1 New Keynesian Model with Capital and Sticky Wages

Preferences:

$$E_0 \sum_{t=0}^{\infty} \beta^t [\log(c_t - hc_{t-1}^a) - \chi \int_0^1 n_t(\ell)^{1+\eta} d\ell/(1+\eta)]$$

Constraints:

$$c_t + x_t + b_t/(s_t i_t) + u_t k_{t-1} + \tfrac{\varphi_w}{2} \int_0^1 (w_t^g(\ell) - 1)^2 y_t^f d\ell = \int_0^1 w_t(\ell) n_t(\ell) d\ell + r_t^k \upsilon_t k_{t-1} + b_{t-1}/\pi_t + d_t$$

$$k_t = (1-\delta)k_{t-1} + x_t(1 - \nu(x_t^g - 1)^2/2)$$

$$x_t^g = x_t/(\bar{g} x_{t-1})$$

$$w_t^g(\ell) = \pi_t w_t(\ell)/(\bar{\pi}\bar{g} w_{t-1}(\ell))$$

$$n_t(\ell) = (w_t(\ell)/w_t)^{-\theta_w} n_t$$

$$u_t = \bar{r}^k(\exp(\sigma_\upsilon(\upsilon_t - 1)) - 1)/\sigma_\upsilon$$

Equilibrium system:

$$r_t^k = \bar{r}^k \exp(\sigma_\upsilon(\upsilon_t - 1)) \tag{1}$$

$$y_t = (\upsilon_t k_{t-1})^\alpha (z_t n_t)^{1-\alpha} \tag{2}$$

$$u_t = \bar{r}^k(\exp(\sigma_\upsilon(\upsilon_t - 1)) - 1)/\sigma_\upsilon \tag{3}$$

$$r_t^k = \alpha m c_t y_t/(\upsilon_t k_{t-1}) \tag{4}$$

$$w_t = (1-\alpha) m c_t y_t / n_t \tag{5}$$

$$w_t^g = \pi_t w_t/(\bar{\pi}\bar{g} w_{t-1}) \tag{6}$$

$$y_t^{gdp} = [1 - \varphi_p(\pi_t/\bar{\pi} - 1)^2/2 - \varphi_w(w_t^g - 1)^2/2] y_t - u_t k_{t-1} \tag{7}$$

$$y_t^g = y_t^{gdp}/(\bar{g} y_{t-1}^{gdp}) \tag{8}$$

$$i_t = i_{t-1}^{\rho_i} (\bar{\imath}(\pi_t/\bar{\pi})^{\phi_\pi} (y_t^g)^{\phi_y})^{1-\rho_i} \exp(mp_t) \tag{9}$$

$$i_t = \max\{1, i_t^n\} \tag{10}$$

$$\lambda_t = c_t - hc_{t-1} \tag{11}$$

$$w_t^f = \chi n_t^\eta \lambda_t \tag{12}$$

$$c_t + x_t = y_t^{gdp} \tag{13}$$

$$x_t^g = x_t/(\bar{g} x_{t-1}) \tag{14}$$

$$k_t = (1-\delta)k_{t-1} + x_t(1 - \nu(x_t^g - 1)^2/2) \tag{15}$$

$$1 = \beta E_t[(\lambda_t/\lambda_{t+1})(s_t i_t/\pi_{t+1})] \tag{16}$$

$$q_t = \beta E_t[(\lambda_t/\lambda_{t+1})(r_{t+1}^k \upsilon_{t+1} - u_{t+1} + (1-\delta) q_{t+1})] \tag{17}$$

$$1 = q_t[1 - \nu(x_t^g - 1)^2/2 - \nu(x_t^g - 1)x_t^g] + \beta\nu\bar{g} E_t[q_{t+1}(\lambda_t/\lambda_{t+1})(x_{t+1}^g)^2(x_{t+1}^g - 1)] \tag{18}$$

$$\varphi_p(\pi_t/\bar{\pi} - 1)(\pi_t/\bar{\pi}) = 1 - \theta_p + \theta_p m c_t + \beta\varphi_p E_t[(\lambda_t/\lambda_{t+1})(\pi_{t+1}/\bar{\pi} - 1)(\pi_{t+1}/\bar{\pi})(y_{t+1}/y_t)] \tag{19}$$

