Pseudo Code of the Simulation Program for:

"**Unemployment Benefits and Financial Leverage in an Agent Based Macroeconomic Model**"

by

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We provide a "pseudo code" of the simulation program which describes the algorithmic structure of our agent based macroeconomic model. In what follows the symbol % is used to introduce some comments about variables, parameters, etc. In particular, the pseudo code is organized in different "modules" which describe the various markets of the economy and other characteristics. We hope that the pseudo code can be of help, together with the description of the model proposed in the paper, in reproducing simulation results, independently of the particular programming software.

% SET TIME SPAN AND NUMBER OF AGENTS

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T = 150;        % number of simulation periods
H = 500;        % number of households/workers
F = 80;         % number of firms
B = 10;         % number of banks
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% PARAMETER SETTING

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phi = 3;                % (fixed) labour productivity
c1 = 0.8; c2 = 0.3;     % propensity to consume income/wealth
chi = 0.2;              % matching imperfect information
pw = round(0.33*H); % fraction of public workers
wagemin = 0.5;          % setting of a lower bound for wages
tau = 0.3;              % tax rate on income
taupatr = 0.05;         % tax rate on wealth
parpatr = 3;            % setting of tax wealth
parsc = 0.1;            % setting of firms' inventories
beta = 0.1;             % maximum banks' exposure on a single firm
reg1 = 10;              % regulatory parameter for credit supply
reg2 = 0.5;             % regulatory parameter for credit supply
alpha = 0.05;           % adjustment parameter
rho = 2;                % setting of firm-specific component of interest rate on bank loans
rCB = 0.01;             % policy rate set by the central bank
levatmin = 0.01;        % setting of a lower bound for firm leverage
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%%%

%%%

%%% interest rate setting: banks %%%

FOR each bank

IF the bank did not manage to lend all credit supply
bank-specific component of the interest rate (t) = bank-specific component of the interest rate (t-1) * (1 – *alpha**U(0,1));
ELSE
bank-specific component of the interest rate (t) = bank-specific component of the interest rate (t-1) * (1 + *alpha**U(0,1));
ENDIF
ENDFOR

%%% banks' credit supply %%%

banks' money from the CB = CB's total money supply .* (banks' net worth / banking sector's net worth capital);

interests paid to the CB = *rCB* * banks' money from the CB

bank capital "k1" = *reg1* * banks' net worth;

bank capital "k2" = *reg2* * banks' net worth + banks' deposits + banks' money from the CB;

banks' credit supply = min(bank capital "k1", bank capital "k2");

banks' max credit supply to single firm = *beta* * banks' credit supply

%%% Credit market matching %%%

residual bank credit supply = bank credit supply

residual firm credit demand = credit demand

WHILE (total residual firms' credit demand > 0 AND total residual banks' credit supply > 0)

SET a random list of "active" firms (that is, with positive residual credit demand)

FOR each firm (according to the random order)

observe a random subset (*chi* * B) of "active" banks (that is, with positive credit supply)
choose the bank with lowest interest rate
effective bank loan to firm = min(residual firm credit demand, residual bank credit supply, banks' max credit supply to single firm)
residual firm credit supply = residual firm credit supply – effective bank loan to firm

ENDFOR

ENDWHILE

firms' capital = firms' net worth + firms' bank loans

%%% central bank %%%

CB's total money supply(t+1) = max(0 , ½ * CB's total money supply(t) + ½ * (residual firms' credit demand – residual banks' credit supply))

%%%%%%%%%% LABOUR MARKET MATCHING %%%%%%%%%%%%%%%

%%% Public workers %%%

SET a random set of "public" workers (to be employed by the government)

%%% Labor market matching %%%

WHILE (there are unemployed workers AND at least one firm has enough money to hire a worker)

SET a random list of "active" firms (that is, with open vacancies)

FOR each firm (according to the random order)

observe a random subset of unemployed workers
choose the worker asking for the lowest wage
IF (firm's capital ≥ worker's wage)
firm's workers = firm's workers + 1
firm's capital = firm's capital – worker's wage
ENDIF

ENDFOR

ENDWHILE

net workers' wage = (1 - *tau*) * workers' wage

tax revenues = sum(*tau* * workers' wage)

%%% wage updating rule %%%

FOR each worker

IF employed at time t
worker's wage (t+1) = worker's wage * (1 + *alpha* * U(0,1))
ELSE (if unemployed)
worker's wage (t+1) = worker's wage * (1 – *alpha* * U(0,1))
ENDIF

workers' wage(t+1) = max(workers' wage, *wagemin**(1+*tau*)*max(prices))

ENDFOR

%%% dividends to households %%%

cash = cash(t-1) + a fraction of total dividends proportional to individual wealth

