I'm sorry for how messy this is. Hopefully, the notes on what goes where make sense.

I worked with Stephanie to figure out the initial analytical parts.
I worked with Beatrice, Natalia, Adrian, David, and Jack to figure out the final coding process.

$$U(x_t, L_t) = \frac{x_t^{1-\gamma}}{1-\gamma} - \chi \frac{N_t^{1+\varphi}}{1+\varphi}$$

$$x_t = \left[(1-\vartheta) C_t^{1-\nu} + \vartheta \left(\frac{M_t}{P_t}\right)^{1-\nu} \right]^{\frac{1}{1-\nu}}$$

a) $\max E\left[\sum_{t=0}^{\infty} \beta^t U(x_t, L_t)\right]$

s.t. $P_t C_t + B_t + M_t \leq W_t N_t + Q_{t-1} B_{t-1} + M_{t-1} + P_t(TR_t + PR_t)$

$$\mathcal{L} = \Sigma E[\beta^t U(x_t, L_t)] + \lambda_t [W_t N_t + Q_{t-1} B_{t-1} + M_{t-1} + P_t(TR_t + PR_t) - P_t C_t - B_t - M_t]$$

FOC:

$[N_t]$ $\quad -\beta^t \chi N_t^{\varphi} + \lambda_t W_t = 0$

$[C_t]$ $\quad E\left[\beta^t \left(\frac{1}{1-\nu}\right)(1-\vartheta)(1-\nu) C_t^{-\nu} \left[(1-\vartheta) C_t^{1-\nu} + \vartheta\left(\frac{M_t}{P_t}\right)^{1-\nu}\right]^{\frac{\nu}{1-\nu}} x_t^{-\gamma}\right] = \lambda_t P_t$

$$E\left[\beta^t (1-\vartheta) C_t^{-\nu} \left[(1-\vartheta) C_t^{1-\nu} + \vartheta\left(\frac{M_t}{P_t}\right)^{1-\nu}\right]^{\frac{\nu-\gamma}{1-\nu}}\right] = \lambda_t P_t = E[\beta^t (1-\vartheta) C_t^{-\nu} X_t^{\nu-\gamma}]$$

$[M_t]$ $\quad E\left[\beta^t \frac{\vartheta}{P_t} (1-\nu) \left(\frac{M_t}{P_t}\right)^{-\nu} \left(\frac{1}{1-\nu}\right) \left[(1-\vartheta) C_t^{1-\nu} + \vartheta\left(\frac{M_t}{P_t}\right)^{1-\nu}\right]^{\frac{\nu}{1-\nu}} X_t^{-\gamma}\right] + \lambda_{t+1} = \lambda_t$

$$E\left[\beta^t \frac{\vartheta}{P_t} \left(\frac{M_t}{P_t}\right)^{-\nu} \left[(1-\vartheta) C_t^{1-\nu} + \vartheta\left(\frac{M_t}{P_t}\right)^{1-\nu}\right]^{\frac{\nu-\gamma}{1-\nu}}\right] + \lambda_{t+1} = \lambda_t = \lambda_{t+1} + E\left[\beta^t \frac{\vartheta}{P_t}\left(\frac{M_t}{P_t}\right)^{-\nu} X_t^{\nu-\gamma}\right]$$

$[B_t]$ $\quad \lambda_{t+1} Q_t = \lambda_t$

b) This economy has complementarity of M and C so we don't automatically get neutrality as we did in class

Firm's FOC: $A_t = \frac{W_t}{P_t}$

Govt's BC: $B_t + M_t = P_t TR_t + Q_{t-1} B_{t-1} + M_{t-1}$

Combining w/ HH BC:

$$C_t = \frac{W_t}{P_t} N_t + PR_t = A_t N_t + PR_t \leftarrow \text{No money!}$$

LL: $\frac{W_t}{P_t}(1-\vartheta) C_t^{-\nu} X_t^{\nu-\gamma} = \chi N_t^{\varphi}$