$$\varphi_w(w_t^g - 1) w_t^g = [(1-\theta_w) w_t + \theta_w w_t^f] n_t/y_t + \beta\varphi_w E_t[(\lambda_t/\lambda_{t+1})(w_{t+1}^g - 1) w_{t+1}^g (y_{t+1}/y_t)] \tag{20}$$

$$g_t = \bar{g} + \sigma_g \varepsilon_{g,t} \tag{21}$$

$$s_t = (1-\rho_s)\bar{s} + \rho_s s_{t-1} + \sigma_s \varepsilon_{s,t} \tag{22}$$

$$mp_t = \sigma_i \varepsilon_{i,t} \tag{23}$$

$$z_t = z_{t-1} g_t \tag{24}$$

Variables: $c, n, x, k, y^{gdp}, y, u, \upsilon, w^g, x^g, y^g, w, w^f, r^k, \pi, i, i^n, q, mc, \lambda, g, s, mp, z$

De-trended Equilibrium System:

$$r_t^k = \bar{r}^k \exp(\sigma_\upsilon(\upsilon_t - 1)) \tag{1}$$

$$\tilde{y}_t = (\upsilon_t \tilde{k}_{t-1}/g_t)^\alpha n_t^{1-\alpha} \tag{2}$$

$$u_t = \bar{r}^k(\exp(\sigma_\upsilon(\upsilon_t - 1)) - 1)/\sigma_\upsilon \tag{3}$$

$$r_t^k = \alpha mc_t g_t \tilde{y}_t/(\upsilon_t \tilde{k}_{t-1}) \tag{4}$$

$$\tilde{w}_t = (1-\alpha) mc_t \tilde{y}_t/n_t \tag{5}$$

$$w_t^g = \pi_t g_t \tilde{w}_t/(\bar{\pi}\bar{g}\tilde{w}_{t-1}) \tag{6}$$

$$\tilde{y}_t^{gdp} = [1 - \varphi_p(\pi_t/\bar{\pi} - 1)^2/2 - \varphi_w(w_t^g - 1)^2/2]\tilde{y}_t - u_t \tilde{k}_{t-1}/g_t \tag{7}$$

$$y_t^g = g_t \tilde{y}_t^{gdp}/(\bar{g}\tilde{y}_{t-1}^{gdp}) \tag{8}$$

$$i_t^n = (i_{t-1}^n)^{\rho_i}(\bar{\imath}(\pi_t/\bar{\pi})^{\phi_\pi}(y_t^g)^{\phi_y})^{1-\rho_i}\exp(\sigma_i \varepsilon_{i,t}) \tag{9}$$

$$i_t = \max\{1, i_t^n\} \tag{10}$$

$$\tilde{\lambda}_t = \tilde{c}_t - h\tilde{c}_{t-1}/g_t \tag{11}$$

$$\tilde{w}_t^f = \chi n_t^\eta \tilde{\lambda}_t \tag{12}$$

$$\tilde{c}_t + \tilde{x}_t = \tilde{y}_t^{gdp} \tag{13}$$

$$x_t^g = g_t \tilde{x}_t/(\bar{g}\tilde{x}_{t-1}) \tag{14}$$

$$\tilde{k}_t = (1-\delta)(\tilde{k}_{t-1}/g_t) + \tilde{x}_t(1 - \nu(x_t^g - 1)^2/2) \tag{15}$$

$$1 = \beta E_t[(\tilde{\lambda}_t/\tilde{\lambda}_{t+1})(s_t i_t/(g_{t+1}\pi_{t+1}))] \tag{16}$$

$$q_t = \beta E_t[(\tilde{\lambda}_t/\tilde{\lambda}_{t+1})(r_{t+1}^k \upsilon_{t+1} - u_{t+1} + (1-\delta)q_{t+1})/g_{t+1}] \tag{17}$$

