

Materials 10 - Is overshooting endemic to constant gain learning?

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1 Model summary

$$x_t = -\sigma i_t + \hat{\mathbb{E}}_t \sum_{T=t}^{\infty} \beta^{T-t} ((1-\beta)x_{T+1} - \sigma(\beta i_{T+1} - \pi_{T+1}) + \sigma r_T^n) \quad (1)$$

$$\pi_t = \kappa x_t + \hat{\mathbb{E}}_t \sum_{T=t}^{\infty} (\alpha\beta)^{T-t} (\kappa\alpha\beta x_{T+1} + (1-\alpha)\beta\pi_{T+1} + u_T) \quad (2)$$

$$i_t = \psi_\pi \pi_t + \psi_x x_t + \rho i_{t-1} + \bar{i}_t \quad (3)$$

I consider two variations of the learning rule. The first is a “mean-only” rule:

$$\hat{\mathbb{E}}_t z_{t+h} = \begin{bmatrix} \bar{\pi}_{t-1} \\ 0 \\ 0 \end{bmatrix} + b h_x^{h-1} s_t \quad \forall h \geq 1 \quad b = g_x h_x, \quad \text{PLM1} \quad (4)$$

$$\text{but the first row of } b \text{ is } b_1 = \begin{bmatrix} 0 & 0 & 0 \end{bmatrix} \quad (5)$$

$$\bar{\pi}_t = \bar{\pi}_{t-1} + k_t^{-1} \underbrace{(\pi_t - \bar{\pi}_{t-1})}_{\text{fcst error using (4)}} \quad (6)$$

The second is a “learning the slope too” rule:

$$\hat{\mathbb{E}}_t z_{t+h} = \begin{bmatrix} \bar{\pi}_{t-1} \\ 0 \\ 0 \end{bmatrix} + b_{t-1} h_x^{h-1} s_t \quad \forall h \geq 1 \quad b = g_x h_x, \quad \text{PLM2} \quad (7)$$

$$\text{but the first row of } b \text{ is } b_{1,t} \text{ and is also learned. Let } \phi_t = \begin{bmatrix} \bar{\pi}_t & b_{1,t} \end{bmatrix} \quad (8)$$

$$\phi_t = \left(\underbrace{\phi'_{t-1} + k_t^{-1} (\pi_t - \phi_{t-1} \begin{bmatrix} 1 \\ s_{t-1} \end{bmatrix})}_{\text{fcst error using (7)}} \right)' \quad (9)$$

2 Compact notation

$$z_t = A_p^{RE} \mathbb{E}_t z_{t+1} + A_s^{RE} s_t \quad (10)$$

$$z_t = A_a^{LH} f_a(t) + A_b^{LH} f_b(t) + A_s^{LH} s_t \quad (11)$$

$$s_t = P s_{t-1} + \epsilon_t \quad \rightarrow \quad s'_t = h x s'_{t-1} + \epsilon'_t \quad (12)$$

$$\text{where } s'_t \equiv \begin{pmatrix} r_t^n \\ \bar{i}_t \\ u_t \\ i_{t-1} \end{pmatrix} \quad h x \equiv \begin{pmatrix} \rho_r & 0 & 0 & 0 \\ 0 & \rho_i & 0 & 0 \\ 0 & 0 & \rho_u & 0 \\ gx_{3,1} & gx_{3,2} & gx_{3,3} & gx_{3,4} \end{pmatrix} \quad \epsilon'_t \equiv \begin{pmatrix} \varepsilon_t^r \\ \varepsilon_t^i \\ \varepsilon_t^u \\ 0 \end{pmatrix} \quad \text{and} \quad \Sigma' = \begin{pmatrix} \sigma_r & 0 & 0 & 0 \\ 0 & \sigma_i & 0 & 0 \\ 0 & 0 & \sigma_u & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \quad (13)$$