EE: $1 = \underbrace{\frac{P_t}{P_{t+1}} Q_t}_{R_t} \beta \left(\frac{C_{t+1}}{C_t}\right)^{-\nu} \left(\frac{x_{t+1}}{x_t}\right)^{\nu-\gamma}$

if $\nu = \gamma$ then all the x terms are eliminated and consequently there is neutrality of money

[Dynamic FOC WRT M_t : $1 = \frac{P_t}{P_{t+1}} \beta \left(\frac{C_{t+1}}{C_t}\right)^{-\nu} \left(\frac{x_{t+1}}{x_t}\right)^{\nu-\gamma} + \frac{\vartheta}{1-\vartheta}\left(\frac{M_t}{P_t}\right)^{-\nu}\left(\frac{1}{C_t}\right)^{-\nu}$]

c) $C^{ss} = N^{ss} + PR^{ss}$

$W_t = P_t$

$(1-\vartheta) C^{ss^{-\nu}} X^{ss^{\nu-\gamma}} = \chi N^{ss^{\varphi}}$ $\longrightarrow$ $(1-\vartheta) X^{ss^{\nu-\gamma}} = \chi C^{ss^{\nu+\varphi}}$

$1 = R^{ss}\beta \Rightarrow R^{ss} = \frac{1}{\beta}$

$C^{ss} = Y^{ss} = N^{ss}$ $\longrightarrow$ $PR^{ss} = 0$

$\left[\text{Call } \Pi_t = \frac{P_{t+1}}{P_t}\right] \Rightarrow 1 = \frac{\beta}{\Pi^{ss}} + \frac{\vartheta}{1-\vartheta}\left(\frac{M_t}{P_t}\right)^{-\nu}\left(\frac{1}{C^{ss}}\right)^{-\nu} \Rightarrow$

$$\frac{M_t}{P_t} = \left(\frac{\vartheta}{1-\vartheta}\right)^{\frac{1}{\nu}} C^{ss}\left[1-\frac{\beta}{\Pi^{ss}}\right]^{-\frac{1}{\nu}}$$

$$\left(\frac{M_t}{P_t}\right)^{1-\nu} = \left(\frac{\vartheta}{1-\vartheta}\right)^{\frac{1-\nu}{\nu}} C^{ss^{1-\nu}}\left[1-\frac{\beta}{\Pi^{ss}}\right]^{\frac{\nu-1}{\nu}}$$

$$X^{ss} = \left[(1-\vartheta) C^{ss^{1-\nu}} + \vartheta\left(\frac{\vartheta}{1-\vartheta}\right)^{\frac{1-\nu}{\nu}} C^{ss^{1-\nu}}\left[1-\frac{\beta}{\Pi^{ss}}\right]^{\frac{\nu-1}{\nu}}\right]^{\frac{1}{1-\nu}}$$

$$= \left[1-\vartheta+\vartheta\left(\frac{\vartheta}{1-\vartheta}\right)^{\frac{1-\nu}{\nu}}\left[1-\frac{\beta}{\Pi^{ss}}\right]^{\frac{\nu-1}{\nu}}\right]^{\frac{1}{1-\nu}} C^{ss}$$

$$\chi C^{ss^{\nu+\varphi}} = (1-\vartheta)\left[\left[1-\vartheta+\vartheta\left(\frac{\vartheta}{1-\vartheta}\right)^{\frac{1-\nu}{\nu}}\left[1-\frac{\beta}{\Pi^{ss}}\right]^{\frac{\nu-1}{\nu}}\right]^{\frac{1}{1-\nu}} C^{ss}\right]^{\nu-\gamma}$$

$$C^{ss} = \left[\frac{(1-\vartheta)}{\chi}\left[1-\vartheta+\vartheta\left(\frac{\vartheta}{1-\vartheta}\right)^{\frac{1-\nu}{\nu}}\left[1-\frac{\beta}{\Pi^{ss}}\right]^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu-\gamma}{1-\nu}}\right]^{\frac{1}{\varphi+\gamma}}$$ ← C_{ss} in terms of model parameters!