$$1 = q_t[1 - \nu(x_t^g - 1)^2/2 - \nu(x_t^g - 1)x_t^g] + \beta\nu\bar{g}E_t[q_{t+1}(\tilde{\lambda}_t/\tilde{\lambda}_{t+1})(x_{t+1}^g)^2(x_{t+1}^g - 1)/g_{t+1}] \tag{18}$$

$$\varphi_p(\pi_t/\bar{\pi} - 1)(\pi_t/\bar{\pi}) = 1 - \theta_p + \theta_p mc_t + \beta\varphi_p E_t[(\tilde{\lambda}_t/\tilde{\lambda}_{t+1})(\pi_{t+1}/\bar{\pi} - 1)(\pi_{t+1}/\bar{\pi})(\tilde{y}_{t+1}/\tilde{y}_t)] \tag{19}$$

$$\varphi_w(w_t^g - 1)w_t^g = [(1-\theta_w)\tilde{w}_t + \theta_w \tilde{w}_t^f]n_t/\tilde{y}_t + \beta\varphi_w E_t[(\tilde{\lambda}_t/\tilde{\lambda}_{t+1})(w_{t+1}^g - 1)w_{t+1}^g(\tilde{y}_{t+1}/\tilde{y}_t)] \tag{20}$$

$$g_t = \bar{g} + \sigma_g \varepsilon_{g,t} \tag{21}$$

$$s_t = (1-\rho_s)\bar{s} + \rho_s s_{t-1} + \sigma_s \varepsilon_{s,t} \tag{22}$$

$$mp_t = \sigma_i \varepsilon_{i,t} \tag{23}$$

Variables: $\tilde{c}, n, \tilde{x}, \tilde{k}, \tilde{y}^{gdp}, \tilde{y}, u, \upsilon, w^g, x^g, y^g, \tilde{w}^f, \tilde{w}, r^k, \pi, i, i^n, q, mc, \tilde{\lambda}, g, s, mp$, $\tilde{x}_t \equiv x_t/z_t$

De-trended Level-Linear Equilibrium System:

$$\hat{r}^k_t = \bar{r}^k \sigma_\upsilon \hat{\upsilon}_t \tag{1}$$

$$\hat{y}_t/\bar{y} = \alpha(\hat{\upsilon}_t + \hat{k}_{t-1}/\bar{k} - \hat{g}_t/\bar{g}) + (1-\alpha)\hat{n}_t/\bar{n} \tag{2}$$

$$\hat{u}_t = \bar{r}^k \hat{\upsilon}_t \tag{3}$$

$$\hat{r}^k_t/\bar{r}^k = \hat{mc}_t/\bar{mc} + \hat{g}_t/\bar{g} + \hat{y}_t/\bar{y} - \hat{\upsilon}_t - \hat{k}_{t-1}/\bar{k} \tag{4}$$

$$\hat{w}_t/\bar{w} = \hat{mc}_t/\bar{mc} + \hat{y}_t/\bar{y} - \hat{n}_t/\bar{n} \tag{5}$$

$$\hat{w}^g_t = \hat{g}_t/\bar{g} + \hat{\pi}_t/\bar{\pi} + \hat{w}_t/\bar{w} - \hat{w}_{t-1}/\bar{w} \tag{6}$$

$$\hat{y}^{gdp}_t = \hat{y}_t - (\bar{k}/\bar{g})\hat{u}_t \tag{7}$$

$$\hat{y}^g_t = \hat{g}_t/\bar{g} + \hat{y}^{gdp}_t/\bar{y}^{gdp} - \hat{y}^{gdp}_{t-1}/\bar{y}^{gdp} \tag{8}$$

$$\hat{\imath}_t/\bar{\imath} = \rho_i \hat{\imath}_{t-1}/\bar{\imath} + (1-\rho_i)(\phi_\pi \hat{\pi}_t/\bar{\pi} + \phi_y \hat{y}^g_t) + \hat{mp}_t \tag{9}$$

$$\hat{\imath}_t = \hat{\imath}^n_t \tag{10}$$

$$\hat{\lambda}_t = \hat{c}_t - (h/\bar{g})\hat{c}_{t-1} + (h\bar{c}/\bar{g}^2)\hat{g}_t \tag{11}$$

