```
%% Kooma-model file.
% Valtiovarainministeriö
% Kansantalousosasto
% Mika Kuismanen & Mikko Sariola &
% Samuli Pietiläinen September 2013

%----------------------------------
% Meri Obstbaum November 2013
% adds frictional labour market



%linear

!transition_variables

    %Households
    'Private consumption' cp
    'Transitory UIP shock process (risk premium)' i_e

    % Ricardian Households
    'Consumption of forward looking households' cp_fl
    'Marginal utility of consumption' muc
    'Shadow value of consumption' iso_lambda
    'Capital-labour ratio in production' k
    'Effective capital' K
    'Physical capital' Kp
    'Capacity utilisation rate' nu
    'Investment' ip
    'Rental rate on capital k' yint_roc
    'Real value of installed capital - Tobin Q' tobin_q
    'Nominal interest rate' i
    'Price of domestic wholesale good' pyint
    'Consumer price' p
    'CPI inflation' pie_p
    'Producer price inflation' pie_yint
    'Real price of K-L product' preal_kl
    'Price of K-L product in terms of the CPI' pyint_kl
    'Marginal productivity of capital' mpk
    'Shock process of household consumption' cp_fl_e
    'Shock process of investment adjustment costs' eps_ip
    'Shock process of Tobin Q ' eps_tobin_q
    'Process of TFP shock' yint_z
    'Operating surplus / dividents' D

    % Rule of thumb households
    'Consumption of hand-to-mouth households' cp_lc

    % Labour Market matching
    % PRODUCTION
    'Output of labour and capital intermediate' yint_kl
    'Aggregate output n*yint_kl' yint

    % LABOUR MARKET
    'number of matches' match
    'unemployment' u
```

```
    'Employment, number of workers' n
    'Working hours, per person' h
    'Total hours =n*h' total_h
    'Vacancies' v
    'job destruction rate' rhohat
    'firms vacancy-filling probability' qf
    'workers job-finding probability' qw
    'labour market tightness' theta
    'Shock process of labour shock' n_e

    % Wage bargaining
    'Firm surplus' J
    'Worker surplus' H
    'Marginal Productivity of Labour' mpl
    'Contract wage' w_contract
    'Nominal wage' w
    'Employers social contribution' tau_sc
    'Marginal rate of substitution btw consumption and labour' mrs
    'Workers tax on earned income' tau_w
    'Value added tax' tau_cp
    'Bargaining strenght of workers' etahat


    % Job creation and determination of hours worked (per person)
    'Vacancy posting cost' kappahat

    %Marginal cost of wholesale firm
    'price mark-up domestic market' yint_phi

    % RETAILERS, final goods producers
    %Retailer of investment good
    'price of composite investment good' pip
    'demand of domestic intermediate investment good' iph
    'imported investment good' mi

    %Importer price setting: consumption good
          'pcp price of imported consumption good' pmc_pcp     % PCP pri-
ce equation for imported intermediate input ($)
          'lcp price of imported consumption good' pmc_lcp     % LCP pri-
ce equation for imported intermediate input (€)
          'price of imported consumption good' pmc         % aggregate
import price equation of consumption good

    %Retailer of consumption good
    'price of composite consumption good' pcp
    'imported consumption good' mc
    %'price of domestic intermediate good' pcph
    'demand of domestic intermediate consumption good' cph

    %Retailer of export good
    'demand for imports used in exports' mex
    'demand for domestic goods used in exports' hex

    %Importer price setting: export good
```

```
    'PCP price of imported intermediate good used in exports ($)'
pmex_pcp
    'LCP price of imported intermediate good used in exports (€)'
pmex_lcp
    'price of composite import good used in exports' pmex

    % EXTERNAL SECTOR: Exports, imports

    %Total imports
    'imports' m
    'import price' pm


    %%Importer price setting: investment good
    'PCP price equation for imported intermediate input ($)' pmi_pcp
    'LCP price equation for imported intermediate input (€)' pmi_lcp
    'aggregate import price equation of investment good' pmi

    % Exports
    'marginal cost of exports' mcex
    'export market size' xd
    'aggregate export price level' px
    'LCP export price' px_lcp
    'PCP export price' px_pcp
    'aggregate exports' x
    'LCP export volume' x_lcp
    'PCP export volume' x_pcp
    'Foreign price level ($) competing with finnish exporters' f_pex
% one foreign price level, $ equal to f_pim

    % Some general variables
          'exchange rate' e
          'foreign price level ($) competing with finnish importers'
f_pim       % foreign price level

    'Trade balance' tb;
    'Foreign bond' BF;
    'Foreign interest rate' istar

    % Shock processes to imports and exports
    'Transitory price shock process to imported consumption goods' pmc_e
    'Transitory price shock process to mc of exports' mcex_e
    'Transitory price shock process to imported investment goods' pmi_e
    'Transitory price shock process to imported goods used in exports'
pmex_e
    'Transitory shock process to imported consumption goods' mc_e
    'Transitory shock process to imported investment goods' mi_e
    'Transitory shock process to imported goods used in exports' mex_e

    % Public sector / General government
    'General government bonds' BH
    'Tax on dividents' tau_d
    'Tax on investment/ investment tax credit' tau_ip
    'Tax on capital' tau_k
    'general government consumption (real)' cg
```

```
    'transfers to households' ott

    % Some reporting variables
    'General government income' GG_income
    'General government income, VAT' GG_income_VAT
    'General government income, tau_W+tau_SC' GG_income_W_SC
    'General government income, tau_W' GG_income_W
    'General government income, tau_SC' GG_income_SC
    'General government income, tau_D' GG_income_D

    'price of oil, $' poil
    'export price aggegation' px_e


     'general government investment (real)' ig

!transition_shocks

    'UIP shock (risk premium)' e_i_e
    'Transitory shock to investments' e_ip
    'Transitory shock to Tobin q' e_eps_q
    'Transitory household consumption preference shock' e_cp_fl
    'Transitory shock in productivity' e_yint_z
    'Labour shock' e_n
        'Shock to job destruction rate' e_rhohat
    'Shock to vacancy costs' e_kappahat
