelevance result because we put Θ_t directly into the household utility function.

Household Preferences

- Representative household preferences:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ u\left(C_t\right) - \exp\left(\tau_t\right) \frac{l_t^{1+\varphi}}{1+\varphi} + h_t\left(\Theta_t\right) \right\}$$

where

$$\Theta_t \equiv \frac{S_t D_t^*}{S_t D_t^* + D_t}, \quad h_t\left(\Theta_t\right) = -\frac{\gamma}{2} \left(\Theta_t - \overbrace{\qquad\qquad}^{\text{target deposit dollarization}} \Upsilon_t \right)^2 .$$

- Household has a specific preference about it's own holdings of dollars.

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Experiments

- We now consider 3 experiments in the model:
  - Exp#1: An exogenous sterilized shock to F_t^* for different values of γ and ϕ.
  - Exp#2: How the sterilized intervention rule affects the transmission of a positive shock to the foreign interest rate.
  - Exp#3: How well a sterilize intervention works when the interest rate is 'stuck' because the 'effective lower bound' (ELB) on the interest rate is binding.

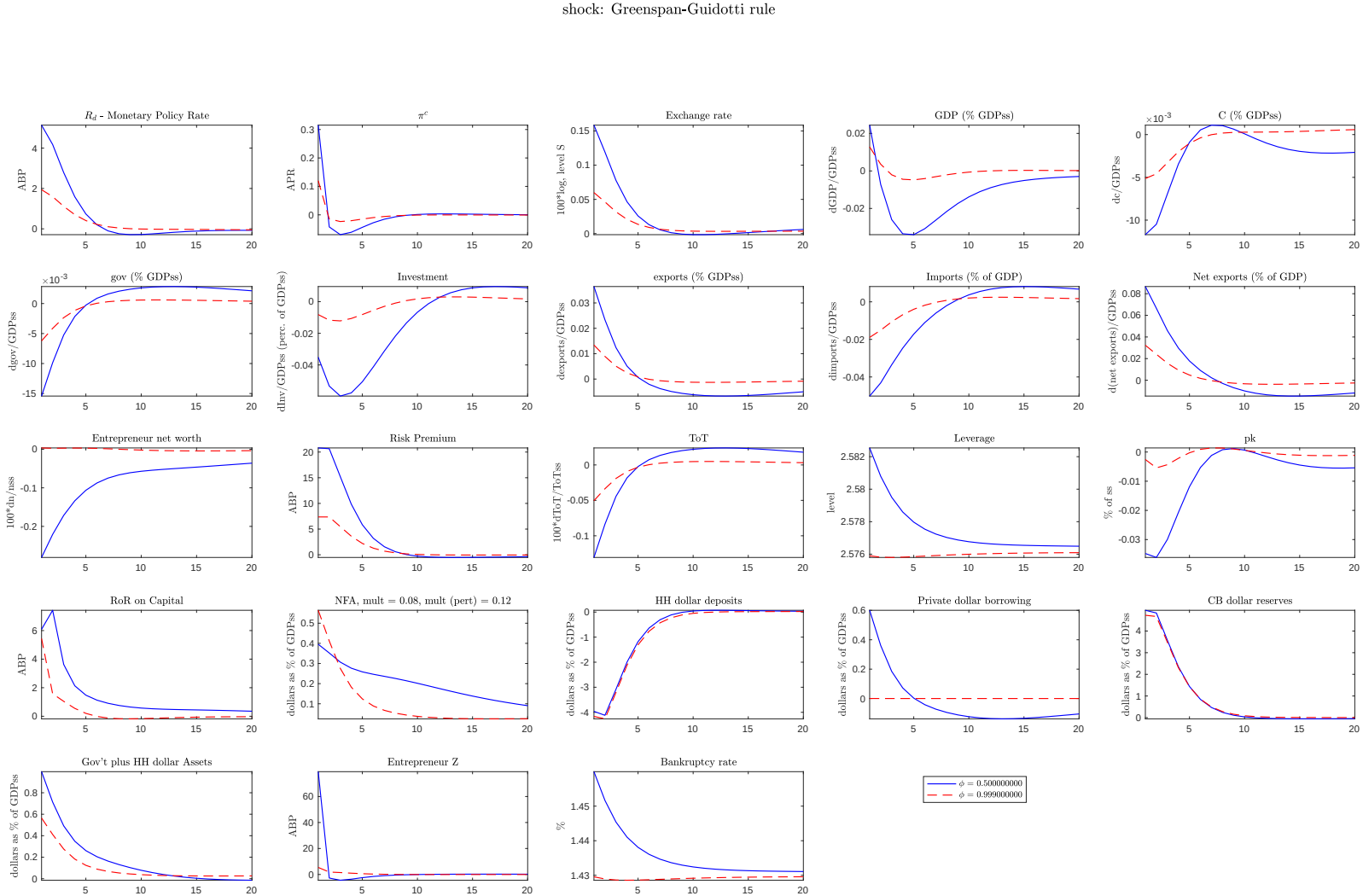
Exp#1: Effects of a Jump in υ_t^{cb} that Raises F_t^* by 5% of GDP