can plug this back into above eqns to get $\frac{M_t}{P_t}$ in ss

d) Start by setting (Q_t) and (M_t^{ss}) as given

Then specify model parameters $(\vartheta, \chi, \beta, \nu, \gamma, \varphi)$

Get Π from $Q = \frac{\Pi}{\beta}$

Plug all values into the equation for C^{ss}

Use $C^{ss} = N^{ss}$ to get N^{ss}

Use C^{ss} and model parameters to get $\frac{M_t}{P_t}$

Given (M_t^{ss}) we can derive P_t

e) Assuming knowledge of data on C^{ss} (or some measure of the first moment of consumption in the data) we could back out the value of ϑ using the steady state equation in (c)

f) If $\rho = 1$ in SS then M is also constant.

Using the gov't BC

$$B^* + M^* = TR^* + \frac{1}{\beta} B^* + M^*$$

$$\Downarrow$$

$$B^* = TR^* + \frac{1}{\beta} B^* \Rightarrow \left(1 - \frac{1}{\beta}\right) B^* = TR^* \Rightarrow B^* = \frac{\beta}{1-\beta} TR^*$$

combining with the hh BC

$$C^* + \cancel{B^*} + \cancel{M^*} = N^* + \cancel{\frac{1}{\beta} B^*} + \cancel{M^*} + \cancel{TR^*} + PR^*$$

$$C^* = N^* + PR^* \quad \text{(as before!)}$$

See page 5 for new \$ demand eqn. Then

$$\frac{M_t}{P_t} = \left[\left(1 - \frac{1}{Q_t}\right)\left(\frac{1-\nu}{\nu}\right)\right]^{-\frac{1}{\nu}} C_t$$

$$\Rightarrow M^* = \left[(1-\beta)\left(\frac{1-\nu}{\nu}\right)\right]^{-\frac{1}{\nu}} C^* \quad \text{where } C^* \text{ is } C^{SS} \text{ from (c)}$$

g) $f(x,y)=g(z) \iff f_1(x,y)\,x\,\hat{x} + f_2(x,y)\,y\,\hat{y} = g'(z)\,z\,\hat{z}$

$$\log\left(\frac{w_t}{P_t}(1-\vartheta)\, C_t^{-v}\, x_t^{v-\gamma}\right) = \log\left(\chi N_t^{\varphi}\right)$$

$$\boxed{\hat{w}_t - \hat{P}_t - v\,\hat{C}_t + (v-\gamma)\,\hat{x}_t = \varphi\,\hat{N}_t} \Rightarrow \hat{C}_t = \frac{1}{v}(\hat{w}_t - \hat{P}_t) + \frac{1}{v}(v-\gamma)\,\hat{x}_t - \frac{1}{v}\varphi\,\hat{N}_t$$

$$\boxed{0 = -v\left[\hat{C}_{t+1} - \hat{C}_t\right] + (v-\gamma)\left[\hat{x}_{t+1} - \hat{x}_t\right] + \left(\hat{P}_t - \hat{P}_{t+1}\right) + \hat{Q}_t}$$

$$\ln(1) = \ln\Big[\overbrace{\frac{P_t}{P_{t+1}}\,\beta\left(\frac{C_{t+1}}{C_t}\right)^{-v}\left(\frac{x_{t+1}}{x_t}\right)^{v-\gamma} + \frac{\vartheta}{1-\vartheta}\left(\frac{M_t}{P_t}\right)^{-v}\left(\frac{1}{C_t}\right)^{-v}}^{z}\Big]$$

$$0 = \ln\left[z^*\right]$$

$$+ \frac{1}{z^*}\left(\frac{\beta}{P_{t+1}}\left(\frac{C_{t+1}}{C_t}\right)^{-v}\left(\frac{x_{t+1}}{x_t}\right)^{v-\gamma} + \frac{\vartheta}{1-\vartheta}(-v)\,M_t^{-v}\,P_t^{-v-1}\left(\frac{1}{C_t}\right)^{-v}\right)(P_t - P^*)$$

$$+ \frac{1}{z^*}\left(-P_t\,P_{t+1}^{-2}\,\beta\left(\frac{C_{t+1}}{C_t}\right)^{-v}\left(\frac{x_{t+1}}{x_t}\right)^{v-\gamma}\right)(P_{t+1} - P^*)$$