    'Shock to workers negotiation weight' e_etahat
    'Shock to average wage process' e_w
    'Shock to unemployment rate'e_u

    'Price markup shock of intermediate firm' e_yint_phi

    'exchange rate shock' e_e
    'foreign price shock' e_f_pim
    'export demand shock' e_xd
    'Price shock to imported consumption goods' e_pmc
    'Price shock to MC of exports' e_mcex
    'Price shock to imported investment goods' e_pmi
    'Price shock to imported goods used in exports' e_pmex
    'Shock to aggregate imports' e_m_e
    'Shock to imported consumption goods' e_mc_e
    'Shock to imported investment goods' e_mi_e
    'Shock to imported consumption goods used in exports' e_mex_e

          'Shock to wage tax parameter' e_tau_w
          'Shock to VAT tax parameter' e_tau_cp
    'Shock to capital tax' e_tau_k
    'Shock to employers social contributions' e_tau_sc
    'Shock to dividend tax' e_tau_d
    'Shock to investment tax or subsidy if minus sign' e_tau_ip
    'Shock to government transfers' e_ott
    'Shock to government consumption' e_cg
    'Shock to government investment' e_ig

    'Shock to oil price' e_poil
```

```
    'shock to export price aggregation' e_px


%

!parameters

    omega_lc                % share of liquidity constrained households,
set =0 with matching
    istar_ss                % SS foreign interest rate
    gamma_sastar            % debt elastic interest rate penalty parame-
ter
    rho_i_e                 % AR-coefficient of UIP shock process
    tau_cp_ss               % SS VAT on consumption
    sigma_cp                % household risk aversion
    varkappa                % habit persistence
    rho_cp_fl_e             % AR coefficient of consumption shock
    beta                    % discount factor
    cp_ss                   % SS consumption
    cp_lc_ss                % SS consumption of liquidity constraint hou-
seholds
    cp_fl_ss                % SS consumption of forward-looking house-
holds
    ott_ss                  % SS transfers to households
    % Investment and capital
    %-----------------------
    kappa_i                 % investment adjustment cost parameter
    rho_ip                  % AR coefficient of investment shock
    delta_k                 % depreciation of capital
    gamma_yint              % share of capital in intermediate goods pro-
duction
    eta_nu                  % capital utilization rate
    yint_roc_ss             % SS return on capital
    rho_tobin_q             % AR coefficient of equity premium shock
    rho_z                   % AR coefficient of transitory technology
shock
    % Labour market matching and wage bargaining
    %-------------------------------------------
    sigma_M                 % elasticity of matches w.r.t. unemployment
    rho                     % SS job destruction rate
    match_ss                % SS matches
    n_ss                    % SS employment
    u_ss                    % SS unemployment
    pyint_kl_ss             % SS price of K-L good, = preal_kl_ss
    mpl_ss                  % SS marginal productivity of labour
    h_ss                    % SS hours worked per person
    J_ss                    % SS firm surplus
    w_ss                    % SS wage
    b                       % unemployment benefit
    tau_sc_ss               % SS employer's social contribution
    k_ss                    % SS operative capital
    tau_w_ss                % SS worker's tax on earned income
    H_ss                    % SS worker surplus
    mrs_ss                  % SS marginal rate of substitution
```

```
    sigma_n                 % Frish elasticity of labour
    qw_ss                   % SS job-finding probability
    eta                     % SS bargaining power
    omega_w                 % Weight of contract wage
    rho_n_e                 % AR of labour supply shock
    rho_rhohat              % AR of job destruction shock
    rho_kappahat            % AR of vacancy cost shock
    rho_etahat              % AR of shock to workers' negotiation weight
    % Wholesale firm
    %---------------
    rho_yint_phi            % AR-coeff. of markup shock%
    pyint_ksi               % probability of taking the price as given
(calvo)
    pyint_ss                % SS price of domestic intermediate input
SAMULI
    yint_ss                 % SS production of intermediate firm

    %-----------------------------------
          f_pim_ss        % foreign SS price level ($) for intermediate
import input market.
    rhoe            % ar coefficient in exchange rate shock
    rho_f_pim       % ar coefficient in foreign price shock
    i_ss            % SS nominal interest rate
    % importer price setting: investment good
    %---------------------------------------
    omegai          % share of LCP importing firms. (1-omegai) is the
share of pcp firms
    gammai_lcp      % calvo parameter, share of LCP import firms that are
NOT allowed to change price at period t
    gammai_pcp      % calvo parameter, share of PCP import firms that are
NOT allowed to change price at period t

    % retailer of investment good
    thetaip         % demand elasticity for domestic and foreign interme-
diate investment good
    omegaip         % share of domestic intermediate investment good in
production of composite investment good

          % Importer price setting: consumption good
    %---------------------------------------

          omegac          % share of LCP importing firms. (1-omegac) is
the share of pcp firms
          gammac_lcp      % calvo parameter, share of LCP import firms
that are NOT allowed to change price at period t
          gammac_pcp      % calvo parameter, share of PCP import firms
that are NOT allowed to change price at period t

    %Retailer of consumption good
    thetacp         % demand elasticity for domestic and foreign interme-
diate consumption good
    omegacp         % share of domestic intermediate consumtion good in
production of composite consumption good

    %Exporter
```

```
    %------------

    gammax_pcp      % calvo parameter, share of PCP firms that are NOT
allowed to change price at period t,
    gammax_lcp      % calvo parameter, share of LCP firms that are NOT
allowed to change price at period t
    omegax          % share of LCP firms in exports
    thetax          % price elasticity of demand for the export product.
