Lab 09 Matlab Conversion

Aaron Swoboda and Oliver Hall

2025-04-15

This file aims to convert a series of Matlab scripts and data files into a R Markdown file that replicates the Tol (2023) Lab 9 for the economics of climate change. https://github.com/rtol/ClimateEconomics

The Matlab files this replicates are:

- MLIAM.mat
- init01.m
- MRHparam.m
- MRH.m
- RFparam.m
- RadForc.m
- STparam.m
- ST.m
- init02.m
- Popparam
- Outputparam
- CO2param
- init03.m
- CobbDouglas.m
- invest.m
- init04.m
- init05.m
- init06.m
- init07.m
- impactcc.m
- MLIAM05.m
- MLIAM09.m

Overview - the MLIAM06.m script

```
# clear all
# load MLIAM
# perturb = zeros(551,1); %note the fragility
# MLIAM05
# output0 = output;
# CO2conc0 = CO2conc;
# atmtemp1 = atmtemp;
# impact0 = impact;
# dr0 = discountrate;
# perturb(266) = 1;
# MLIAM05
#
# discountfactor = zeros(NYear,NReg);
```

```
# for i=1:NReg,
#     discountfactor(266,i) = 1;
# end
# for i=267:NYear,
#     discountfactor(i,:) = discountfactor(i-1,:)./(1+dr0(i-1,:));
# end
#
# addrelimp = impact0 - impact;
# addabsimp = addrelimp.*output/100;
# SCC= discountfactor.*addabsimp;
# SCC = 1000*sum(SCC)
#
# globaveinc = sum(output(266,:))/sum(population(266,:));
# equityweight = output(266,:)./population(266,:);
# equityweight = equityweight/globaveinc;
# equityweight = equityweight.^RRA;
#
# globalSCC = equityweight*SCC';
```

Step 1 - load the MLIAM.mat file

```
library(R.matlab)
```

```
## R.matlab v3.7.0 (2022-08-25 21:52:34 UTC) successfully loaded. See ?R.matlab for help.
```

```
##
## Attaching package: 'R.matlab'
```

```
## The following objects are masked from 'package:base':
##
##     getOption, isOpen
```

```
#MLIAM <- readMat("../TolMatlabFiles/MLIAM.mat")
MLIAM <- readMat("./MLIAM.mat")
ls.str()
```

```
## MLIAM : List of 11
##  $ CO2global   : num [1:551, 1] 0 3 3 3 3 3 3 3 3 3 ...
##  $ CO2emit     : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ CO2concobs  : num [1:689, 1:2] 2006 2005 2004 2003 2002 ...
##  $ population  : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ output      : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ atmtempobs  : num [1:551, 1] 0 0 0 0 0 0 0 0 0 0 ...
##  $ oceantempobs: num [1:551, 1] 0 0 0 0 0 0 0 0 0 0 ...
##  $ CO2emitobs  : num [1:551, 1] 0 3 3 3 3 3 3 3 3 3 ...
##  $ outputobs   : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ energy      : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ NReg        : num [1, 1] 3
```

```
CO2global <- MLIAM$CO2global        # should we use this?
CO2emit <- MLIAM$CO2emit
# CO2concobs  <- MLIAM$CO2concobs
population  <- MLIAM$population
# output  <- MLIAM$output
# atmtempobs  <- MLIAM$atmtempobs
```

```r
# oceantempobs  <- MLIAM$oceantempobs
# CO2emitobs  <- MLIAM$CO2emitobs    # should we use this?
outputobs  <- MLIAM$outputobs
energy  <- MLIAM$energy
NReg  <- MLIAM$NReg
```