- Consider first, $\phi = 0.5$ (solid blue line)
- $D_t^* + F_t^*$ up by 1% of GDP (fall in D_t^* does not fully offset rise in F_t^*)
  - this rise in the demand for dollar assets leads to a depreciation (0.2%).
- Consequences of depreciation for entrepreneur:
  - Interest payments on debt, Z, jump (80ABS)
    - ⋆ two reasons: (i) jump in local currency debt service costs and (ii) jump in bankruptcies, putting yet more costs on banks.
  - Entrepreneurial net worth drops (0.3%), accelerated by a drop in the price of capital, P^k, as they buy less of it.
  - Mean reversion implies capital gains in the future, so R^k is high, allowing entrepreneurs to borrow more $\rightarrow$ $B^{\$}$ rises and leverage rises.
  - Still, investment falls.
- Consumption drops (high R_d); net exports up (expenditure switching), but not enough.

Exp#1: Experiment: υ_t^{cb} Jumps and Raises F_t^* by 5% of GDP

- Now, consider $\phi = 0$ (dashed line): essentially no balance sheet effect from depreciation.
  - Impact on investment is modest.
- All effects much smaller, though exchange rate depreciation by sterilized intervention does not boost output beyond the first period.

Exp#1: υ_t^{cb} Jumps and Raises F_t^* by 5% of GDP



Exp#1: Understanding the Previous Results

- The non-neutrality of $dF_t^* > 0$ requires that it not be offset by $dD_t^* < 0$, as would happen under the irrelevance result ($\gamma = 0$).
- With γ large D_t^* would fall by less in the wake of $dF_t^* > 0$ (we used $\gamma = 2$).
- Bayoumi, Gagnon, and Saborowski (2014) argue that, according to the data, $d\left(\text{current account}_t\right)/dF_t^* \sim .24 - .42$.
  - Recall,

$$\overbrace{\frac{P_t}{S_t}X_t - P_t^f\left(I_{m,t} + C_{m,t}\right) + r_{t-1}^*\left(F_{t-1}^* + D_{t-1}^* - B_{t-1}^{\$}\right)}^{\text{current account}}$$
$$= \overbrace{F_t^* + D_t^* - B_t^{\$} - \left(F_{t-1}^* + D_{t-1}^* - B_{t-1}^{\$}\right)}^{\text{change in net dollar assets}}$$

  - In the model with $\phi = 0.5$,$d\left(\text{current account}_t\right)/dF_t^* = 0.08$, in the period of the shock.
  - With $\gamma = 15$ and $\phi = 0.5$, $d\left(\text{current account}_t\right)/dF_t^* = 0.44$, more in line with Bayoumi et. al.