Determined by rhox
    x_ss            % SS of exports
    rhoxd           % ar-parameter of foreign market shock

    rhostar
    thetaex
    deltaex
    mex_ss

    %Importer price setting: export good
    %-----------------------------------
    mcex_ss         % SS marginal cost of exports
    pmex_ss         % aggregate steady state import price level for goods
used in export production(€)
    omegaex         % share of LCP importing firms. (1-omegaex) is the
share of pcp firms
    gammaex_lcp     % calvo parameter, share of LCP import firms that are
NOT allowed to change price at period t
    gammaex_pcp     % calvo parameter, share of PCP import firms that are
NOT allowed to change price at period t

    m_ss            % SS imports
    mc_ss           % SS imported C goods share of total imports
    mi_ss           % SS imported I goods share of total imports

    rho_pmc_e       % ar coefficient in imported consumption good price
shock
    rho_mcex_e      % ar coefficient in mc of exports shock
    rho_pmi_e       % ar coefficient in imported investment good price
shock
    rho_pmex_e      % ar coefficient in imported goods used in exports
price shock
    rho_mc_e        % the following 3 are ar's of import volume shocks
    rho_mi_e
    rho_mex_e

    % Public sector
    %--------------
    BH_ss           % General government bonds in SS
    tau_d_ss        % Tax on dividents in SS
    tau_k_ss        % Tax on effective capital in SS
    tau_ip_ss       % Tax on investments in SS
    rho_cg          % AR of public spending shock
    rho_ig          % AR of public investment shock
    rho_ott         % AR-coeff of transfers to households (ott_e) shock
    rho_tau_w
    rho_tau_cp
```

```
    rho_tau_k
    rho_tau_sc
    rho_tau_d
    rho_tau_ip

    rho_poil

    % Closing the model
    %------------------
    ip_ss           % Investment in SS
    cg_ss           % Government consumption
    ig_ss           % Government investment
    v_ss            % Vacancies in SS
    kappa           % Vacancy posting cost in SS
    K_ss            % Effective capital in SS
    rho_istar       % AR coefficient of foreign interest
    D_ss            % Dividends in SS
    total_h_ss      % Total hours worked in SS

    % shock magnitude parameters
    std_e_rhohat    % std error of job destruction shock
    std_e_kappahat  % std error of vacancy cost shock
    std_e_etahat    % std error of shock to negotiation weight
    std_e_pmc       % st. error of the shock
    std_e_mcex      % st. error of the shock
    std_e_pmi       % st. error of the shock
    std_e_pmex      % st. error of the shock
    std_e_m_e
    std_e_mc_e
    std_e_mi_e
    std_e_mex_e
    std_e_e         % st. error of the shock
    std_e_f_pim     % st. error of the shock

    std_e_i_e       % st. error of the shock
    std_e_xd        % st. error of the shock
    std_e_px

    std_e_n


    std_e_ott       % St. error of transfers to households (ott_e) shock
    std_e_tau_w
    std_e_tau_k
    std_e_tau_cp
    std_e_tau_sc
    std_e_tau_d
    std_e_tau_ip
    std_e_cg




!transition_equations
```

```
%% Debt-elastic interest rate

    i=istar-gamma_sastar*(BF-yint-pyint)+i_e;



    i_e=rho_i_e*i_e{-1}+e_i_e;

    poil = rho_poil*poil{-1}+e_poil;

%% Ricardian Households



    % Consumption
    iso_lambda = iso_lambda{+1}+i-(p{+1}-p);             % Euler equation
    iso_lambda = muc-(tau_cp_ss)/(1+tau_cp_ss)*tau_cp;   % Marginal uti-
lity of wealth
    muc = -((sigma_cp)/(1-varkappa))*(cp_fl-varkappa*cp_fl{-1})+cp_fl_e;
% where muc is marginal utility of consumption

    % Investment and capital accumulation
    nu = eta_nu*yint_roc;                                % Capital utili-
zation rate
    ip = (1/(1+beta))*ip{-
1}+(beta/(1+beta))*ip{+1}+(1/(1+beta))*(1/kappa_i)*tobin_q-
(1/(1+beta))*(beta*eps_ip{+1}-eps_ip); % Investment
    Kp = (1-delta_k)*Kp{-1}+delta_k*ip{-1};              % (physical)
Capital accumulation equation
    K = nu+Kp{-1};                                       % Effective ca-
pital
    tobin_q = -(i-(p{+1}-p))+((1-delta_k)/(1-
delta_k+yint_roc_ss))*tobin_q{+1}+((yint_roc_ss)/(1-
delta_k+yint_roc_ss))*yint_roc{+1}+eps_tobin_q; % Real value of capital,
Tobin Q
    yint_roc = pyint_kl+mpk;                             % Rental rate
for capital
    pyint_kl = pyint-p+preal_kl;
    mpk = (1-gamma_yint)*(h-k)+yint_z;
    k = K-n;                                             % Capital-Labour
ratio

    % shocks
    cp_fl_e=rho_cp_fl_e*cp_fl_e{-1}+e_cp_fl;             % AR consumption
shock process
    eps_ip=rho_ip*eps_ip{-1}+e_ip;                       % Investment