$$\hat{w}^f_t/\bar{w}^f = \eta \hat{n}_t/\bar{n} + \hat{\lambda}_t/\bar{\lambda} \tag{12}$$

$$\hat{c}_t + \hat{x}_t = \hat{y}^{gdp}_t \tag{13}$$

$$\hat{x}^g_t = \hat{g}_t/\bar{g} + \hat{x}_t/\bar{x} - \hat{x}_{t-1}/\bar{x} \tag{14}$$

$$\hat{k}_t = ((1-\delta)/\bar{g})[\hat{k}_{t-1} - (\bar{k}/\bar{g})\hat{g}_t] + \hat{x}_t \tag{15}$$

$$\hat{\lambda}_t/\bar{\lambda} + \hat{s}_t/\bar{s} + \hat{\imath}_t/\bar{\imath} = E_t\hat{\lambda}_{t+1}/\bar{\lambda} + E_t\hat{g}_{t+1}/\bar{g} + E_t\hat{\pi}_{t+1}/\bar{\pi} \tag{16}$$

$$\hat{q}_t = \hat{\lambda}_t/\bar{\lambda} - E_t\hat{\lambda}_{t+1}/\bar{\lambda} + (\beta/\bar{g})[E_t\hat{r}^k_{t+1} + \bar{r}^k E_t\hat{\upsilon}_{t+1} - E_t\hat{u}_{t+1} + (1-\delta)E_t\hat{q}_{t+1}] - E_t\hat{g}_{t+1}/\bar{g} \tag{17}$$

$$\nu \hat{x}^g_t = \hat{q}_t + \beta\nu E_t \hat{x}^g_{t+1} \tag{18}$$

$$\varphi_p \hat{\pi}_t/\bar{\pi} = \theta_p \hat{mc}_t + (\beta\varphi_p/\pi)E_t\hat{\pi}_{t+1} \tag{19}$$

$$\varphi_w \hat{w}^g_t = (1-\theta_w)(\bar{w}\bar{n}/\bar{y})(\hat{w}_t/\bar{w} - \hat{w}^f_t/\bar{w}^f) + \beta\varphi_w E_t\hat{w}^g_{t+1} \tag{20}$$

$$\hat{g}_t = \sigma_g \varepsilon_{g,t} \tag{21}$$

$$\hat{s}_t = \rho_s \hat{s}_{t-1} + \sigma_s \varepsilon_{s,t} \tag{22}$$

$$\hat{mp}_t = \sigma_i \varepsilon_{i,t} \tag{23}$$

Variables: $\hat{c}, \hat{n}, \hat{x}, \hat{k}, \hat{y}^{gdp}, \hat{y}, \hat{u}, \hat{\upsilon}, \hat{w}^g_t, \hat{x}^g, \hat{y}^g, \hat{w}, \hat{w}^f, \hat{r}^k, \hat{\pi}, \hat{\imath}, \hat{\imath}^n, \hat{q}, \hat{mc}, \hat{\lambda}, \hat{g}, \hat{s}, \hat{mp}$
Shocks: $\varepsilon_{g,t}, \varepsilon_{s,t}, \varepsilon_{i,t}$
Forecast Errors: $\hat{\lambda}, \hat{g}, \hat{\pi}, \hat{r}^k, \hat{\upsilon}, \hat{q}, \hat{x}^g, \hat{w}^g$

2 New Keynesian Model without Capital

Preferences:

$$E_0 \sum_{t=0}^{\infty} \beta^t [\log(c_t - hc^a_{t-1}) - \chi n_t^{1+\eta}/(1+\eta)]$$