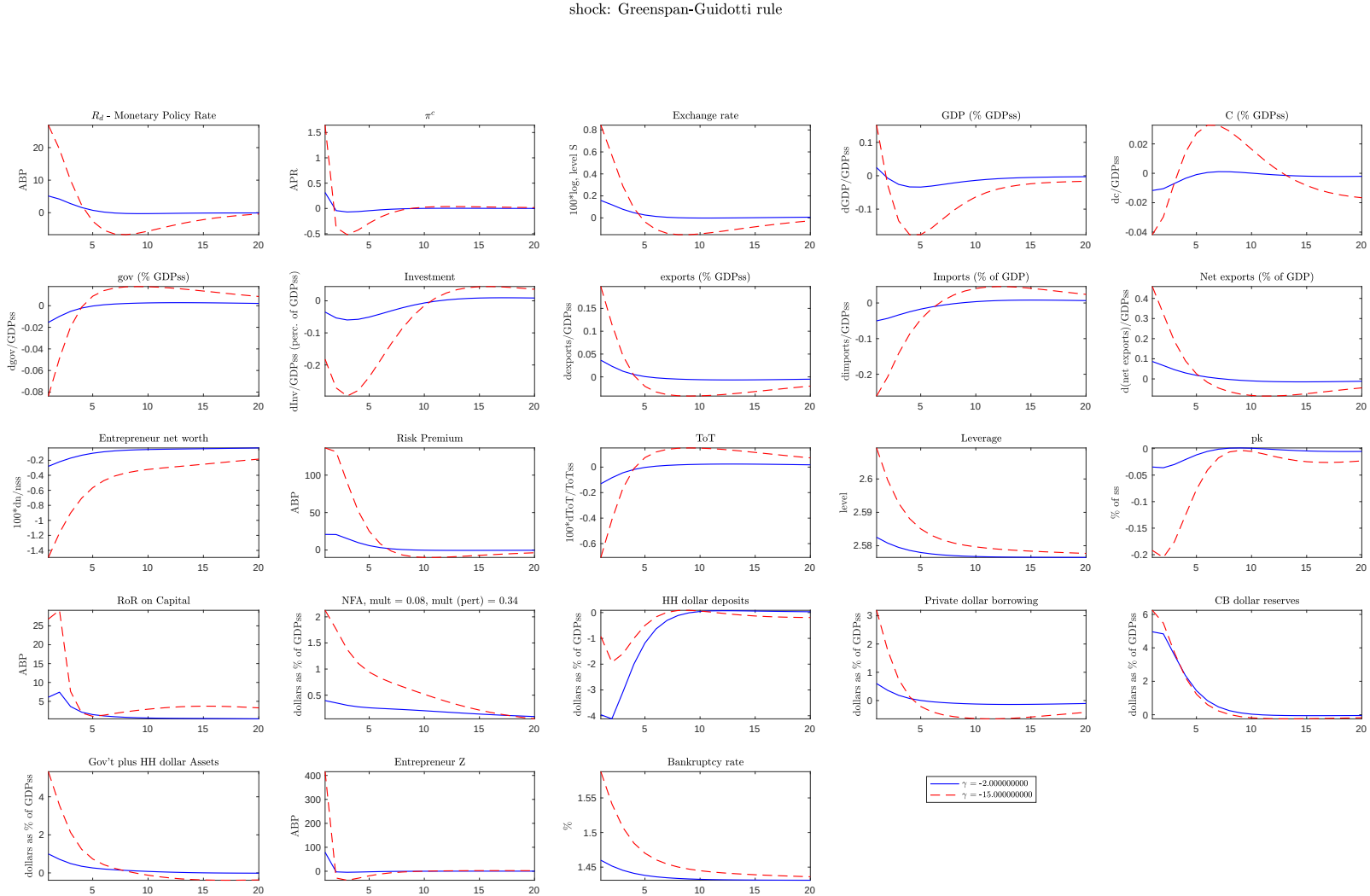
Exp#1: Repeating Previous Experiment with $\gamma = 15$

- Next, see effect of positive shock to F_t^* with $\gamma = 2, 15$, and $\phi = 0.5$.
- With $\gamma = 15$, the current account rises by 44 cents per dollar assets purchased by the government in the period of the shock.
  - The government has to buy the dollars on the open market, because private households are not easily induced by pecuniary incentives to reallocate their assets from dollars to local currency-denominated government debt.
  - Households resist budging from their 'preferred habitat' portfolio target.
- We now get a much bigger depreciation in the exchange rate and higher domestic rate of interest.
  - High exchange rate makes exports jump as competitive firms can afford to cut their dollar export prices.
  - Monetary authority responds to 0.8 percent jump in exchange rate by raising R_d by 24ABS in period of shock.
    - ⋆ 0.4 percent jump in P^c in the period of the shock translates by Taylor principle alone into $0.6 = 1.5 \times 0.4$ or 240ABS rise in R_d.
    - ⋆ But, with interest rate smoothing, $\rho_R = 0.90$, Taylor rule raises the interest rate by 25ABS.

Exp#1: Repeating Previous Experiment with $\gamma = 15$,cnt'd

- The big exchange rate depreciation hits entrepreneur net worth hard (drops by 1.4%).
  - Investment falls more.
- The rise in the interest rate makes consumption fall.
- Net exports rises, but not by enough to prevent (outside the first period) a prolonged drop in GDP.