AR1-Shock
    eps_tobin_q = rho_tobin_q*eps_tobin_q{-1}+e_eps_q;   %
    yint_z=rho_z*yint_z{-1}+e_yint_z;                    % Technology
shock

%% Rule of thumb households


    %Liquidity constrained households consume all their income
```

```
     cp_lc = ((n_ss*w_ss*h_ss*(1-
tau_w_ss))/((1+tau_cp_ss)*cp_lc_ss))*(w+h) + ((n_ss*(w_ss*h_ss*(1-
tau_w_ss)-b))/((1+tau_cp_ss)*cp_lc_ss))*n +
(ott_ss/((1+tau_cp_ss)*cp_lc_ss))*ott
    - (1-((b*(1-n_ss))/((1+tau_cp_ss)*cp_lc_ss)))*p -
(tau_cp_ss/(1+tau_cp_ss))*tau_cp -
((n_ss*w_ss*h_ss*tau_w_ss)/((1+tau_cp_ss)*cp_lc_ss))*tau_w;

    % Aggregate consumption
    cp = ((omega_lc*cp_lc_ss)/cp_ss)*cp_lc + (((1-
omega_lc)*cp_fl_ss)/cp_ss)*cp_fl;


    %% Labour Market matching

% On intermediate firms:
    % Matching and employment dynamics
    match = sigma_M*u+(1-sigma_M)*v ;                    % Nr of new mat-
ches in each period
    n = (1-rho)*n{-1}+(match_ss/n_ss)*match{-1}-rho*rhohat ;     % Total
nr of matches that enter each period = employment
    u = -((1-u_ss)/u_ss)*n + e_u ;                                % unem-
ployment, e_u added to be able to exogenise in conditional forecast
    qf = match-v ;                                                % vacancy-
filling probability
    qw = match-u ;                                                % job-
finding probability
    theta = v-u ;                                        % labour market
tightness
    rhohat = rho_rhohat*rhohat{-1}+e_rhohat ;                % Shock to
job destruction rate
    %rhohat = -7.79*yint_z+e_rhohat ;

 %% Wage bargaining

%


    % Firm surplus
    J = ((pyint_kl_ss*mpl_ss*h_ss)/((1-
gamma_yint)*J_ss))*(pyint_kl+mpl+h)-
((w_ss*h_ss*(1+tau_sc_ss))/J_ss)*(w+h-p)
-((w_ss*h_ss*tau_sc_ss)/J_ss)*tau_sc-
(((yint_roc_ss)*k_ss)/J_ss)*(yint_roc+k)+(beta*(1-
rho))*(J{+1}+iso_lambda{+1}-iso_lambda)
-(beta*rho)*(rhohat{+1});

    % where the marginal productivity of labour is
%    mpl = gamma_yint*(k-h)+yint_z
    mpl = gamma_yint*(k-h)+yint_z ;

    % Worker surplus
    H = ((w_ss*h_ss*(1-tau_w_ss))/H_ss)*(w+h-p)-
((w_ss*h_ss*tau_w_ss)/H_ss)*tau_w-
((mrs_ss*h_ss*(1+tau_cp_ss))/((1+sigma_n)*H_ss))*(mrs+h)
```

```
-((mrs_ss*h_ss*tau_cp_ss)/((1+sigma_n)*H_ss))*tau_cp+(beta*(1-rho-
qw_ss))*(H{+1}+iso_lambda{+1}-iso_lambda)-(beta*rho)*rhohat{+1}-
(beta*qw_ss)*qw;

    % where the marginal rate of substitution is
    mrs = sigma_n*h+(1-sigma_n)*n_e-muc;


    % Negotiated wage
    w_contract = ((eta*pyint_kl_ss*mpl_ss)/((1+tau_sc_ss)*(1-
gamma_yint)*w_ss))*(pyint_kl+mpl)-
((eta*yint_roc_ss*k_ss)/(w_ss*h_ss*(1+tau_sc_ss)))*(yint_roc+k)
+(((1-eta)*H_ss*beta*qw_ss)/(w_ss*h_ss*(1-
tau_w_ss)))*(H{+1}+iso_lambda{+1}-iso_lambda+qw)+(((1-
eta)*mrs_ss*(1+tau_cp_ss))/((1-tau_w_ss)*(1+sigma_n)*w_ss))*mrs
-(1-((eta*pyint_kl_ss*mpl_ss)/((1+tau_sc_ss)*(1-gamma_yint)*w_ss))-(((1-
eta)*mrs_ss*(1+tau_cp_ss))/((1-tau_w_ss)*(1+sigma_n)*w_ss)))*h
+((((1-eta)*tau_w_ss)/(1-tau_w_ss))*(1-(H_ss/(w_ss*h_ss*(1-
tau_w_ss)))))*tau_w
+((((1-eta)*tau_w_ss)/(1-tau_w_ss))*((H_ss*beta*(1-rho))/(w_ss*h_ss*(1-
tau_w_ss))))*tau_w{+1}
-
(((eta*tau_sc_ss)/(1+tau_sc_ss))*(1+(J_ss/(w_ss*h_ss*(1+tau_sc_ss)))))*ta
u_sc
+(((eta*tau_sc_ss)/(1+tau_sc_ss))*((J_ss*beta*(1-
rho))/(w_ss*h_ss*(1+tau_sc_ss))))*tau_sc{+1}
+(((1-eta)*mrs_ss*tau_cp_ss)/((1-tau_w_ss)*(1+sigma_n)*w_ss))*tau_cp
+(1/(1-eta))*etahat-((H_ss*beta*(1-rho))/(w_ss*h_ss*(1-
tau_w_ss)))*etahat{+1}+p;

    % Average wage
    w = omega_w*w_contract + (1-omega_w)*w{-1} + e_w;

    % Shock to workers' negotiation weight
    etahat = rho_etahat*etahat{-1}+e_etahat;

    % Hours supply shock process
    n_e=rho_n_e*n_e{-1}+e_n;

%% Job creation and determination of hours worked (per person)
%--------------------------
%
% Comments here

    % Vacancy posting / job creation condition (analogous to labour de-
mand in conventional models
    kappahat-qf = J{+1}+iso_lambda{+1}-iso_lambda;

    % Hours worked xmpl(1-tau_w)=mrs(1+tau_sc)(1+tau_cp)
    pyint_kl+mpl = mrs+(tau_w_ss/(1-
tau_w_ss))*tau_w+(tau_sc_ss/(1+tau_sc_ss))*tau_sc+(tau_cp_ss/(1+tau_cp_ss
))*tau_cp;

    % Shock to vacancy costs
    kappahat = rho_kappahat*kappahat{-1}+e_kappahat;
```

```
%

%% Wholesale firm, price setting
%------------------------------


    % New Keynesian Phillips curve
    pie_yint = (((1-pyint_ksi)*(1-
(pyint_ksi*beta)))/pyint_ksi)*(preal_kl+yint_phi)+beta*pie_yint{1};
    pie_yint = pyint-pyint{-1};
    yint_phi = rho_yint_phi*yint_phi{-1}+e_yint_phi;



%% External sector: Imports, Exports
%
% Comments here
%

    % Aggregate imports

    m = (mex_ss/m_ss)*mex+(mc_ss/m_ss)*mc+(mi_ss/m_ss)*mi+e_m_e;