Budget Constraint:

$$c_t + b_t/(i_t s_t) = w_t n_t + b_{t-1}/\pi_t + d_t$$

Equilibrium system:

$$c_t = y_t^{gdp} \tag{1}$$

$$y_t^{gdp} = [1 - \varphi_p(\pi_t/\bar{\pi} - 1)^2/2] y_t \tag{2}$$

$$y_t^g = y_t^{gdp}/(\bar{g} y_{t-1}^{gdp}) \tag{3}$$

$$i_t^n = i_{t-1}^{\rho_i} (\bar{\imath}(\pi_t/\bar{\pi})^{\phi_\pi} (y_t^g)^{\phi_y})^{1-\rho_i} \exp(mp_t) \tag{4}$$

$$i_t = \max\{1, i_t^n\} \tag{5}$$

$$\lambda_t = c_t - hc_{t-1} \tag{6}$$

$$y_t = z_t n_t \tag{7}$$

$$w_t = \chi n_t^\eta \lambda_t \tag{8}$$

$$1 = \beta E_t[(\lambda_t/\lambda_{t+1})(s_t i_t/\pi_{t+1})] \tag{9}$$

$$\varphi_p(\pi_t/\bar{\pi} - 1)(\pi_t/\bar{\pi}) = 1 - \theta_p + \theta_p(w_t/z_t) + \beta\varphi_p E_t[(\lambda_t/\lambda_{t+1})(\pi_{t+1}/\bar{\pi} - 1)(\pi_{t+1}/\bar{\pi})(y_{t+1}/y_t)] \tag{10}$$

$$g_t = \bar{g} + \sigma_g \varepsilon_{g,t} \tag{11}$$

$$s_t = (1 - \rho_s)\bar{s} + \rho_s s_{t-1} + \sigma_s \varepsilon_{s,t} \tag{12}$$

$$mp_t = \sigma_i \varepsilon_{i,t} \tag{13}$$

$$z_t = z_{t-1} g_t \tag{14}$$

Variables: $\lambda, w, c, y^{gdp}, y, y_t^g, n, i, i^n, \pi, g, s, mp, z$

De-trended Equilibrium System:

$$\tilde{c}_t = \tilde{y}_t^{gdp} \tag{1}$$
$$\tilde{y}_t^{gdp} = [1 - \varphi(\pi_t/\bar{\pi} - 1)^2/2]\tilde{y}_t \tag{2}$$
$$y_t^g = g_t \tilde{y}_t^{gdp}/(\bar{g}\tilde{y}_{t-1}^{gdp}) \tag{3}$$
$$i_t^n = (i_{t-1}^n)^{\rho_i}(\bar{\imath}(\pi_t/\bar{\pi})^{\phi_\pi}(y_t^g)^{\phi_y})^{1-\rho_i}\exp(\sigma_i \varepsilon_{i,t}) \tag{4}$$
$$i_t = \max\{1, i_t^n\} \tag{5}$$
$$\tilde{\lambda}_t = \tilde{c}_t - h\tilde{c}_{t-1}/g_t \tag{6}$$
$$\tilde{y}_t = n_t \tag{7}$$
$$\tilde{w}_t = \chi n_t^\eta \tilde{\lambda}_t \tag{8}$$
$$1 = \beta E_t[(\tilde{\lambda}_t/\tilde{\lambda}_{t+1})(s_t i_t/(g_{t+1}\pi_{t+1}))] \tag{9}$$
$$\varphi_p(\pi_t/\bar{\pi} - 1)(\pi_t/\bar{\pi}) = 1 - \theta_p + \theta_p \tilde{w}_t + \beta\varphi_p E_t[(\tilde{\lambda}_t/\tilde{\lambda}_{t+1})(\pi_{t+1}/\bar{\pi} - 1)(\pi_{t+1}/\bar{\pi})(\tilde{y}_{t+1}/\tilde{y}_t)] \tag{10}$$
$$g_t = \bar{g} + \sigma_g \varepsilon_{g,t} \tag{11}$$
$$s_t = (1 - \rho_s)\bar{s} + \rho_s s_{t-1} + \sigma_s \varepsilon_{s,t} \tag{12}$$
$$mp_t = \sigma_i \varepsilon_{i,t} \tag{13}$$

Variables: $\tilde{\lambda}, \tilde{w}, \tilde{c}, \tilde{y}^{gdp}, \tilde{y}, y^g, n, i, i^n, \pi, g, s, mp$