Exp#1: υ_t^{cb} Jumps Makes F_t^* Rise 6% of GDP, $\gamma = 15$

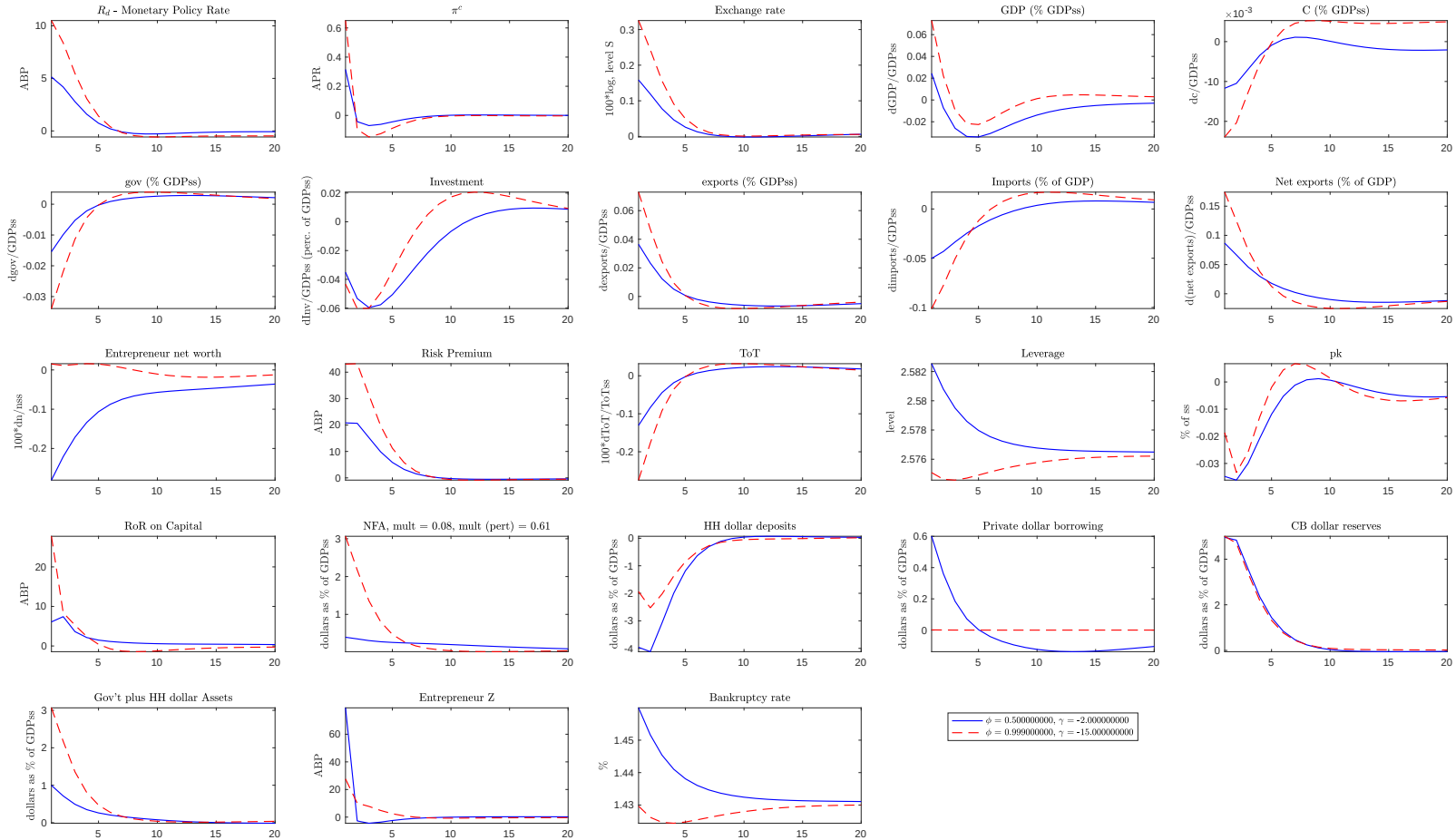


Exp#1: parameters - $\phi = 1, \gamma = 15$

- The previous result suggests that without balance sheet effects and with high γ, maybe a depreciation by exchange rate intervention will have a bigger impact.
- But, the effects turn out to be small even with foreign reserves of 5% of GDP.