    pm = (mex_ss/m_ss)*pmex+(mc_ss/m_ss)*pmc+(mi_ss/m_ss)*pmi;

    % Importer price setting: INVESTMENT good

    pmi = omegai*pmi_lcp - omegai*e +(1-omegai)*pmi_pcp + pmi_e; % aggre-
gate
    pmi_lcp - pmi_lcp{-1} = (1/(1+beta))*(pmi_lcp{-1} - pmi_lcp{-2}) +
(((1-gammai_lcp)*(1-beta*gammai_lcp))/((1+beta)*gammai_lcp))*(f_pim-e-
pmi_lcp)+(beta/(1+beta))*(pmi_lcp{+1}-pmi_lcp); %LCP
    pmi_pcp - pmi_pcp{-1} = (1/(1+beta))*(pmi_pcp{-1} - pmi_pcp{-2}) +
(((1-gammai_pcp)*(1-beta*gammai_pcp))/((1+beta)*gammai_pcp))*(f_pim-
pmi_pcp)+(beta/(1+beta))*(pmi_pcp{+1}-pmi_pcp); %PCP
    pmi_e = rho_pmi_e*pmi_e{-1} + e_pmi;

    % Importer price setting: CONSUMPTION good

    pmc = omegac*pmc_lcp - omegac*e +(1-omegac)*pmc_pcp +0.0463*poil +
pmc_e;
          pmc_lcp - pmc_lcp{-1} = (1/(1+beta))*(pmc_lcp{-1} - pmc_lcp{-
2})  + (((1-gammac_lcp)*(1-
beta*gammac_lcp))/((1+beta)*gammac_lcp))*(f_pim-e-
pmc_lcp)+(beta/(1+beta))*(pmc_lcp{+1}-pmc_lcp); %LCP
          pmc_pcp - pmc_pcp{-1} = (1/(1+beta))*(pmc_pcp{-1} - pmc_pcp{-
2}) + (((1-gammac_pcp)*(1-
beta*gammac_pcp))/((1+beta)*gammac_pcp))*(f_pim-
pmc_pcp)+(beta/(1+beta))*(pmc_pcp{+1}-pmc_pcp); %PCP
          pmc_e = rho_pmc_e*pmc_e{-1} + e_pmc;

    % Importer price setting: EXPORT good
```

```
    pmex = omegaex*pmex_lcp - omegaex*e +(1-omegaex)*pmex_pcp
+0.1043*poil + pmex_e;      % aggregate import price equation that com-
bines PCP and LCP price levels
    pmex_lcp - pmex_lcp{-1} = (1/(1+beta))*(pmex_lcp{-1} - pmex_lcp{-2})
+ (((1-gammaex_lcp)*(1-beta*gammaex_lcp))/((1+beta)*gammaex_lcp))*(f_pim-
e-pmex_lcp)+(beta/(1+beta))*(pmex_lcp{+1}-pmex_lcp);
    pmex_pcp - pmex_pcp{-1} = (1/(1+beta))*(pmex_pcp{-1} - pmex_pcp{-2})
+ (((1-gammaex_pcp)*(1-beta*gammaex_pcp))/((1+beta)*gammaex_pcp))*(f_pim-
pmex_pcp)+(beta/(1+beta))*(pmex_pcp{+1}-pmex_pcp);
    pmex_e = rho_pmex_e*pmex_e{-1} + e_pmex;        % price shock AR to
imported good used in exports

    % Export price setting
    px = omegax*px_lcp - omegax*e+(1-omegax)*px_pcp + px_e;
    px_lcp - px_lcp{-1} = (1/(1+beta))*(px_lcp{-1} - px_lcp{-2}) + (((1-
gammax_lcp)*(1-beta*gammax_lcp))/((1+beta)*gammax_lcp))*(mcex -e -
px_lcp)+(beta/(1+beta))*(px_lcp{+1}-px_lcp);
    px_pcp - px_pcp{-1} = (1/(1+beta))*(px_pcp{-1} - px_pcp{-2}) + (((1-
gammax_pcp)*(1-beta*gammax_pcp))/((1+beta)*gammax_pcp))*(mcex-
px_pcp)+(beta/(1+beta))*(px_pcp{+1}-px_pcp);
    %px = omegax*px_lcp +(1-omegax)*px_pcp;  % aggregate export price
equation that combines PCP and LCP price levels
    px_e = rho_pmex_e*px_e{-1} + e_px;


    % Exchange rate shock
    e = rhoe*e{-1}+e_e;
    f_pim = rho_f_pim*f_pim{-1}+e_f_pim; % foreign price shock
    f_pex = f_pim; %


%% Final goods producers
%
% Comments here
% The public consumption-good is in the section on the public sector

    % Investment good retailer
    iph = thetaip*(pip-pyint)+ip;                   % demand for domestic
intermediate good in investment-good production
    mi = thetaip*(pip-pmi)+ip + mi_e;               % demand for foreign
intermediate good in investment-good production
    mi_e= rho_mi_e*mi_e{-1} + e_mi_e;               % shock to the volume
of imported investment good
    pip = omegaip*pyint+(1-omegaip)*pmi;            % price of composite
investment good

    % Consumption good retailer
    cph = thetacp*(pcp-pyint)+cp;                   % demand for domestic
intermediate good
    mc = thetacp*(pcp-pmc)+cp+mc_e;                 % demand for foreign
intermediate good
    mc_e= rho_mc_e*mc_e{-1} + e_mc_e;               % shock to the volume
of imported consumption good
    pcp = omegacp*pyint+(1-omegacp)*pmc;            % price of composite
consumption good = CPI
```

```
    % Export good retailer: volumes
    hex   = thetaex*(mcex-pyint)+x;                    % demand for domes-
tic intermediate good used in exports
    mex   = thetaex*(mcex-pmex)+x+mex_e;               % demand for impor-
ted foreign goods used in export-good production
    mex_e= rho_mex_e*mex_e{-1} + e_mex_e;          % shock to the volume
of imported export good
    % Export good retailer: marginal costs
    mcex = ((delta-
ex^thetaex)*(pyint_ss/mcex_ss)^(rhostar/(rhostar+1)))*pyint + (((1-
deltaex)^thetaex)*(pmex_ss/mcex_ss)^(rhostar/(rhostar+1)))*pmex + mcex_e
;% mcex of exports
    mcex_e = rho_mcex_e*mcex_e{-1} + e_mcex;       % Price shock to mar-
ginal costs of exports

    % Export volumes
    x_lcp = thetax*(f_pex-px_lcp)+xd;              % LCP export demand
equation
    x_pcp = thetax*(f_pex-px_pcp-e)+xd;            % PCP export demand
equation

    % CHECK THESE
    % aggr. export demand = aggr. export supply, i.e. the aggregator!