And the A_s^{RE} and A_s^{LH} are given by:

$$A_s^{RE} = \begin{pmatrix} \frac{\kappa\sigma}{w} & -\frac{\kappa\sigma}{w} & 1 - \frac{\kappa\sigma\psi_\pi}{w} & 0 \\ \frac{\sigma}{w} & -\frac{\sigma}{w} & -\frac{\sigma\psi_\pi}{w} & 0 \\ \psi_x(\frac{\sigma}{w}) + \psi_\pi(\frac{\kappa\sigma}{w}) & \psi_x(-\frac{\sigma}{w}) + \psi_\pi(-\frac{\kappa\sigma}{w}) + 1 & \psi_x(-\frac{\sigma\psi_\pi}{w}) + \psi_\pi(1 - \frac{\kappa\sigma\psi_\pi}{w}) & \rho \end{pmatrix} \quad (14)$$

$$A_s^{LH} = \begin{pmatrix} g_{\pi s} \\ g_{xs} \\ \psi_\pi g_{\pi s} + \psi_x g_{xs} + \begin{bmatrix} 0 & 1 & 0 & \rho \end{bmatrix} \end{pmatrix} \quad (15)$$

$$g_{\pi s} = (1 - \frac{\kappa\sigma\psi_\pi}{w}) \begin{bmatrix} 0 & 0 & 1 & 0 \end{bmatrix} (I_4 - \alpha\beta hx)^{-1} - \frac{\kappa\sigma}{w} \begin{bmatrix} -1 & 1 & 0 & \rho \end{bmatrix} (I_4 - \beta hx)^{-1} \quad (16)$$

$$g_{xs} = \frac{-\sigma\psi_\pi}{w} \begin{bmatrix} 0 & 0 & 1 & 0 \end{bmatrix} (I_4 - \alpha\beta hx)^{-1} - \frac{\sigma}{w} \begin{bmatrix} -1 & 1 & 0 & \rho \end{bmatrix} (I_4 - \beta hx)^{-1} \quad (17)$$

3 Recap of timing

Define some objects: (*I usually let t denote the time in which the variable is formed.*)

$$f_t^j = \hat{\mathbb{E}}_t(z_{t+1}) \quad \text{one-period-ahead forecast formed at time } t, j = m, e \text{ (morning or evening)} \quad (18)$$

$$FE_t = z_{t+1} - f_t \quad \text{one-period-ahead forecast error realized at time } t + 1 \quad (19)$$

$$= ALM(t + 1) - PLM(t) \quad (20)$$

$$\theta_t = \hat{\mathbb{E}}_{t-1}(z_t) - \mathbb{E}_{t-1}(z_t) \quad \text{CEMP's criterion} \quad (21)$$

$$= PLM(t - 1) - \mathbb{E}_{t-1} ALM(t) \quad (22)$$

$$PLM(t) : \hat{\mathbb{E}}_t z_{t+1} = \bar{z}_{t-1} + bs_t$$

Morning: morning of time t available: $\mathcal{I}_t^m = \{\bar{z}_{t-1}, s_t, k_{t-1}, FE_{t-2}\}$

1. Form all future expectations using $PLM(t)$ (morning forecast) $\rightarrow z_t$ realized, $\rightarrow FE_{t-1}$ realized
2. Form $\theta_t \rightarrow k_t$ realized
3. **Evening:** Update $\bar{z}_t = \bar{z}_{t-1} + k_t^{-1}(FE_{t-1}^e)$

where $FE_{t-1}^e = z_t - f_{t-1}^e = z_t - (\bar{z}_{t-1} + bs_{t-1})$ is the most recent realized FE, so:

$$\bar{z}_t = \bar{z}_{t-1} + k_t^{-1}(z_t - (\bar{z}_{t-1} + bs_{t-1}))$$

\rightarrow evening of time t available: $\mathcal{I}_t^e = \{\bar{z}_t, s_t, k_t, FE_{t-1}\}$