$$+ \frac{1}{z^*}\left(\frac{P_t}{P_{t+1}}\,\beta\,(-v)\,C_{t+1}^{-v-1}\,C_t^{v}\left(\frac{x_{t+1}}{x_t}\right)^{v-\gamma}\right)(C_{t+1} - C^*)$$

$$+ \frac{1}{z^*}\left(\frac{P_t}{P_{t+1}}\,\beta\, v\, C_{t+1}^{-v}\,C_t^{v-1}\left(\frac{x_{t+1}}{x_t}\right)^{v-\gamma} + \frac{\vartheta}{1-\vartheta}\left(\frac{M_t}{P_t}\right)^{-v}(v)\,C_t^{v-1}\right](C_t - C^*)$$

$$+ \frac{1}{z^*}\left(\frac{\vartheta}{1-\vartheta}(-v)\,M_t^{-v-1}\,P_t^{v}\left(\frac{1}{C_t}\right)^{-v}\right)(M_t - M^*)$$

where $z^* = \beta + \frac{\vartheta}{1-\vartheta}\left(\frac{M^*}{P^*}\right)^{-v}\left(\frac{1}{C^*}\right)^{-v}$

$\ln(z^*) = \ln(1) = 0$

$z^* = 1$

$$0 = \left(\frac{\beta}{P_{t+1}}\left(\frac{C_{t+1}}{C_t}\right)^{-v}\left(\frac{x_{t+1}}{x_t}\right)^{v-\gamma} - \frac{\vartheta}{1-\vartheta}\,v\,M_t^{-v}\,P_t^{-v-1}\left(\frac{1}{C_t}\right)^{-v}\right)(P_t - P^*)$$

$$- \left(\frac{P_t}{P_{t+1}^2}\,\beta\left(\frac{C_{t+1}}{C_t}\right)^{-v}\left(\frac{x_{t+1}}{x_t}\right)^{v-\gamma}\right)(P_{t+1} - P^*) - \left(\frac{P_t}{P_{t+1}}\,\beta\, v\, C_{t+1}^{-v-1}\,C_t^{v}\left(\frac{x_{t+1}}{x_t}\right)^{v-\gamma}\right)(C_{t+1} - C^*)$$

$$+ \left(\frac{P_t}{P_{t+1}}\,\beta\, v\, C_{t+1}^{-v}\,C_t^{v-1}\left(\frac{x_{t+1}}{x_t}\right)^{v-\gamma} + \frac{\vartheta}{1-\vartheta}\,v\left(\frac{M_t}{P_t}\right)^{-v}C_t^{v-1}\right)(C_t - C^*)$$

$$- \left(\frac{\vartheta}{1-\vartheta}\,v\,M_t^{-v-1}\,P_t^{v}\left(\frac{1}{C_t}\right)^{-v}\right)(M_t - M^*)$$

Evaluation at SS on next page

g)

$$0 = \ln[z^*] + \frac{1}{z^*}\left[\frac{\beta}{P_*}\left(\frac{c^*}{c^*}\right)^{-v}\left(\frac{x^*}{x^*}\right)^{v-\gamma} + \frac{\vartheta}{1-\vartheta} v M_*^{-v} P_*^{-v-1}\left(\frac{1}{c^*}\right)^{-v}\right)(P_t - P^*]$$

$$+ \frac{1}{z^*}\left[\frac{P_*}{P_*^2}\beta\left(\frac{c^*}{c^*}\right)^{-v}\left(\frac{x^*}{x^*}\right)^{v-\gamma}\right](P_{t+1} - P^*) - \frac{1}{z^*}\left[\frac{P^*}{P^*}\beta v c_*^{-v-1} c_*^{v}\left(\frac{x_*}{x_*}\right)^{v-\gamma}\right](c_{t+1} - c^*)$$