Exp#1: parameters - $\phi = 1, \gamma = 15$

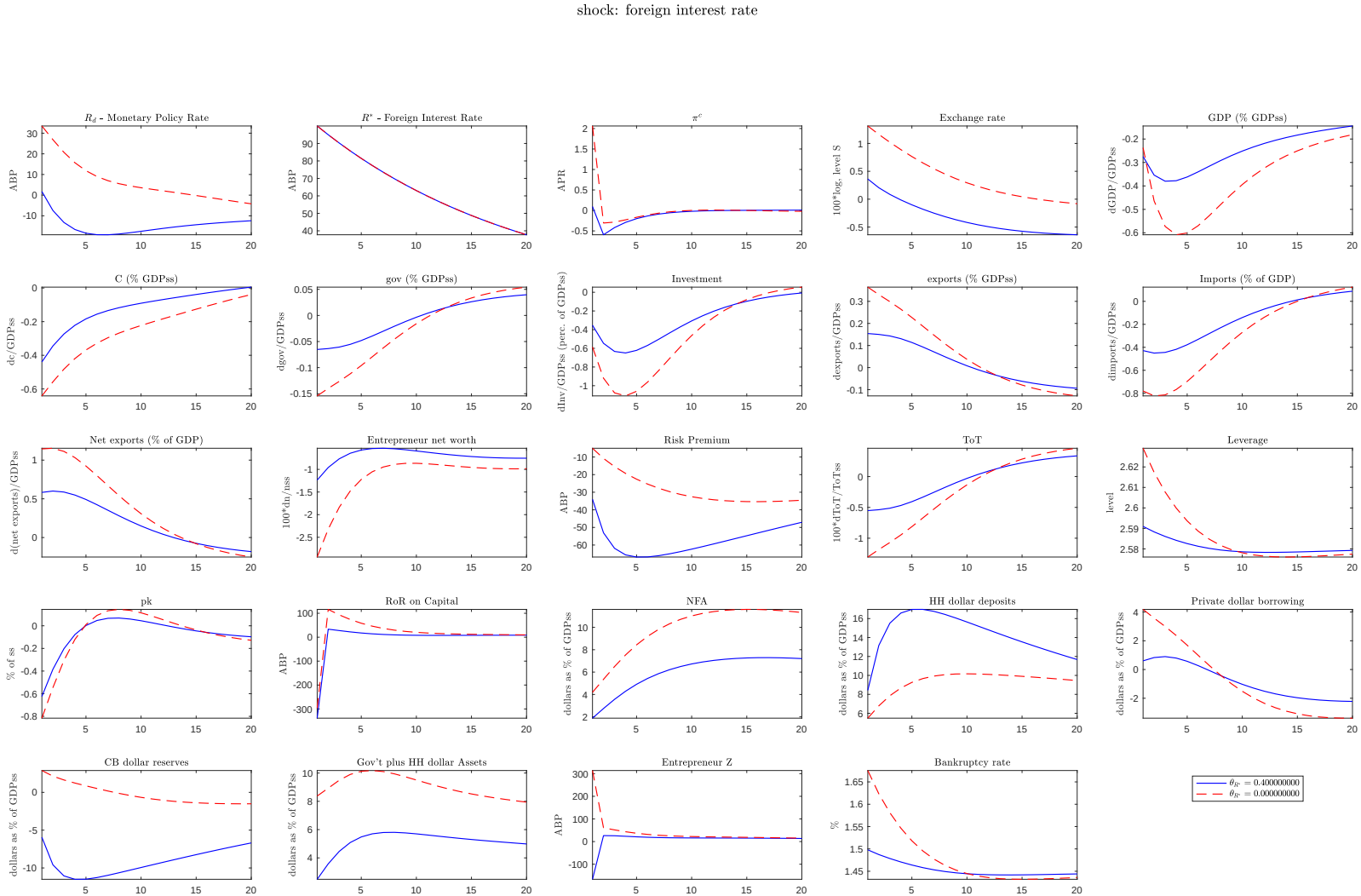
shock: Greenspan-Guidotti rule



Exp#2: Experiment: $R^*_{d,t}$ Jumps 100 Basis Points

- Consider case in which sterilized intervention does not react, $\theta_{R^*} = 0$ (dashed lines).
  - $R^*_{d,t}$ jumps 100 Annualized Basis Points and then returns to zero (1,2)
  - Households increase D^*_t (4,4), causing exchange rate to depreciate about 1.3% $\rightarrow$ P^c jumps 0.5% $\rightarrow$ R_d up by 30ABP.
  - Exchange rate depreciation leads to over 2.5% drop in entrepreneurial net worth (see the jump in Z), making investment drop.
    - ⋆ The drop in investment is cushioned by a rise in leverage and a big rise in in borrowing.
- With $\theta_{R^*} > 0$,
  - Central bank sells a substantial quantity of dollar reserves (up to 2.5% of *annual* GDP).
    - ⋆ Peru's reserves are roughly 31% of annual GDP, so this is not out-of-the-ballpark large.
  - Sterilized intervention greatly moderates the exchange rate depreciation.
  - That in turn stabilizes the drop in GDP, investment, consumption.
    - ⋆ Consistent with earlier results that F^* up drives consumption and output down.
  - This is a plus for sterilized intervention!

