```
clear all
close all

% set parameters
beta = 0.995;
kappa = 1-40^(-1);
spF = 0.03;
spB = 0.01;
psi = 0.81;
epsip = 11;
epsiw = 11;
alpha = 1/3;
delta0 = 0.025;
g = 0.2;
bb = 0.8;
bcs = 0.1; % central bank balance sheet / Y
bcbGs = 0.9; % percentage of balance sheet holding government bonds
by = 0.5; % steady state government debt / GDP
levs = 5;
sigma = 0.95;

% solve for steady state
Rds = beta^(-1);
RFs = (1+spF)^(1/4)*Rds;
RBs = (1+spB)^(1/4)*Rds;
Qs = (RFs - kappa)^(-1);
QBs = (RBs - kappa)^(-1);
M1s = beta/(Qs*(1-beta*kappa));
M2s = 1 + (M1s-1)*psi;
pws = (epsip-1)/epsip;
Ks = (alpha*pws/(M2s*(1/beta - (1-delta0))))^(1/(1-alpha));
Ys = Ks^(alpha);
Is = delta0*Ks;
ws = (1-alpha)*pws*Ks^(alpha);
delta1 = (alpha*pws*Ks^(alpha-1)/M2s);
Cs = (1-g)*Ys - Is;
mus = (1/Cs)*(1-beta*bb)/(1-bb);
mrss = ((epsiw-1)/epsiw)*ws;
chi = mus*mrss;
fws = psi*Is/(Qs*(1-kappa));
res = bcs*Ys;
bcbs = bcbGs*res/QBs;
fcbs = (res - QBs*bcbs)/Qs;
fs = fws - fcbs;
bGs = by*Ys/QBs;
bs = bGs - bcbs;
ns = (Qs*fs + QBs*bs + res)/levs;
ds = Qs*fs + QBs*bs + res - ns;
Delta = (RBs - Rds)/(RFs - Rds);
phis = (Qs*fs + Delta*QBs*bs)/ns;
thetas = (1 - sigma + phis*beta*(1-sigma)*(RFs - Rds))/((1-sigma)*phis -
beta*sigma*phis^2*(RFs - Rds));
X = ns - sigma*( (RFs-Rds)*Qs*fs + (RBs - Rds)*QBs*bs + Rds*ns);
Omegas = 1 - sigma + sigma*phis*thetas;
lams = (thetas/(beta*(RFs - Rds)*(1-sigma + sigma*phis*thetas)) - 1)^(-1);

% parameters unrelated to steady state
phip = 0.75;
phiw = 0.75;
psik = 2; % capital adjustment cost
delta2 = 0.01; % squared term capital adjustment cost
eta = 1; % Frisch elasticity

% Taylor rule
rhor = 0.8;
phipi = 1.5;
phiy = 0.15;
sr = 0.0025;

```

```
% Shock processes
rhof = 0.97;
rhob = 0.97;
sf = 0.01;
sb = 0.01;
rhoA = 0.9;
sA = 0.01;
rhot = 0.95;
st = 0.01;
rhoG = 0.9;
sG = 0.01;
rhoB = 0.9;
sB = 0.9;

addpath('occbin_20140630\toolkit_files')
%addpath('functions')
nperiods=29;
maxiter=50;

modnam = 'sw_2020';
modnamstar = 'sw_2020_zlb';

constraint = 'Rre<-0.005';
constraint_relax = 'Rtr>-0.005';

save param_sw beta kappa spF spB psi epsip epsiw alpha delta0 g bb bcs bcbGs by levs
sigma Rds RFs RBs Qs QBs M1s M2s pws Ks Ys Is ws delta1 Cs mus mrss chi fws res bcbs
fcbs fs bGs bs ns ds Delta phis thetas X Omegas lams phip phiw psik delta2 eta rhor
phipi phiy sr rhof rhob sf sb rhoA sA rhot st rhoG sG rhoB sB

baseline1= zeros(10,3);

scenario= baseline1;
scenario(end,2) = 1;

baseline=baseline1;
baseline(1:9,1) = 25.5;



% Do private QE shocks
irfshock = char('et','ef');

%%%%%%%%%%%%% No ZLB
%%%%%%%%%%%%%%%%%%