$$+ \frac{1}{z^*}\left[\frac{P^*}{P^*}\beta v c_*^{-v} c_*^{v-1}\left(\frac{x_*}{x_*}\right)^{v-\gamma} + \frac{\vartheta}{1-\vartheta} v\left(\frac{M_*}{P_*}\right)^{-v} c_*^{v-1}\right](c_t - c^*)$$

$$- \frac{1}{z^*}\left[\frac{\vartheta}{1-\vartheta} v M_*^{-v-1} P_*^{v}\left(\frac{1}{c^*}\right)^{-v}\right)(M_t - M^*)$$

$$\boxed{\begin{aligned} 0 &= \left[\frac{\beta}{P^*} + \frac{\vartheta}{1-\vartheta} v \frac{c_*^{v}}{M_*^{v} P_*^{v+1}}\right]\hat{P}_t + \left[\frac{1}{P^*}\beta\right]\hat{P}_{t+1} - (\beta v c_*^{-1})\hat{c}_{t+1} \\ &+ \left[\beta v c_*^{-1} + \frac{\vartheta}{1-\vartheta} v\left(\frac{M_*}{P_*}\right)^{-v} c_*^{v-1}\right]\hat{c}_t - \left[\frac{\vartheta}{1-\vartheta} v M_*^{-v-1} P_*^{v} c_*^{v}\right]\hat{M}_t\end{aligned}}$$

$\boxed{\hat{Y}_t = \hat{N}_t}$

$\boxed{\hat{c}_t = \hat{Y}_t}$

$\boxed{\hat{w}_t - \hat{P}_t = 0}$

reattempt \$ eqn:

Divide \$ eqn by EE:

$$1 = \frac{1}{Q_t} + \frac{\vartheta}{1-\vartheta}\left(\frac{M_t}{P_t}\right)^{-v}\underbrace{\left(\frac{P_{t+1}}{P_t}\frac{1}{Q_t}\frac{1}{\beta}c_{t+1}^{v}\left(\frac{x_t}{x_{t+1}}\right)^{v-\gamma}\right)}_{c_t^{v}}$$

$$1 - \frac{1}{Q_t} = \frac{\vartheta}{1-\vartheta}\left(\frac{M_t}{P_t}\right)^{-v} c_t^{v}$$

$$\left(\frac{M_t}{P_t}\right)^{v} = \left(1 - \frac{1}{Q_t}\right)^{-1}\frac{\vartheta}{1-\vartheta}c_t^{v}$$

$$\frac{M_t}{P_t} = \left(1 - \frac{1}{Q_t}\right)^{-\frac{1}{v}}\left(\frac{\vartheta}{1-\vartheta}\right)^{\frac{1}{v}} c_t$$

$$M_t = P_t\left(1 - \frac{1}{Q_t}\right)^{-\frac{1}{v}}\left(\frac{\vartheta}{1-\vartheta}\right)^{\frac{1}{v}} c_t$$

$M_t \to M\hat{M}$

$P_t \to \frac{M}{P}(P\hat{P}) = M\hat{P}$

$c_t \to \frac{M}{c}(c\hat{c}) = M\hat{c}$

$$Q_t \to -\frac{1}{v}P\left(1-\frac{1}{Q}\right)^{-\frac{1}{v}-1}\left(\frac{1}{Q^2}\right)\left(\frac{\vartheta}{1-\vartheta}\right)^{\frac{1}{v}}c\,[Q\hat{Q}] = -\frac{1}{v}\cdot\frac{1}{Q}\underbrace{\left(1-\frac{1}{Q}\right)}_{\frac{Q-1}{Q}}^{-1}M\hat{Q} = -\frac{1}{v}(Q-1)^{-1}M\hat{Q}$$

con't →

g) Combining

$$M^* \hat{M}_t = M^* \hat{P}_t + M^* \hat{C}_t - M^* \left(\frac{1}{v}\right)(Q^* - 1)^{-1} \hat{Q}_t$$

$$\hat{M}_t - \hat{P}_t = \hat{C}_t - \left(\frac{1}{v}\right)\left(\frac{1}{\beta} - 1\right)^{-1} \hat{Q}_t$$

$$\boxed{\hat{M}_t - \hat{P}_t = \hat{C}_t - \left(\frac{1}{v}\right) \frac{\beta}{1-\beta} \hat{Q}_t}$$

h) log linearized eqns:

Firm block:

$$\left.\begin{aligned} \hat{Y}_t &= \hat{N}_t \\ \hat{W}_t - \hat{P}_t &= 0 \end{aligned}\right\} \Rightarrow \begin{aligned} \phi_{y,n} &= I_T \\ \phi_{y,a} &= Z \\ \phi_{wp,a} &= Z \\ \phi_{wp,n} &= Z \end{aligned}$$

HH block:

$$\hat{C}_t = \frac{1}{v}(\hat{W}_t - \hat{P}_t) + \frac{1}{v}(v - \gamma)\hat{x}_t - \frac{1}{v}\varphi \hat{N}_t \Big\} \Rightarrow \begin{aligned} \phi_{c,wp} &= \frac{1}{v} I_T \\ \phi_{c,x} &= \frac{1}{v}(v-\gamma) I_T \\ \phi_{c,n} &= -\frac{1}{v}\varphi \cdot I_T \end{aligned}$$

$$\hat{x}_t = (1-v)\left(\frac{C^*}{x^*}\right)^{1-v} \hat{C}_t + v\left(\frac{M^*}{x^*}\right)^{1-v} (\hat{M}_t - \hat{P}_t)$$

MC:

$$0 = \hat{C}_t - \hat{Y}_t \Big\} \Rightarrow \begin{aligned} \phi_{gm,c} &= I_T \\ \phi_{gm,y} &= -I_T \end{aligned}$$

$$0 = \hat{C}_t - \left(\frac{1}{v}\right)\frac{\beta}{\beta-1}\hat{Q}_t - (\hat{M}_t - \hat{P}_t) \Big\} \Rightarrow \begin{aligned} \phi_{mm,c} &= I_T \\ \phi_{MM,q} &= -\frac{1}{v}\cdot\frac{\beta}{\beta-1} I_T \\ \phi_{MM,m} &= -I_T \\ \phi_{MM,p} &= I_T \end{aligned}$$

$$\cancel{\hat{Q}_t = \frac{\beta-1}{\beta}\left(\frac{v}{1}\right)\left[\hat{C}_t - \hat{M}_t + \hat{P}_t\right]}$$

$$0 = -v\left[\hat{C}_{t+1} - \hat{C}_t\right] + (v-\gamma)\left[\hat{x}_{t+1} - \hat{x}_t\right] + (\hat{P}_t - \hat{P}_{t+1}) + \hat{Q}_t \Big\} \Rightarrow \begin{aligned} \phi_{eul,c} &= v \cdot I_T - v * I_p 1 \\ \phi_{eul,x} &= -(v-\gamma) I_T + (v-\gamma) * I_p 1 \\ \phi_{eul,p} &= I_T - I_p 1 \\ \phi_{eul,q} &= I_T \end{aligned}$$

$$\Updownarrow$$

$$\hat{Q}_t = -(\hat{P}_t - \hat{P}_{t+1}) - (v-\gamma)\left[\hat{x}_{t+1} - \hat{x}_t\right] + v(\hat{C}_{t+1} - \hat{C}_t)$$

h) log linearized blocks:

Firm:

$$\left.\begin{aligned} \hat{Y}_t &= \hat{N}_t \\ \hat{\omega}_t - \hat{P}_t &= 0 \end{aligned}\right\}$$

$$\hat{M}_t - \hat{P}_t = \hat{M}_t - \hat{P}_t$$

$\phi_{yn} = I$ $\quad\phi_{wpn} = Z$ $\quad\phi_{mpm} = Z$

$\phi_{yp} = Z$ $\quad\phi_{wpp} = Z$ $\quad\phi_{mpp} = -I$

$\phi_{ym} = Z$ $\quad\phi_{wpm} = Z$ $\quad\phi_{mpm} = I$

Household Cons:

$$\hat{C}_t = \underbrace{\left[v - (v-\gamma)(1-\vartheta)\left(\frac{C^*}{X^*}\right)^{1-v}\right]^{-1}}_{A}\left[(\hat{\omega}_t - \hat{P}_t) - \varphi \hat{N}_t + (v-\gamma)\vartheta\left(\frac{M^*}{X^*}\right)^{1-v}(\hat{M}_t - \hat{P}_t)\right]$$

$$\phi_{cn} = A\left[\phi_{wpn} - \varphi I\right]$$

$$\phi_{cp} = A\left[\phi_{wpp} - (v-\gamma)\vartheta\left(\frac{M^*}{X^*}\right)^{1-v} I\right]$$

$$\phi_{cm} = A(v-\gamma)\vartheta\left(\frac{M^*}{X^*}\right)^{1-v} I$$

Household X:

$$\hat{X}_t = (1-\vartheta)\left(\frac{C^*}{X^*}\right)^{1-v}\hat{C}_t + \vartheta\left(\frac{M^*}{X^*}\right)^{1-v}(\hat{M}_t - \hat{P}_t)$$

$$\phi_{xn} = (1-\vartheta)\left(\frac{C^*}{X^*}\right)^{1-v}\phi_{cn}$$

$$\phi_{xp} = (1-\vartheta)\left(\frac{C^*}{X^*}\right)^{1-v}\phi_{cp} - \vartheta\left(\frac{M^*}{X^*}\right)^{1-v} I$$

$$\phi_{xm} = (1-\vartheta)\left(\frac{C^*}{X^*}\right)^{1-v}\phi_{cm} + \vartheta\left(\frac{M^*}{X^*}\right)^{1-v} I$$

Bonds Market:

$$\hat{Q}_t = -v(\hat{C}_t - \hat{C}_{t+1}) - (\hat{P}_t - \hat{P}_{t+1}) + (v-\gamma)(\hat{X}_t - \hat{X}_{t+1})$$

$$\phi_{qm} = -v\,\phi_{cn}(I - I\rho 1) + (v-\gamma)\,\phi_{xn}(I - I\rho 1)$$

$$\phi_{qp} = -v\,\phi_{cp}(I - I\rho 1) + (v-\gamma)\,\phi_{xp}(I - I\rho 1) - (I - I\rho 1)$$

$$\phi_{qm} = -v\,\phi_{cm}(I - I\rho 1) + (v-\gamma)\,\phi_{xm}(I - I\rho 1)$$

Market Clearing:

$$\left.\begin{aligned} 0 &= \hat{C}_t - \hat{Y}_t \\ 0 &= \hat{C}_t - \left(\frac{1}{v}\right)\left(\frac{\beta}{1-\beta}\right)\hat{Q}_t - (\hat{M}_t - \hat{P}_t) \end{aligned}\right\}$$