Exp#2: Experiment: Jump in foreign interest rate



What About Sticky-in-Dollar Export Prices?

- It is argued that export prices are 'sticky' in dollars.
- This undermines the expenditure switching channel that lies at the heart of the Mundell-Fleming analysis.
- Sticky-in-dollar prices prevent exporters from reducing their dollar price when the exchange rate depreciates.
  - Weakens the Mundell-Fleming idea that an exchange rate depreciation boosts GDP by driving up net exports.
  - Strengthens our finding that the investment channel can overwhelm the expenditure switching channel.

Sticky-in-Dollar Export Prices

- We assumed that exports require imports (this in itself is an important step in the right direction):

$$X_t = \left[\gamma_x^{\frac{1}{\eta_x}} \left(X_t^d \right)^{\frac{\eta_x - 1}{\eta_x}} + (1 - \gamma_x)^{\frac{1}{\eta_x}} \left(X_t^m \right)^{\frac{\eta_x - 1}{\eta_x}} \right]^{\frac{\eta_x}{\eta_x - 1}}$$

  where we set $\gamma_x = 0.7$, (probably too big):

  - X_t^d ~ domestically produced goods and X_t^m ~ imported goods.
  - X_t^d is produced by a Dixit-Stiglitz-Calvo type mechanism analogous to the production of Y_t
    - ⋆ the price of X_t^d, $P_t^{d,x}$, is sticky in dollars by a Calvo mechanism
    - ⋆ the dollar price of X_t^m, P_t^m, is determined exogenously by the SOE assumption.

Sticky-in-Dollar Export Prices

- The dollar marginal cost (hence, equilibrium price) of exports is:

$$P_t^x = \left[\gamma_x \left(P_t^{d,x}\right)^{1-\eta_x} + (1-\gamma_x)\left(P_t^f\right)^{1-\eta_x}\right]^{\frac{1}{1-\eta_x}},$$

  and this is slow to move when something causes S_t to change.
- Now, we find that a jump in F_t^* always produces a contraction in GDP, whether $\phi = 0.5, 0.99$.
  - Same is true for shock in $R_{d,t}^*$ but already had that anyway with flexible export prices.