De-trended Level-Linear Equilibrium System:

$$\hat{c}_t = \hat{y}_t^{gdp} \tag{1}$$
$$\hat{y}_t^{gdp} = \hat{y}_t \tag{2}$$
$$\hat{y}_t^g = \hat{g}_t/\bar{g} + \hat{y}_t^{gdp}/\bar{y}^{gdp} - \hat{y}_{t-1}^{gdp}/\bar{y}^{gdp} \tag{3}$$
$$\hat{\imath}_t/\bar{\imath} = \rho_i \hat{\imath}_{t-1}/\bar{\imath} + (1 - \rho_i)(\phi_\pi \hat{\pi}_t/\bar{\pi} + \phi_y \hat{y}_t^g) + \hat{mp}_t \tag{4}$$
$$\hat{\imath}_t = \hat{\imath}_t^n \tag{5}$$
$$\hat{\lambda}_t = \hat{c}_t - (h/\bar{g})\hat{c}_{t-1} + (h\bar{c}/\bar{g}^2)\hat{g}_t \tag{6}$$
$$\hat{y}_t = \hat{n}_t \tag{7}$$
$$\hat{w}_t/\bar{w} = \eta\hat{n}_t/\bar{n} + \hat{\lambda}_t/\bar{\lambda} \tag{8}$$
$$\hat{\lambda}_t/\bar{\lambda} + \hat{s}_t/\bar{s} + \hat{\imath}_t/\bar{\imath} = E_t\hat{\lambda}_{t+1}/\bar{\lambda} + E_t\hat{g}_{t+1}/\bar{g} + E_t\hat{\pi}_{t+1}/\bar{\pi} \tag{9}$$
$$\varphi_p\hat{\pi}_t/\bar{\pi} = \theta_p\hat{w}_t + (\beta\varphi_p/\pi)E_t\hat{\pi}_{t+1} \tag{10}$$
$$\hat{g}_t = \sigma_g \varepsilon_{g,t} \tag{11}$$
$$\hat{s}_t = \rho_s \hat{s}_{t-1} + \sigma_s \varepsilon_{s,t} \tag{12}$$
$$\hat{mp}_t = \sigma_i \varepsilon_{i,t} \tag{13}$$

Variables: $\hat{c}, \hat{n}, \hat{y}^{gdp}, \hat{y}, \hat{y}^g, \hat{w}, \hat{\pi}, \hat{\imath}, \hat{\imath}^n, \hat{\lambda}, \hat{g}, \hat{s}, \hat{mp}$
Shocks: $\varepsilon_{g,t}, \varepsilon_{s,t}, \varepsilon_{i,t}$
Forecast Errors: $\hat{\lambda}, \hat{g}, \hat{\pi}$

3 New Keynesian Model without Capital with Sticky Wages

Preferences:

$$E_0 \sum_{t=0}^{\infty} \beta^t [\log(c_t - hc_{t-1}^a) - \chi \int_0^1 n_t(\ell)^{1+\eta} d\ell/(1+\eta)]$$

Constraints:

$$\begin{gathered} c_t + b_t/(s_t i_t) + \tfrac{\varphi_w}{2} \int_0^1 (w_t^g(\ell) - 1)^2 y_t^f d\ell = \int_0^1 w_t(\ell) n_t(\ell) d\ell + b_{t-1}/\pi_t + d_t \\ w_t^g(\ell) = \pi_t w_t(\ell)/(\bar{\pi}\bar{g} w_{t-1}(\ell)) \\ n_t(\ell) = (w_t(\ell)/w_t)^{-\theta_w} n_t \end{gathered}$$