% First time we solve simulation only with baseline shocks
[sim_MP] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline,irfshock,nperiods,maxiter);

% Second time we solve simulation with baseline shocks and scenario
[sim_MP2] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline+scenario,irfshock,nperiods,maxiter);
irf0 = sim_MP2 - sim_MP; % IRF with no Taylor rule

%%%%%%%%%%%%%%%% Impose ZLB
%%%%%%%%%%%%%%%%%%%%%%%%

shock_size = 1;
% First time we solve simulation only with baseline shocks
[~, sim_zlb] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline,irfshock,nperiods,maxiter);

% Second time we solve simulation with baseline shocks and scenario
```

```
[~, sim_zlb2] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline+scenario*shock_size,irfshock,nperiods,maxiter);



irf1 = sim_zlb2 - sim_zlb;

T = size(irf1(10:end,1),1);
t = 1:T;

% variable positions
pY = 49; % note this is log
pC = 50;
pI = 51;
pL = 52;
pPi = 53;
pRd = 54;


figure
subplot(2,3,1)
plot(t,irf0(10:end,pY),'-k',t,irf1(10:end,pY),'--k','Linewidth',1.5)
title('Output')

subplot(2,3,2)
plot(t,irf0(10:end,pC),'-k',t,irf1(10:end,pC),'--k','Linewidth',1.5)
title('Consumption')

subplot(2,3,3)
plot(t,irf0(10:end,pI),'-k',t,irf1(10:end,pI),'--k','Linewidth',1.5)
title('Investment')

subplot(2,3,4)
plot(t,irf0(10:end,pL),'-k',t,irf1(10:end,pL),'--k','Linewidth',1.5)
title('Labor')

subplot(2,3,5)
plot(t,irf0(10:end,pPi),'-k',t,irf1(10:end,pPi),'--k','Linewidth',1.5)
title('\pi')

subplot(2,3,6)
plot(t,irf0(10:end,pRd),'-k',t,irf1(10:end,pRd),'--k','Linewidth',1.5)
title('r^{d}')




% Do government spending shocks
irfshock = char('et','eG');

%%%%%%%%%%%%% No ZLB
%%%%%%%%%%%%%%%%%%
% First time we solve simulation only with baseline shocks
[sim_MP] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline,irfshock,nperiods,maxiter);

% Second time we solve simulation with baseline shocks and scenario
[sim_MP2] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline+scenario,irfshock,nperiods,maxiter);
irf0 = sim_MP2 - sim_MP; % IRF with no Taylor rule

%%%%%%%%%%%%%%%% Impose ZLB
%%%%%%%%%%%%%%%%%%%%%%%%
```

```
204
205   shock_size = 1;
206   % First time we solve simulation only with baseline shocks
207   [~, sim_zlb] = ...
208     solve_one_constraint(modnam,modnamstar,...
209     constraint, constraint_relax,...
210     baseline,irfshock,nperiods,maxiter);
211
212   % Second time we solve simulation with baseline shocks and scenario
213   [~, sim_zlb2] = ...
214     solve_one_constraint(modnam,modnamstar,...
215     constraint, constraint_relax,...