    x  = omegax*x_lcp+(1-omegax)*x_pcp;            % aggregate export
demand, assumes linear combination
    xd = rhoxd*xd{-1}+e_xd;                        % Export demand /
foreign market AR



%% Public sector
%
% General government

    % Government budget constraint / Evolution of gvmt REAL debt

 BH = i_ss*(BH{-1}+i-pie_p) + (cg_ss/BH_ss)*(pyint+cg) +
((b*u_ss*u)/BH_ss) + ((-cg_ss-ig_ss-ott_ss)/BH_ss)*p +
(ig_ss/BH_ss)*(pyint+ig)
+ (ott_ss/BH_ss)*ott -
(((n_ss*w_ss*h_ss)*(tau_w_ss+tau_sc_ss))/BH_ss)*(n+w+h) -
((n_ss*w_ss*h_ss*tau_w_ss)/BH_ss)*tau_w
- ((n_ss*w_ss*h_ss*tau_sc_ss)/BH_ss)*tau_sc -
((tau_cp_ss*cp_ss)/BH_ss)*(tau_cp+cp) - ((tau_d_ss*D_ss)/BH_ss)*(tau_d+D)
- ((yint_roc_ss*tau_k_ss*K_ss)/BH_ss)*(yint_roc+tau_k+K);



    % where dividends to domestic households
    (D_ss/yint_ss)*D = yint -
(((1+tau_sc_ss)*w_ss*total_h_ss)/(yint_ss))*(w+total_h) -
((tau_sc_ss*w_ss*total_h_ss)/(yint_ss))*(tau_sc)
    -(yint_roc_ss*K_ss/yint_ss)*(yint_roc+K)+(1-
(kappa*v_ss/yint_ss))*pyint_kl-(kappa*v_ss/yint_ss)*(kappahat+v)
```

```
    +(x_ss/yint_ss)*px-(mcex_ss*x_ss/yint_ss)*mcex+((1-
mcex_ss)*x_ss/yint_ss)*x+(m_ss/yint_ss)*pm-
(f_pim_ss*m_ss/yint_ss)*f_pim+(1-f_pim_ss/yint_ss)*m_ss*m;

    % For reporting purposes: General government income
    GG_income= (tau_cp_ss*cp_ss)*(tau_cp+p+cp) +
(tau_ip_ss*ip_ss)*(tau_ip+pip+ip) +
                (n_ss*w_ss*h_ss*tau_sc_ss)*(tau_sc+n+w+h) +
(n_ss*w_ss*h_ss*tau_w_ss)*(tau_w+n+w+h) +
                (yint_roc_ss*tau_k_ss*K_ss)*(yint_roc+tau_k+K) +
(D_ss*tau_d_ss)*(tau_d+D);

    GG_income_VAT = (tau_cp_ss*cp_ss)*(tau_cp+p+cp);
    GG_income_W_SC = (n_ss*w_ss*h_ss*tau_sc_ss)*(tau_sc+n+w+h) +
(n_ss*w_ss*h_ss*tau_w_ss)*(tau_w+n+w+h);
    GG_income_W = (n_ss*w_ss*h_ss*tau_w_ss)*(tau_w+n+w+h);
    GG_income_SC = (n_ss*w_ss*h_ss*tau_sc_ss)*(tau_sc+n+w+h);
    GG_income_D = (D_ss*tau_d_ss)*(tau_d+D);

    % Expenditure
    ott = rho_ott*ott{-1}+e_ott;


    cg = rho_cg*cg{-1}+e_cg;
    % Revenue

   ig = rho_ig*ig{-1}+e_ig;


    tau_w = rho_tau_w*tau_w{-1} + e_tau_w;


    tau_cp = rho_tau_cp*tau_cp{-1} + e_tau_cp;


    tau_k = rho_tau_k*tau_k{-1} + e_tau_k;
    tau_sc = rho_tau_sc*tau_sc{-1} + e_tau_sc;
    tau_d = rho_tau_d*tau_d{-1} + e_tau_d;
    tau_ip = rho_tau_ip*tau_ip{-1} + e_tau_ip;


%% Closing the model
%
% Comments here
%

    % Trade Balance

    tb = yint - cp_ss*cp - ip_ss*ip - cg_ss*cg + ((1-mcex_ss)*x_ss)*x +
((1-f_pim_ss)*m_ss)*m + x_ss*px - (mcex_ss*x_ss)*mcex
    + m_ss*pm - (f_pim_ss*m_ss)*f_pim - cp_ss*p - ip_ss*pip + (1-cg_ss-
(kappa*v_ss))*pyint -(kappa*v_ss)*(kappahat+v) - (yint_roc_ss*K_ss)*nu;

    BF = tb + i_ss*istar{-1}+i_ss*(1-gamma_sastar)*BF{-1} +
i_ss*gamma_sastar*f_pim{-1} + i_ss*gamma_sastar*yint{-1};
```

```
    istar=rho_istar*istar{-1}+i_e;

    % Economy wide resource constraint

    yint = (omegacp*cp_ss)*cp + (omegacp*cp_ss*thetacp)*p + (ome-
gaip*ip_ss)*ip + (omegaip*ip_ss*thetaip)*pip + (omegaex*x_ss)*x + (omega-
ex*x_ss*thetaex)*px
    + cg_ss*cg - (ome-
gacp*cp_ss*thetacp+omegaip*ip_ss*thetaip+omegaex*x_ss*thetaex)*pyint;

    %Production
    yint_kl = gamma_yint*k+(1-gamma_yint)*h+yint_z;
    yint = n+yint_kl;
    total_h=n + h;

    p = pcp;
    pie_p = p-p{-1};




%% Measurement / Data
%
% Comments here
%

!measurement_variables

    'Consumption' cp_
    'Output' yint_
    'Imports' m_
    'Exports' x_
    'Private investment' ip_

    'Interest rate' i_
    'Nominal wage' w_
    'Exchange rate' e_
    'Consumption good price level' pcp_

    'Labour force, total hours' total_h_
    'Unemployment' u_
    'Operating surplus / Dividents (nominal)' D_

    'Import price level' pm_   %%%hankala
    'Export price level' px_   %%%hankala
    'price of composite investment good' pip_
    'Foreign price level ($) competing with finnish importers' f_pim_
%%%hankala
    'Foreign price level ($) competing with finnish exporters' f_pex_
%%
    'External demand' xd_
    'Price of imported consumption good' pmc_
```

```
    'Price of imported investment good' pmi_
    'Price of imported good used in exports' pmex_

    'General government consumption (real)' cg_

    'Price of oil' poil_



!measurement_shocks

 'measurement error on foreign prices competing with importers' m_f_pim
 'measurement error on foreign prices competing with exporter' m_f_pex
 'measurement error on price of imported consumption good' m_pmc
 'measurement error on price of imported investment good' m_pmi
 'measurement error on price of imported good used in exports' m_pmex
 'measurement error on external demand' m_xd
 'measurement error on output' m_yint

!measurement_equations


    cp_ = cp;
    yint_ = yint;
    m_ = m;
    x_ = x;
    ip_ = ip;
    e_ = e;
    i_ = i;
    w_ = w;
    pcp_ = pcp;
    total_h_ = total_h;
    u_ = u;
    D_ = D; %osv
    cg_ = cg;
    pm_ = pm;
    px_ = px;
    pip_ = pip; %
    f_pim_ = f_pim+m_f_pim;
    f_pex_ = f_pex +m_f_pex; %
    xd_ = xd+m_xd;   %

    pmc_ = pmc + m_pmc;  %
    pmi_ = pmi+ m_pmi; %