$\phi_{gmy} = -I$ $\quad\phi_{mmy} = Z$

$\phi_{gmwp} = Z$ $\quad\phi_{mmwp} = Z$

$\phi_{gmmp} = Z$ $\quad\phi_{mmmp} = Z - I$

$\phi_{gmc} = I$ $\quad\phi_{mmc} = I$

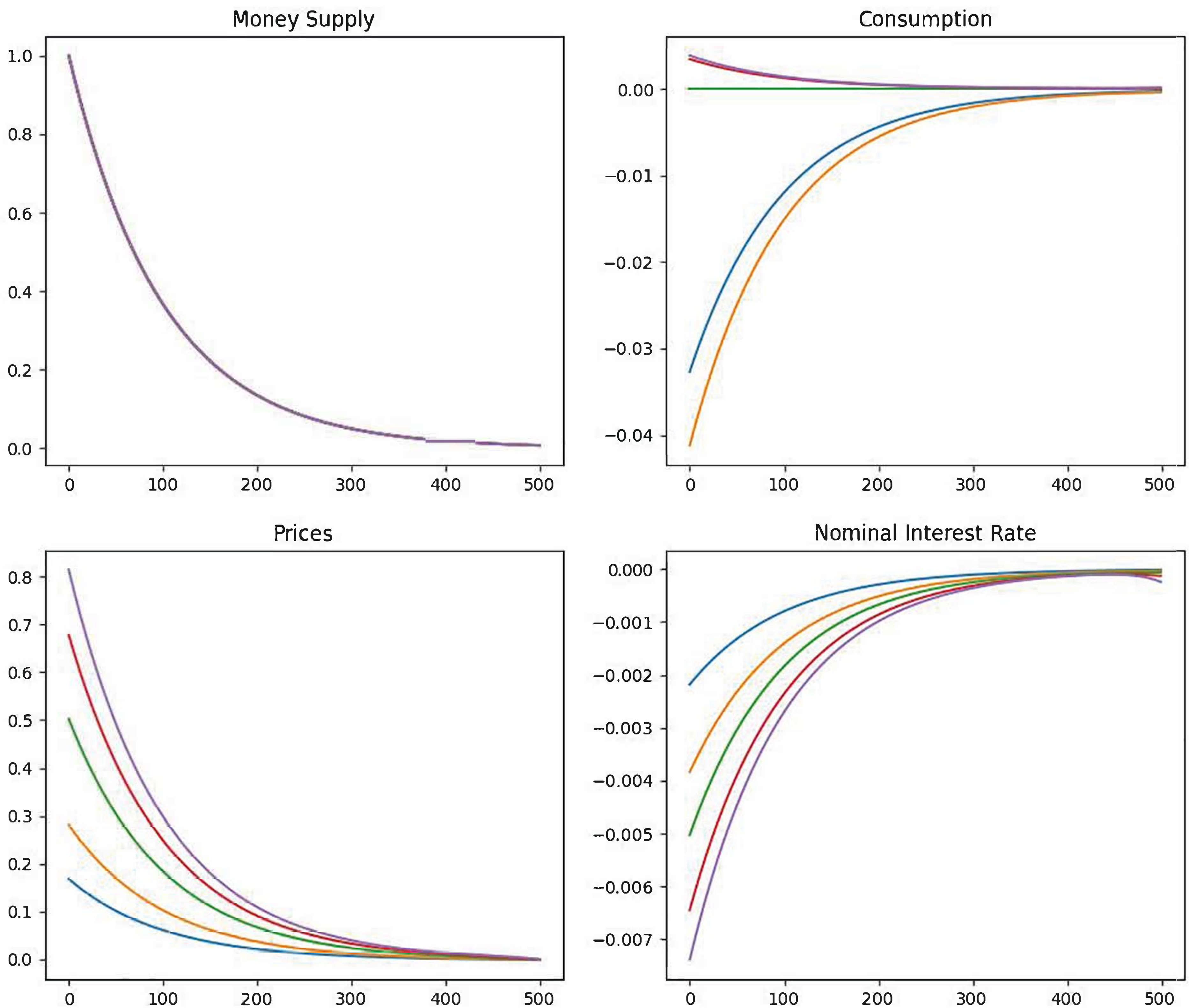
$\phi_{gmx} = Z$ $\quad\phi_{mmx} = Z$

$\phi_{gmq} = Z$ $\quad\phi_{mmq} = -\left(\frac{1}{v}\right)\left(\frac{\beta}{1-\beta}\right) I$

[Graphs in "IRFs"

0.25: blue, 0.5: orange, 1: green, 2: red, 4: purple]

0.25:blue
0.5 orange
1: green
2: red
4: purple



i) It makes sense that when money supply increases prices should increase as well. Similarly, when M and P both increase, it makes sense that the nominal interest rate should decrease since money is now worth "more". /y, the bond interest rates should decline.

Consumption affects depend on whether ν is <1, >1, $=1$

- $\nu < 1 \to (1-\nu) > 0$: the exponents on C and M in the X equation are positive. An increase in money supply decreases the MU of consumption so households lower consumption
- $\nu > 1 \to (1-\nu) < 0$: the exponents on C and M in the X equation are negative. Increasing money supply increases the MU of consumption. Households increase consumption
- $\nu = 1 \to \nu = \gamma$: neutrality of money! Increasing money supply has no effect on real variables