216     baseline+scenario*shock_size,irfshock,nperiods,maxiter);
217
218
219
220   irf1 = sim_zlb2 - sim_zlb;
221
222   T = size(irf1(10:end,1),1);
223   t = 1:T;
224
225   % variable positions
226   pY = 49; % note this is log
227   pC = 50;
228   pI = 51;
229   pL = 52;
230   pPi = 53;
231   pRd = 54;
232
233
234   figure
235   subplot(2,3,1)
236   plot(t,irf0(10:end,pY),'-k',t,irf1(10:end,pY),'--k','Linewidth',1.5)
237   title('Output')
238
239   subplot(2,3,2)
240   plot(t,irf0(10:end,pC),'-k',t,irf1(10:end,pC),'--k','Linewidth',1.5)
241   title('Consumption')
242
243   subplot(2,3,3)
244   plot(t,irf0(10:end,pI),'-k',t,irf1(10:end,pI),'--k','Linewidth',1.5)
245   title('Investment')
246
247   subplot(2,3,4)
248   plot(t,irf0(10:end,pL),'-k',t,irf1(10:end,pL),'--k','Linewidth',1.5)
249   title('Labor')
250
251   subplot(2,3,5)
252   plot(t,irf0(10:end,pPi),'-k',t,irf1(10:end,pPi),'--k','Linewidth',1.5)
253   title('\pi')
254
255   subplot(2,3,6)
256   plot(t,irf0(10:end,pRd),'-k',t,irf1(10:end,pRd),'--k','Linewidth',1.5)
257   title('r^{d}')
258
259
260   % Do credit shocks
261   irfshock = char('et','et2'); % note extra shock that is the same to rig this to work
262
263   %%%%%%%%%%%%% No ZLB
264   %%%%%%%%%%%%%%%%%%
265   % First time we solve simulation only with baseline shocks
266   [sim_MP] = ...
267     solve_one_constraint(modnam,modnamstar,...
268     constraint, constraint_relax,...
269     baseline,irfshock,nperiods,maxiter);
270
271   % Second time we solve simulation with baseline shocks and scenario
272   [sim_MP2] = ...
```

```
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline+scenario,irfshock,nperiods,maxiter);
irf0 = sim_MP2 - sim_MP; % IRF with no Taylor rule

%%%%%%%%%%%%%%% Impose ZLB
%%%%%%%%%%%%%%%%%%%%%

shock_size = 1;
% First time we solve simulation only with baseline shocks
[~, sim_zlb] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline,irfshock,nperiods,maxiter);

% Second time we solve simulation with baseline shocks and scenario
[~, sim_zlb2] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline+scenario*shock_size,irfshock,nperiods,maxiter);



irf1 = sim_zlb2 - sim_zlb;

T = size(irf1(10:end,1),1);
t = 1:T;

% variable positions
pY = 49; % note this is log
pC = 50;
pI = 51;
pL = 52;
pPi = 53;
pRd = 54;


figure
subplot(2,3,1)
plot(t,irf0(10:end,pY),'-k',t,irf1(10:end,pY),'--k','Linewidth',1.5)
title('Output')

subplot(2,3,2)
plot(t,irf0(10:end,pC),'-k',t,irf1(10:end,pC),'--k','Linewidth',1.5)
title('Consumption')

subplot(2,3,3)
plot(t,irf0(10:end,pI),'-k',t,irf1(10:end,pI),'--k','Linewidth',1.5)
title('Investment')

subplot(2,3,4)
plot(t,irf0(10:end,pL),'-k',t,irf1(10:end,pL),'--k','Linewidth',1.5)
title('Labor')

subplot(2,3,5)
plot(t,irf0(10:end,pPi),'-k',t,irf1(10:end,pPi),'--k','Linewidth',1.5)
title('\pi')

subplot(2,3,6)
plot(t,irf0(10:end,pRd),'-k',t,irf1(10:end,pRd),'--k','Linewidth',1.5)
title('r^{d}')

% Do productivity shocks
irfshock = char('et','eA');

%%%%%%%%%%%%%% No ZLB
%%%%%%%%%%%%%%%%%%%
% First time we solve simulation only with baseline shocks
[sim_MP] = ...
```

```
342     solve_one_constraint(modnam,modnamstar,...
343     constraint, constraint_relax,...
344     baseline,irfshock,nperiods,maxiter);
345
346   % Second time we solve simulation with baseline shocks and scenario
347   [sim_MP2] = ...
348     solve_one_constraint(modnam,modnamstar,...
349     constraint, constraint_relax,...
350     baseline+scenario,irfshock,nperiods,maxiter);
351   irf0 = sim_MP2 - sim_MP; % IRF with no Taylor rule
352
353   %%%%%%%%%%%%%%%% Impose ZLB
354   %%%%%%%%%%%%%%%%%%%%%
355
356   shock_size = 1;
357   % First time we solve simulation only with baseline shocks
358   [~, sim_zlb] = ...
359     solve_one_constraint(modnam,modnamstar,...
360     constraint, constraint_relax,...