%%% consumption %%%

workers' consumption = *c1* * net workers' wage + *c2* * (deposit + cash)

workers' consumption = max(workers' consumption, max(prices))

workers' consumption = min(workers' consumption, net workers' wage + deposits + cash)

%%% production %%%

Firms' production = phi * firms' workers + inventories

%%% Updating rule for prices %%%

FOR each firm

    IF (no inventories AND positive production in the previous period)
        price(t+1) = price(t) * (1 + *alpha* * U(0,1))
    ELSE
        price(t+1) = price(t) * (1 – *alpha* * U(0,1))
    ENDIF

END

price = max(price, firms' unitary cost)

%%% GOODS MARKET MATCHING %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

firms' with goods to be sold = firm's production + inventories

WHILE (firms have unsold goods AND there is at least a household with enough money to buy goods)

    SET a random list of "active" households (that is, with money to be spent)

    FOR each household (according to the random order)

        observe a random subset of firms for which firms' with goods to be sold > 0

choose the firms asking for the lowest price
IF (household's money ≥ price of a single good)
household's money = household's money – price
firm's goods to be sold = firm's goods to be sold – 1
ENDIF

ENDFOR

ENDWHILE

firms' inventories = firms' goods to be sold (at the end of the goods market matching)

households' expenditure = sum(prices of goods bought from firms)

households' savings = net worker wage – households' expenditure + interests on deposits

%%% Public deficit and debt

public deficit = public expenditures (public workers' wage) + interests on public debt (+ eventually bailouts) – tax revenues – transfer of interests from the CB

public debt = public debt(t-1) + public deficit

%%% private banks and public debt

FOR each bank with residual available money (residual "k2")

IF public debt > 0 AND sum(banks' residual credit supply) ≥ public debt
banks' government bonds are a share of public debt proportional to bank size
ELSEIF public debt > 0 AND sum(banks' residual credit supply) < public debt
banks' government bonds = a portion of public dedt equal to banks' residual credit supply
ELSE
banks' government bonds = 0
ENDIF

IF sum(banks' government bonds) < public debt
CB's government bonds = public debt – sum(banks' government bonds) % that is, the central bank is committed to buy outstanding government securities
ENDIF

%%% DEPOSIT MARKET %%%%

%%% firms' profits

firms' gross profits = revenues from selling goods – wage bill – interest paid on bank loans

FOR each firm

IF firm's gross profit > 0
firm's profit tax = *tau* * firm's gross profit
firm's net profit = firm's gross profit – firm's profit tax
ELSE
firm's net profit = firm's gross profit
negative profits will be subtracted from next profits to compute the tax
ENDIF

%%% firms' dividend policy

FOR each firm

IF (firm's inventories = 0 AND firms' production >0)
firms' dividend share = firms' dividend share(t-1) * (1 – *alpha**U(0,1))
ELSE
firms' dividend share = firms' dividend share(t-1) * (1 + *alpha**U(0,1))
ENDIF

ENDFOR

firms' dividend share = min(firms' dividend share,1)

firms' dividends = firms' dividend share * firm's net positive profit

firms' profit after dividends = firm's net profit – firms' dividends

firms' net worth = firms' net worth(t-1) + firms' profit after dividends

FOR each firm

IF firm's net worth > *parpatr* * average price
firm's net worth = (1 – *taupatr*) * firm's net worth
ENDIF

ENDFOR

%%% banks' profit

banks' profit = interests on loans + interests on public debt – interests paid on deposits – interests on money from the CB – bad debt (non-performing loans according to the LGD rate of bankrupted firms)

FOR each bank

IF bank's gross profit > 0
bank's profit tax = *tau* * bank's gross profit
bank's net profit = bank's gross profit – bank's profit tax
ELSE
bank's net profit = bank's gross profit
negative profits will be subtracted from next profits to compute the tax
ENDIF

%%% banks' dividend policy

FOR each bank

IF the bank did not manage to lend all the credit supply
banks' dividend share = banks' dividend share(t-1) * (1 + *alpha**U(0,1))
ELSE
banks' dividend share = banks' dividend share(t-1) * (1 + *alpha**U(0,1))
ENDIF

ENDFOR

banks' dividend share = min(banks' dividend share,1)

banks' dividends = banks' dividend share * bank's net positive profit

banks' profit after dividends = bank's net profit – banks' dividends

banks' net worth = banks' net worth(t-1) + banks' profit after dividends

FOR each bank

IF bank's net worth > *parpatr* * average price
bank's net worth = (1 – *taupatr*) * bank's net worth
ENDIF

ENDFOR

%%% households' wealth

FOR each household

IF default of the related bank
Household's wealth decreases due to loss deposits, according to the LGD rate
ENDIF

ENDFOR

ENDFOR (end of main program)