Equilibrium system:

$$c_t = y_t^{gdp} \tag{1}$$

$$w_t^g = \pi_t w_t/(\bar{\pi}\bar{g} w_{t-1}) \tag{2}$$

$$y_t^{gdp} = [1 - \varphi_p(\pi_t/\bar{\pi} - 1)^2/2 - \varphi_w(w_t^g - 1)^2/2] y_t \tag{3}$$

$$y_t^g = y_t^{gdp}/(\bar{g} y_{t-1}^{gdp}) \tag{4}$$

$$i_t^n = i_{t-1}^{\rho_i} (\bar{\imath}(\pi_t/\bar{\pi})^{\phi_\pi} (y_t^g)^{\phi_y})^{1-\rho_i} \exp(mp_t) \tag{5}$$

$$i_t = \max\{1, i_t^n\} \tag{6}$$

$$\lambda_t = c_t - hc_{t-1} \tag{7}$$

$$y_t = z_t n_t \tag{8}$$

$$w_t^f = \chi n_t^\eta \lambda_t \tag{9}$$

$$1 = \beta E_t[(\lambda_t/\lambda_{t+1})(s_t i_t/\pi_{t+1})] \tag{10}$$

$$\varphi_p(\pi_t/\bar{\pi} - 1)(\pi_t/\bar{\pi}) = 1 - \theta_p + \theta_p(w_t/z_t) + \beta\varphi_p E_t[(\lambda_t/\lambda_{t+1})(\pi_{t+1}/\bar{\pi} - 1)(\pi_{t+1}/\bar{\pi})(y_{t+1}/y_t)] \tag{11}$$

$$\varphi_w(w_t^g - 1) w_t^g = [(1-\theta_w) w_t + \theta_w w_t^f]/z_t + \beta\varphi_w E_t[(\lambda_t/\lambda_{t+1})(w_{t+1}^g - 1) w_{t+1}^g (y_{t+1}/y_t)] \tag{12}$$

$$g_t = \bar{g} + \sigma_g \varepsilon_{g,t} \tag{13}$$

$$s_t = (1-\rho_s)\bar{s} + \rho_s s_{t-1} + \sigma_s \varepsilon_{s,t} \tag{14}$$

$$mp_t = \sigma_i \varepsilon_{i,t} \tag{15}$$

$$z_t = z_{t-1} g_t \tag{16}$$

Variables: $\lambda, w, w^f, w^g, c, y^{gdp}, y, y_t^g, n, i, i^n, \pi, g, s, mp, z$

De-trended Equilibrium System:

$$\tilde{c}_t = \tilde{y}_t^{gdp} \tag{1}$$
$$w_t^g = \pi_t g_t \tilde{w}_t/(\bar{\pi}\bar{g}\tilde{w}_{t-1}) \tag{2}$$
$$\tilde{y}_t^{gdp} = [1 - \varphi_p(\pi_t/\bar{\pi} - 1)^2/2 - \varphi_w(w_t^g - 1)^2/2]\tilde{y}_t \tag{3}$$
$$y_t^g = g_t\tilde{y}_t^{gdp}/(\bar{g}\tilde{y}_{t-1}^{gdp}) \tag{4}$$
$$i_t^n = (i_{t-1}^n)^{\rho_i}(\bar{\imath}(\pi_t/\bar{\pi})^{\phi_\pi}(y_t^g)^{\phi_y})^{1-\rho_i}\exp(\sigma_i\varepsilon_{i,t}) \tag{5}$$
$$i_t = \max\{1, i_t^n\} \tag{6}$$
$$\tilde{\lambda}_t = \tilde{c}_t - h\tilde{c}_{t-1}/g_t \tag{7}$$
$$\tilde{y}_t = n_t \tag{8}$$
$$\tilde{w}_t^f = \chi n_t^\eta \tilde{\lambda}_t \tag{9}$$
$$1 = \beta E_t[(\tilde{\lambda}_t/\tilde{\lambda}_{t+1})(s_t i_t/(g_{t+1}\pi_{t+1}))] \tag{10}$$
$$\varphi_p(\pi_t/\bar{\pi} - 1)(\pi_t/\bar{\pi}) = 1 - \theta_p + \theta_p\tilde{w}_t + \beta\varphi_p E_t[(\tilde{\lambda}_t/\tilde{\lambda}_{t+1})(\pi_{t+1}/\bar{\pi} - 1)(\pi_{t+1}/\bar{\pi})(\tilde{y}_{t+1}/\tilde{y}_t)] \tag{11}$$
$$\varphi_w(w_t^g - 1)w_t^g = [(1-\theta_w)\tilde{w}_t + \theta_w\tilde{w}_t^f] + \beta\varphi_w E_t[(\tilde{\lambda}_t/\tilde{\lambda}_{t+1})(w_{t+1}^g - 1)w_{t+1}^g(\tilde{y}_{t+1}/\tilde{y}_t)] \tag{12}$$
$$g_t = \bar{g} + \sigma_g\varepsilon_{g,t} \tag{13}$$
$$s_t = (1-\rho_s)\bar{s} + \rho_s s_{t-1} + \sigma_s\varepsilon_{s,t} \tag{14}$$
$$mp_t = \sigma_i\varepsilon_{i,t} \tag{15}$$