    pmex_ = pmex+ m_pmex ; %

    poil_ = poil;



%%
%% Set parameters

omega_lc = 0.2 ;         % share of liquidity constrained households
i_ss=0.03/4 ;          % SS nominal interest rate
```

```
istar_ss = i_ss ;      % SS foreign interest rate

gamma_sastar = 0.01 ;    % debt elastic interest rate penalty parameter
rho_i_e = 0.8;           % AR-coefficient of UIP shock process
tau_cp_s = 0.11;         % " SS VAT on consumption"
sigma_cp = 1.6;          % household risk aversion
varkappa = 0.6;          % habit persistence
rho_cp_fl_e = 0.8;       % AR coefficient of consumption shock
beta = 0.99;             % discount factor
BH_ss = 0.6;             % SS gvmt debt

       % Investment and capital
       %           ----------------------
kappa_i = 6.617;             % investment adjustment cost parameter
rho_ip= 0.485;               % AR coefficient of investment shock
delta_k= 0.025;                % depreciation of capital
gamma_yint = 0.33;              % share of capital in intermediate goods
production
eta_nu = 0.43;                   % capital utilization rate
yint_roc_ss = i_ss+delta_k;         % SS return on capital
rho_tobin_q = 0.3;           % AR coefficient of equity premium shock
rho_z = 0.9 ;                   % AR coefficient of transitory techno-
logy shock
tau_ip_ss = 0.1;             % check this value
tau_k_ss = 0.1;              % check this value
tau_d_ss = 0.1;              % check this value

       % Labour market matching and wage bargaining
       %           ----------------------------------------
sigma_n = 10;              % Frish elasticity of labour
eta = 0.5;                 % SS bargaining power
b = 0.3;                    % unemployment benefit
tau_w_ss = 0.15;            % SS worker's tax on earned income 0.30
tau_sc_ss = 0.12;           % sotut/palkkasumma, keskiarvo v. 2010-2013.
SS employer's social contribution 0.23
tau_cp_ss = 0.11;            % SS Consumption tax
omega_w = 0.3; %0.5              % Ad hoc wage rigidity parameter
sigma_M = 0.6;                                    % Elasticity of mat-
ching w.r.t unemployment (exponent of Cobb-Douglas matching function
rho = 0.06;                                       % SS job destruction
rate

qf_ss = 0.7;                                      % Steady state vacancy
filling rate
u_ss = 0.1;                                       % Steady state unem-
ployment, keskiarvo 1994-2010 = 10.2
n_ss = 1-u_ss;                                  % Steady state emplo-
yment rate
match_ss = rho*n_ss;                           % Steady state matches are
equal to ss separations
v_ss = match_ss/qf_ss;                         % Steady state vacancies
theta_ss = v_ss/u_ss;                          % Labour market tightness;
vacancies per unemployed searching workers
eff_match = match_ss/((u_ss^sigma_M)*(v_ss^(1-sigma_M)));  % Efficiency
of matching
```

```
qw_ss = match_ss/u_ss;                          % Steady state job finding
rate, 1994-2010 datan keskiarvo = 0.28

h_ss = 0.33;                                      % SS hours worked per
person


preal_kl_ss = (5-1)/5;                                  % =1/markup =>
implies a markup of 20 %
pyint_kl_ss = P.preal_kl_ss;                       % SS price of K-L
good, = preal_kl_ss. Equal to marginal cost of wholesale firm
mpk_ss = yint_roc_ss/pyint_kl_ss;                % SS marginal producti-
vity of capital
k_ss = gamma_yint*(1/(n_ss*mpk_ss));         % SS capital-labour ratio in
the firm-level production function
K_ss = k_ss*n_ss;                                % SS aggregate capital

yint_z_ss = 1/((K_ss^(gamma_yint))*((n_ss*h_ss)^(1-gamma_yint)));   %
Technology
yint_kl_ss=P.yint_z_ss*(k_ss)^(gamma_yint)*(h_ss)^(1-gamma_yint);     %
SS output of K-L good

mpl_ss = yint_z_ss*(1-gamma_yint)*k_ss^(gamma_yint)*(h_ss)^(-gamma_yint);
% SS marginal productivity of labour

mrs_ss = ((1-tau_w_ss)/((1+tau_sc_ss)*(1+tau_cp_ss)))*preal_kl_ss*mpl_ss;
% SS marginal rate of substitution

w_ss = 1.5849;
kappa = 0.0976;

% The resulting Firm and Worker surpluses are
H_ss = (1/1-beta*(1-rho-qw_ss))*(w_ss*h_ss*(1-tau_w_ss)-
(mrs_ss*h_ss*(1+tau_cp_ss))/(1+sigma_n)-b);          % SS worker surplus
J_ss = (1/(1-beta*(1-rho)))*(pyint_kl_ss*yint_kl_ss -
(1+tau_sc_ss)*w_ss*h_ss - yint_roc_ss*k_ss);                % SS firm
surplus

R_rate = b/(w_ss*h_ss*(1-tau_w_ss));


% Fiscal policy rule parameters
tau_share = 0.5;
w_para = 1;

%% Closing the model
%------------------
ip_ss = 0.172;                    % Investment in SS
cg_ss = 0.28;                     % Government consumption
ig_ss = 0.04;                     % Government investment
yint_ss = yint_kl_ss*n_ss;    % Aggregate SS production of intermediate
firm

cp_ss = yint_ss-ip_ss-cg_ss-kappa*v_ss ;          % SS consumption
```

```
cp_lc_ss = 0.2*cp_ss;           % SS consumption of liquidity constrained
households
cp_fl_ss = 0.8*cp_ss;           % SS consumption of forward-looking hou-
seholds

D_ss = yint_kl_ss - ((1+tau_sc_ss)*n_ss*w_ss*h_ss) - (yint_roc_ss*K_ss) -