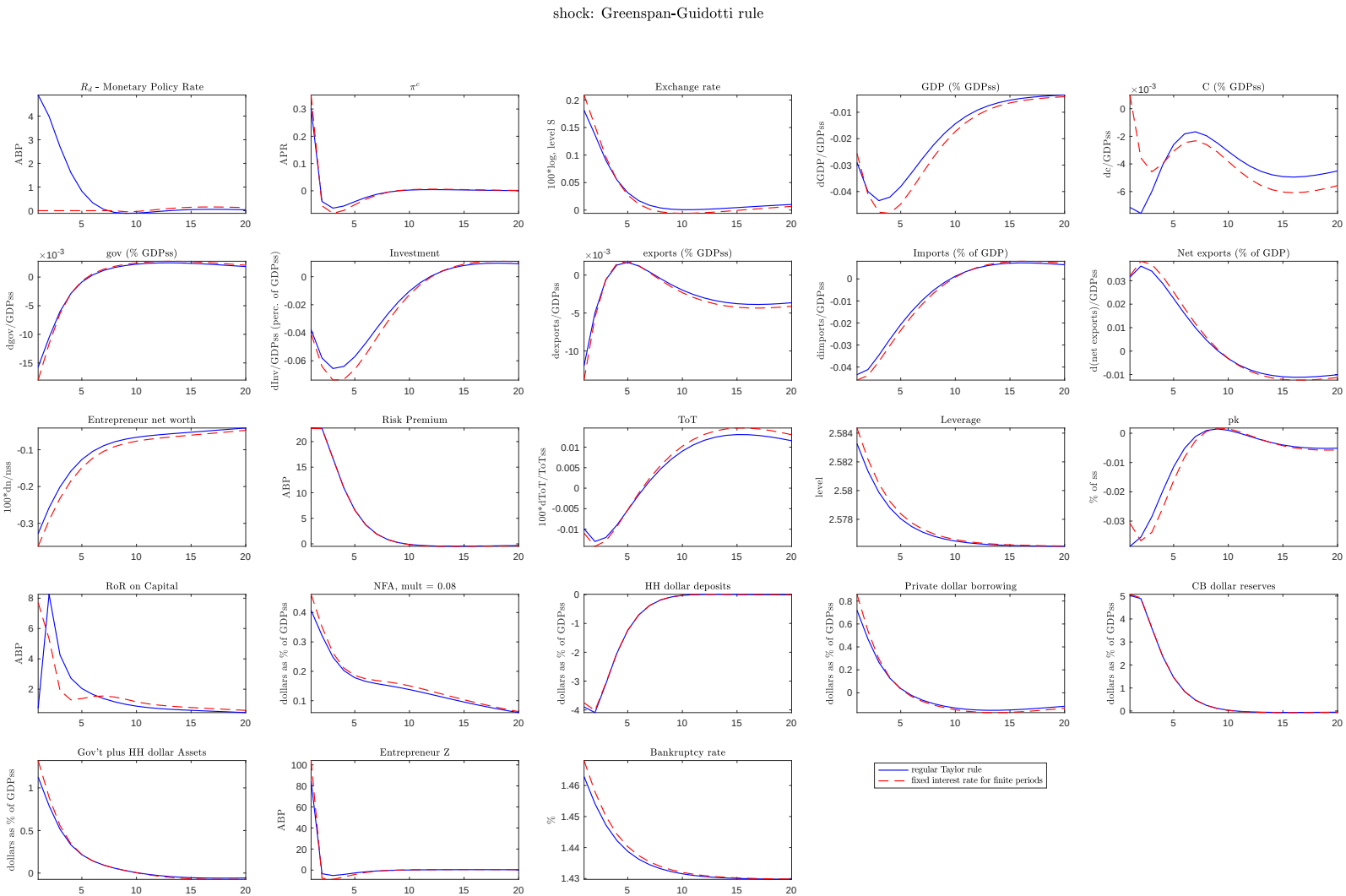
Sterilized Intervention: A Fool-proof Way Out of the ELB?

- Experiment #1 suggested that depreciating the exchange rate by sterilized intervention does not expand output.
  - But, part of the result followed from the rise in $R_{d,t}$ in response to the depreciation.
  - Suppose that the lower bound on the interest rate is so binding that $R_{d,t}$ is, in effect, stuck at the ELB ('effective lower bound').
- Experiment #3 asks whether a depreciation of the exchange rate can drive the economy out of the ELB.
  - Will adapt our linearization method to get a 'back of the envelope' way to address the issue (Christiano, et. al. JPE2011).
  - We impose the following (see part 1(c) in syllabus):
    - ⋆ In period 0 the economy is in steady state and in period 1 monetary policy replaces the Taylor rule with $R_{d,t} = R_c$ for $t = 1, 2, ..., 8$,and then return to the Taylor rule.
    - ⋆ Idea - captures a situation in which the ELB is binding for 8 periods (for reasons not specified) and then ceases to bind thereafter.

Exp 3: A Jump in F_t^* With and Without the Interest Rate 'Stuck'

- The next figure shows results for the baseline model ($\gamma = 2, \phi = 0.5$) which has sticky-in-dollar export prices.
  - When F_t^* jumps and the Taylor rule is in place, then GDP falls, consistent with what we saw before.
  - Note that whether $R_{d,t}$ is stuck or follows the Taylor makes little difference.
  - Still get the result that output falls.