Variables: $\tilde{\lambda}, \tilde{w}, \tilde{w}^f, w^g, \tilde{c}, \tilde{y}^{gdp}, \tilde{y}, y^g, n, i, i^n, \pi, g, s, mp$

De-trended Level-Linear Equilibrium System:

$$\hat{c}_t = \hat{y}_t^{gdp} \tag{1}$$
$$\hat{w}_t^g = \hat{g}_t/\bar{g} + \hat{\pi}_t/\bar{\pi} + \hat{w}_t/\bar{w} - \hat{w}_{t-1}/\bar{w} \tag{2}$$
$$\hat{y}_t^{gdp} = \hat{y}_t \tag{3}$$
$$\hat{y}_t^g = \hat{g}_t/\bar{g} + \hat{y}_t^{gdp}/\bar{y}^{gdp} - \hat{y}_{t-1}^{gdp}/\bar{y}^{gdp} \tag{4}$$
$$\hat{\imath}_t/\bar{\imath} = \rho_i\hat{\imath}_{t-1}/\bar{\imath} + (1-\rho_i)(\phi_\pi\hat{\pi}_t/\bar{\pi} + \phi_y\hat{y}_t^g) + \hat{mp}_t \tag{5}$$
$$\hat{\imath}_t = \hat{\imath}_t^n \tag{6}$$
$$\hat{\lambda}_t = \hat{c}_t - (h/\bar{g})\hat{c}_{t-1} + (h\bar{c}/\bar{g}^2)\hat{g}_t \tag{7}$$
$$\hat{y}_t = \hat{n}_t \tag{8}$$
$$\hat{w}_t^f/\bar{w}^f = \eta\hat{n}_t/\bar{n} + \hat{\lambda}_t/\bar{\lambda} \tag{9}$$
$$\hat{\lambda}_t/\bar{\lambda} + \hat{s}_t/\bar{s} + \hat{\imath}_t/\bar{\imath} = E_t\hat{\lambda}_{t+1}/\bar{\lambda} + E_t\hat{g}_{t+1}/\bar{g} + E_t\hat{\pi}_{t+1}/\bar{\pi} \tag{10}$$
$$\varphi_p\hat{\pi}_t/\bar{\pi} = \theta_p\hat{w}_t + (\beta\varphi_p/\pi)E_t\hat{\pi}_{t+1} \tag{11}$$
$$\varphi_w\hat{w}_t^g = (1-\theta_w)(\hat{w}_t - \hat{w}_t^f\bar{w}/\bar{w}^f) + \beta\varphi_w E_t\hat{w}_{t+1}^g \tag{12}$$
$$\hat{g}_t = \sigma_g\varepsilon_{g,t} \tag{13}$$
$$\hat{s}_t = \rho_s\hat{s}_{t-1} + \sigma_s\varepsilon_{s,t} \tag{14}$$
$$\hat{mp}_t = \sigma_i\varepsilon_{i,t} \tag{15}$$

Variables: $\hat{c}, \hat{n}, \hat{y}^{gdp}, \hat{y}, \hat{y}^g, \hat{w}, \hat{w}^f, \hat{\pi}, \hat{\imath}, \hat{\imath}^n, \hat{\lambda}, \hat{g}, \hat{s}, \hat{mp}$
Shocks: $\varepsilon_{g,t}, \varepsilon_{s,t}, \varepsilon_{i,t}$
Forecast Errors: $\hat{\lambda}, \hat{g}, \hat{\pi}, \hat{w}^g$