361     baseline,irfshock,nperiods,maxiter);
362
363   % Second time we solve simulation with baseline shocks and scenario
364   [~, sim_zlb2] = ...
365     solve_one_constraint(modnam,modnamstar,...
366     constraint, constraint_relax,...
367     baseline+scenario*shock_size,irfshock,nperiods,maxiter);
368
369
370
371   irf1 = sim_zlb2 - sim_zlb;
372
373   T = size(irf1(10:end,1),1);
374   t = 1:T;
375
376   % variable positions
377   pY = 49; % note this is log
378   pC = 50;
379   pI = 51;
380   pL = 52;
381   pPi = 53;
382   pRd = 54;
383
384
385   figure
386   subplot(2,3,1)
387   plot(t,irf0(10:end,pY),'-k',t,irf1(10:end,pY),'--k','Linewidth',1.5)
388   title('Output')
389
390   subplot(2,3,2)
391   plot(t,irf0(10:end,pC),'-k',t,irf1(10:end,pC),'--k','Linewidth',1.5)
392   title('Consumption')
393
394   subplot(2,3,3)
395   plot(t,irf0(10:end,pI),'-k',t,irf1(10:end,pI),'--k','Linewidth',1.5)
396   title('Investment')
397
398   subplot(2,3,4)
399   plot(t,irf0(10:end,pL),'-k',t,irf1(10:end,pL),'--k','Linewidth',1.5)
400   title('Labor')
401
402   subplot(2,3,5)
403   plot(t,irf0(10:end,pPi),'-k',t,irf1(10:end,pPi),'--k','Linewidth',1.5)
404   title('\pi')
405
406   subplot(2,3,6)
407   plot(t,irf0(10:end,pRd),'-k',t,irf1(10:end,pRd),'--k','Linewidth',1.5)
408   title('r^{d}')
409
410   % Do public QE shocks
```

```
irfshock = char('et','eb');

%%%%%%%%%%%%% No ZLB
%%%%%%%%%%%%%%%%%%
% First time we solve simulation only with baseline shocks
[sim_MP] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline,irfshock,nperiods,maxiter);

% Second time we solve simulation with baseline shocks and scenario
[sim_MP2] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline+scenario,irfshock,nperiods,maxiter);
irf0 = sim_MP2 - sim_MP; % IRF with no Taylor rule

%%%%%%%%%%%%%%% Impose ZLB
%%%%%%%%%%%%%%%%%%%%%%%

shock_size = 1;
% First time we solve simulation only with baseline shocks
[~, sim_zlb] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline,irfshock,nperiods,maxiter);

% Second time we solve simulation with baseline shocks and scenario
[~, sim_zlb2] = ...
  solve_one_constraint(modnam,modnamstar,...
  constraint, constraint_relax,...
  baseline+scenario*shock_size,irfshock,nperiods,maxiter);



irf1 = sim_zlb2 - sim_zlb;

T = size(irf1(10:end,1),1);
t = 1:T;

% variable positions
pY = 49; % note this is log
pC = 50;
pI = 51;
pL = 52;
pPi = 53;
pRd = 54;


figure
subplot(2,3,1)
plot(t,irf0(10:end,pY),'-k',t,irf1(10:end,pY),'--k','Linewidth',1.5)
title('Output')

subplot(2,3,2)
plot(t,irf0(10:end,pC),'-k',t,irf1(10:end,pC),'--k','Linewidth',1.5)
title('Consumption')

subplot(2,3,3)
plot(t,irf0(10:end,pI),'-k',t,irf1(10:end,pI),'--k','Linewidth',1.5)
title('Investment')

subplot(2,3,4)
plot(t,irf0(10:end,pL),'-k',t,irf1(10:end,pL),'--k','Linewidth',1.5)
title('Labor')

subplot(2,3,5)
plot(t,irf0(10:end,pPi),'-k',t,irf1(10:end,pPi),'--k','Linewidth',1.5)
title('\pi')
```

```
480
481   subplot(2,3,6)
482   plot(t,irf0(10:end,pRd),'-k',t,irf1(10:end,pRd),'--k','Linewidth',1.5)
483   title('r^{d}')
484
485
```