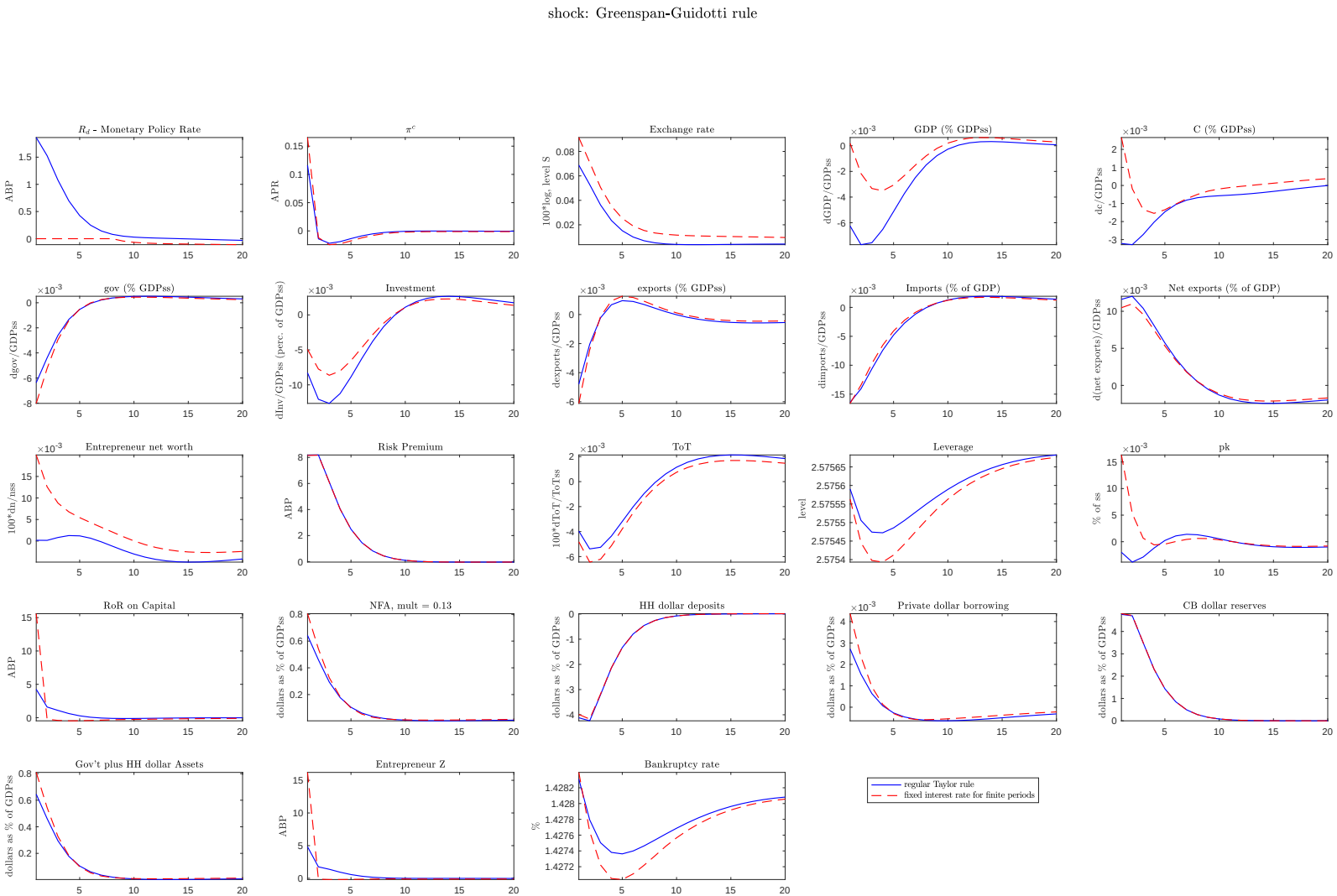
Exp#3: Jump F_t^*, $R_{d,t}$ Stuck for Years, $\phi = 1/2$



Exp 3: A Jump in F_t^* With and Without the Interest Rate 'Stuck'

- The next figure shows results for the same model as in the previous slide, except $\phi = 0.99$, so balance sheets are not vulnerable to an exchange rate change.
  - Again, depreciating the exchange rate leads to a contraction, not an expansion.
  - This is strongly contrary to Mundell-Fleming intuition.
  - In this case, sticky-in-dollar pricing plays an important role.

Exp#3: Jump F_t^*, $R_{d,t}$ Stuck Two Years, $\phi = 0.99$



Concluding Remarks

- Showed that empirically compelling deviations from the textbook Mundell-Fleming model lead to very different results.
  - This is important because that model summarizes the basic intuition that most economists carry around in the back of their mind.
  - Two deviations that we looked at are:
    - ⋆ Sticky dollar export prices and inclusion of investment.
- My objective is to show how DSGE models are used to think about policy questions in the open economy.
  - The models I discussed are not 'black boxes' designed to 'tell policymakers what to do'.
- On the contrary, the models are in effect a language that economists use to:
  - sharpen their ideas about the economy
  - efficiently transmit their ideas to other researchers for feedback
  - find creative ways to test the ideas against the data.