4 Current set of baseline parameters

β	0.99	stochastic discount factor	standard (Woodford 2003/2011)
σ	1	IES	consistent with balanced growth
α	0.5	Calvo probability of not adjusting	match 6-month duration of prices (can increase to 0.75)
ψ_π	1.5	coefficient of inflation in Taylor rule	Taylor
ψ_x	0	coefficient of output gap in Taylor rule	focus on π
\bar{g}	0.145	value of the constant gain	CEMP
$\bar{\theta}$	1	threshold deviation between $\hat{\mathbb{E}}$ & \mathbb{E}	CEMP: 0.029
ρ_r	0	persistence of natural rate shock	n.a.
ρ_i	0.6	persistence of monetary policy shock	CEMP: 0.877 (can increase to 0.78 if $\alpha = 0.75$)
ρ_u	0	persistence of cost-push shock	CEMP
σ_r	0.1	standard deviation of natural rate shock	n.a.
σ_i	0.359	standard deviation of mon. policy shock	CEMP
σ_u	0.277	standard deviation of cost-push shock	CEMP
θ	10	price elasticity of demand	Woodford 2003/2011, Chari, Kehoe & McGrattan 2000
ω	1.25	elasticity of marginal cost to output	Woodford 2003/2011, Chari, Kehoe & McGrattan 2000

5 Cross-sectional IRFs, mon. pol shock only, cgain & dgain only, “mean-only” PLM ◀

Figure 1: IRF for observables, shock imposed at t

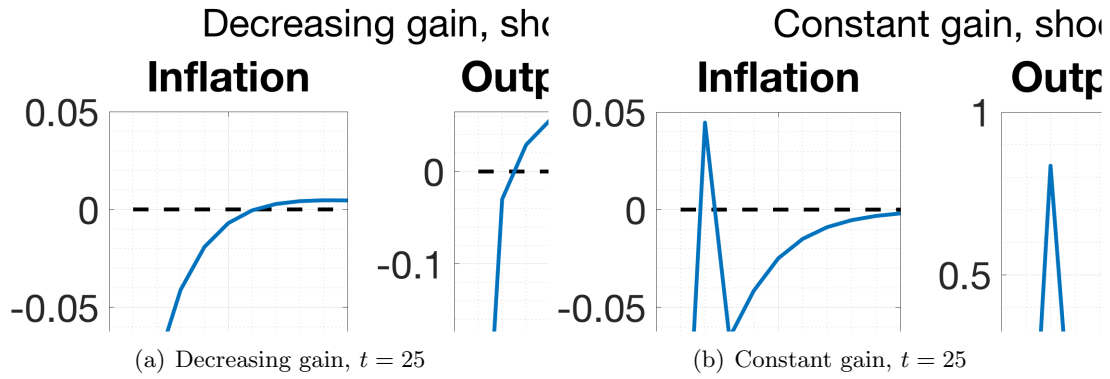


Figure 2: IRF for 1-period ahead forecasts and FEs, together, morning and evening, shock imposed at t

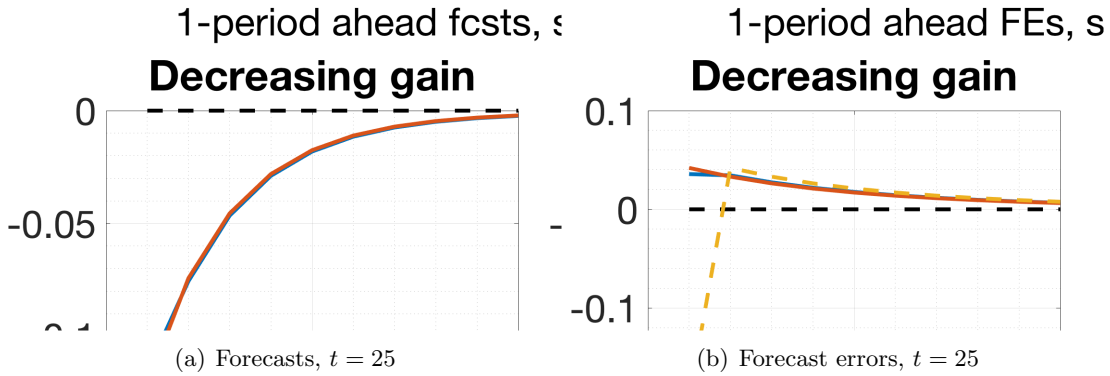
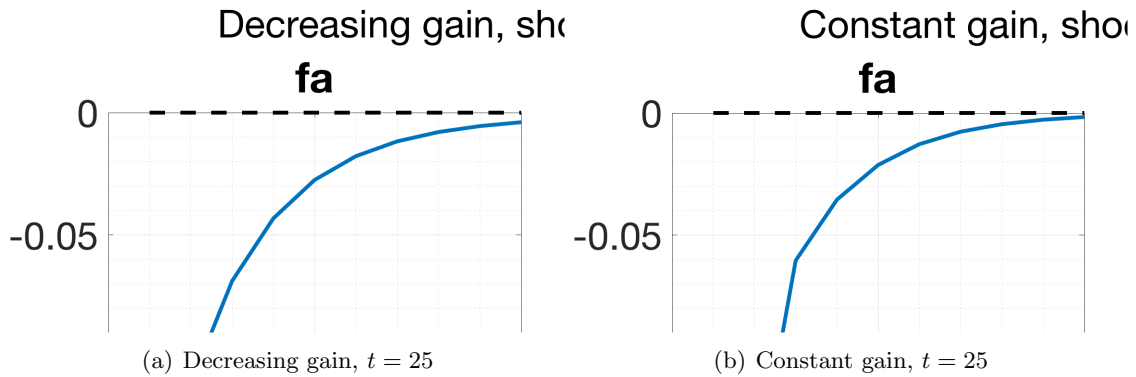