(kappa*v_ss);


ott_ss = (tau_cp_ss*cp_ss) + (tau_ip_ss*ip_ss) +
((tau_w_ss+tau_sc_ss)*n_ss*w_ss*h_ss) + (tau_k_ss*yint_roc_ss*K_ss) +
(tau_d_ss*D_ss) - cg_ss - (1-n_ss)*b - (1-i_ss)*BH_ss;


total_h_ss = n_ss*h_ss;       % Total hours worked in SS

%%
% parameter values
rho_istar=0.95;           % AR coefficient of foreign interest
rho_n_e=0.37;             % AR of labour supply shock
rho_rhohat=0.75;          % AR of job destruction shock
rho_kappahat=0.75;        % AR of vacancy cost shock
rho_etahat=0.75;          % AR of shock to workers' negotiation weight

% Wholesale firm
%---------------
rho_yint_phi=0.80;       % AR-coeff. of markup shock
pyint_ksi= 0.75;         % probability of taking the price as given (cal-
vo)
pyint_ss=5;              % SS price of domestic intermediate input

% These needed to calculate ss prices
%-----------------------------------
f_pim_ss= 1 ;            % foreign SS price level ($) for intermediate
import input market.
rhoe= 0.4;              % ar coefficient in exchange rate shock
rho_f_pim=0.4 ;          % ar coefficient in foreign price shock
rho_f_pex=0.4 ;          % ar coefficient in foreign price shock

% importer price setting: investment good
%----------------------------------------
omegai= 0.15; %0.8 ;             % share of LCP importing firms. (1-
omegai) is the share of pcp firms
gammai_lcp= 0.4; %0.5  ;         % calvo parameter, share of LCP import
firms that are NOT allowed to change price at period t
gammai_pcp=0.5  ;         % calvo parameter, share of PCP import firms
that are NOT allowed to change price at period t
%
% retailer of investment good
thetaip=0.22;              % demand elasticity for domestic and foreign
intermediate investment good, previously 2.2
omegaip=0.67;             % share of domestic intermediate investment
good in production of composite investment good

% Importer price setting: consumption good
```

```
%---------------------------------------
omegac=0.15; %0.8;               %" share of LCP importing firms. (1-
omegac) is the share of pcp firms
gammac_lcp=0.4; %0.5;           %" calvo parameter, share of LCP import
firms that are NOT allowed to change price at period t
gammac_pcp=0.5;           %" calvo parameter, share of PCP import firms
that are NOT allowed to change price at period t

%Retailer of consumption good
thetacp=0.45;              % demand elasticity for domestic and foreign
intermediate consumption good, previously 4.5
omegacp=0.65;             % share of domestic intermediate consumtion
good in production of composite consumption good

% Exporter
%------------
gammax_pcp=0.65; %0.5;           % calvo parameter, share of PCP firms
that are NOT allowed to change price at period t,
gammax_lcp=0.65; %0.5;           % calvo parameter, share of LCP firms
that are NOT allowed to change price at period t
omegax=0.1; %0.5;               % share of LCP firms in exports
thetax=0.5882;            % price elasticity of demand for the export
product. Determined by rhox
x_ss=0.39;                % SS of exports
rhoxd=0.7346;             % ar-parameter of foreign market shock

rhostar=1;
thetaex=0.4545;           % phi
deltaex=0.8;              % delta
mex_ss=0.22;              % SS imports used in export production
%
% Importer price setting: export good
%-----------------------------------
mcex_ss=1;                % SS marginal cost of exports
pmex_ss=1;                % aggregate steady state import price level for
goods used in export production(€)
omegaex=0.15;               % share of LCP importing firms. (1-omegaex)
is the share of pcp firms
gammaex_lcp=0.4;           % calvo parameter, share of LCP import firms
that are NOT allowed to change price at period t
gammaex_pcp=0.5;          % calvo parameter, share of PCP import firms
that are NOT allowed to change price at period t
       %
m_ss=0.39;                % SS imports
mc_ss=0.09;               % SS imported C goods share of total imports
mi_ss=0.08;               % SS imported I goods share of total imports
       %
rho_pmc_e=0.7;            % ar coefficient in imported consumption good
price shock
rho_mcex_e=0.4;           % ar coefficient in mc of exports shock
rho_pmi_e=0.7;            % ar coefficient in imported investment good
price shock
rho_pmex_e=0.7;           % ar coefficient in imported goods used in ex-
ports price shock
rho_mc_e=0.7;             %
```

```
rho_mi_e=0.7;              %
rho_mex_e=0.7;             %
       %
       % Public sector
       %--------------
rho_cg= 0.9;              % AR of public spending shock
rho_ig= 0.9;              % AR of public investment shock
rho_ott=0.9;              % AR-coeff of transfers to households (ott_e)
shock
rho_tau_w=0.9;
rho_tau_cp=0.9;
rho_tau_k=0.9;
rho_tau_sc=0.9;
rho_tau_d=0.9;
rho_tau_ip=0.9;

rho_poil=0.6;

std_e_tau_w= 0.01;
std_e_tau_cp= 0.01;
std_e_tau_k= 0.01;
std_e_tau_sc= 0.01;
std_e_tau_d= 0.01;
std_e_tau_ip= 0.01;
std_e_ott= 0.01;
std_e_cg= 0.01;
```