Figure 3: IRF for LH forecasts, shock imposed at t



6 Cross-sectional IRFs, mon. pol shock only, cgain & dgain only, “slope and constant” PLM ◀

Figure 4: IRF for observables, shock imposed at t

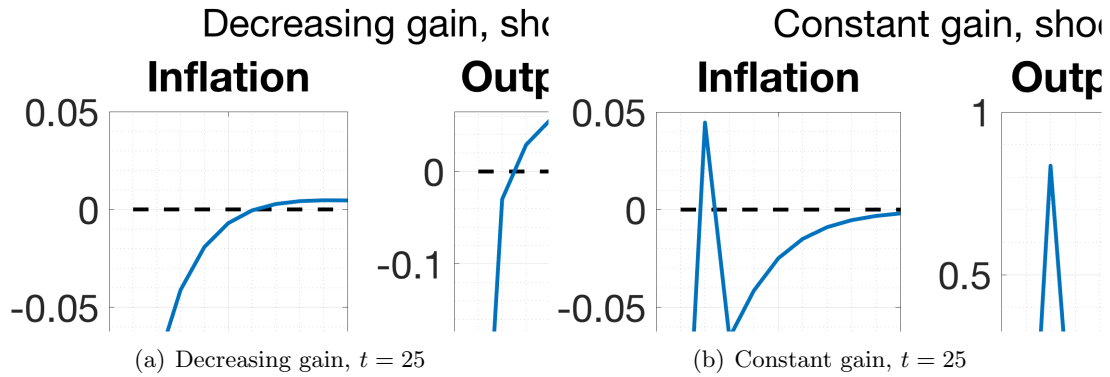


Figure 5: IRF for 1-period ahead forecasts and FEs, together, morning and evening, shock imposed at t

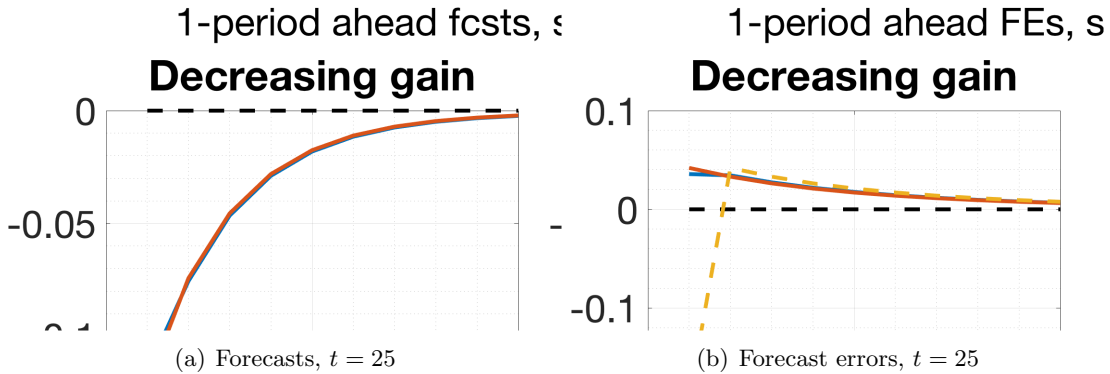


Figure 6: IRF for LH forecasts, shock imposed at t