Step 2 - create perturb matrix

```r
perturb <- rep(0, 551)
```

Step 3 - run all init scripts, helper scripts, and define functions as in Lab 05

```r
## init01
climsens = 4.260547;
EndYear = 2300;
StartYear = 1750;
year = StartYear:EndYear
NYear = length(year)

# %MRHparam
MRHlife <- c(0, 1-exp(-1/363), 1-exp(-1/74), 1-exp(-1/17), 1-exp(-1/2))
#
MRH1750 <- c(275, 0, 0, 0, 0);
#
MRHshare <- c(0.13, 0.20, 0.32, 0.25, 0.10);
#
CO2convert = 1/2.13/1000;
#
MRHbox = matrix(0, NYear, 5); # "five boxes" for each year
MRHbox[1, ] = MRH1750;
CO2conc = matrix(0, NYear, 1);
CO20 = sum(MRH1750);
CO2conc[1] = CO20;

# %RFparam
### RadForc
RadForc <-function(CO2,RF0,CO20) RF0*log(CO2/CO20);
#
RF0 = 5.35;
RF = matrix(0, NYear, 1);
RF[1] = RadForc(CO20, RF0, CO20) #Needs the RadForc function

# %STparam
atmtemp0 = 0;
oceantemp0 = 0;

atmtemp = matrix(0, NYear, 1);
oceantemp = matrix(0, NYear, 1);

atmtemp[(1)] = atmtemp0;
oceantemp[(1)] = oceantemp0;
```

```r
STpar <- c(climsens/RF0/log(2), 0.0256, 0.00738, 0.00568)

## init02
consumption <- matrix(0, nrow = NYear, ncol = NReg)

# %Popparam
popgrowth <- population[2010 - StartYear + 1, ] / population[2009 - StartYear + 1, ] - 1
popdecline <- 0.95
popgrowth <- popdecline * popgrowth

# %Outputparam
capital <- matrix(0, nrow = NYear, ncol = NReg)
TFP <- matrix(0, nrow = NYear, ncol = NReg)
output <- matrix(0, nrow = NYear, ncol = NReg)
outputpc <- matrix(0, nrow = NYear, ncol = NReg)

TFPgrowth <- c(0.0206, 0.0260, 0.0236)
TFPdecline <- 0.99
outputpc2010 <- c(33498, 3170, 954)

lambda <- 0.2
savings <- 0.2
depreciation <- 0.1

A0 <- (outputobs[1960 - StartYear + 1, ] / population[1960 - StartYear + 1, ])^(1 - lambda)
A0 <- A0 * (depreciation / savings)^lambda
K0 <- (A0 ^ (1 / (1 - lambda))) * population[1960 - StartYear + 1, ]
K0 <- (savings / depreciation)^(1 / (1 - lambda)) * K0

capital[1960 - StartYear + 1, ] <- K0
TFP[1960 - StartYear + 1, ] <- A0

# %CO2param
CO2emitbau <- CO2emit
energyint <- energy / outputobs
emissint <- CO2emit / energy

AEEI <- energyint[(2010 - StartYear + 1), ] / energyint[(1960 - StartYear + 1), ]
AEEI <- AEEI ^ (1 / 50)
ACEI <- emissint[(2010 - StartYear + 1), ] / emissint[(1960 - StartYear + 1), ]
ACEI <- ACEI ^ (1 / 50)

AEEI <- c(0.98926539, 0.98782002, 0.99025746)
ACEI <- c(0.99594960, 1.00029674, 1.00979371)

### MRH - Maier-Reimer Hasselmann model
MRH <- function(CO2concold, CO2emit, CO2life, CO2share, CO2convert) {
  CO2concnew = (1-CO2life)*CO2concold + CO2convert*CO2share*CO2emit
  CO2concnew
}

### Schneider-Thompson model of Ocean and Atm Temps
# updates the temperature of the atmosphere and the ocean using the Schneider-Thompson model
```

```r
ST <- function(atmtempold,oceantempold,radforc,STpar) {
atmtempnew   = atmtempold   +
    STpar[2]*(STpar[1]*radforc-atmtempold) +
    STpar[3]*(oceantempold-atmtempold)
oceantempnew = oceantempold +
  STpar[4]*(atmtempold-oceantempold)
temps <- c(atmtempnew, oceantempnew)
names(temps) <- c("atm", "ocean")
temps
}

### Cobb-Douglas function
CobbDouglas <- function(A, K, L, lambda) {
  Y <- A * (K^lambda) * (L^(1 - lambda))
  return(Y)
}

### invest function
invest <- function(oldK, Y, s, d) {
  newK <- (1 - d) * oldK + s * Y
  return(newK)
}

## init03
unitabcost <- c(0.1, 0.1, 0.1)
emred <- matrix(0, nrow = NYear, ncol = NReg)
relabcost <- matrix(0, nrow = NYear, ncol = NReg)
totabcost <- matrix(0, nrow = NYear, ncol = NReg)
margabcost <- matrix(0, nrow = NYear, ncol = NReg)

PRTP <- 0.03
RRA <- 1

discountrate <- matrix(0, nrow = NYear, ncol = NReg)
globalDR <- matrix(0, nrow = NYear, ncol = 1)

## init04
emitalloc <- matrix(0, nrow = NYear, ncol = NReg)
emitalloc[266:NYear, ] <- emitalloc[266:NYear, ] + 0.05
permittrade <- matrix(0, nrow = NYear, ncol = NReg)
permitprice <- matrix(0, nrow = NYear, ncol = 1)

## init05
partol <- matrix(c(5.88, -2.31, 0, 3.57, -1.70, 0, 1.96, -1.26, 0), nrow = 3, ncol = 3)
parweitzman <- matrix(c(0, 0.5563, -0.0113, 0, 0.2561, -0.0106, 0, 0.0655, -0.0101), nrow = 3, ncol = 3
impactpar <- partol
impelas <- 0
impact <- matrix(0, nrow = NYear, ncol = NReg)

## init06
perturbation <- matrix(perturb, nrow = NYear, ncol = 1)

## init07
```

```
impelas <- -0.25

### impactcc function
impactcc <- function(temp, impar, impelas, inccap, inccap0) {
  imp <- impar[1,] * temp + impar[2,] * temp^2 + impar[3,] * temp^6
  imp <- imp * (inccap / inccap0)^impelas
  return(imp)
}
```

Step 4 - run MLIAM05

```
for (t in (StartYear+1):EndYear) {
    i <- t - StartYear + 1
    MRHbox[i,] <- MRH(MRHbox[i-1,], CO2global[i-1], MRHlife, MRHshare, CO2convert)
    CO2conc[i] <- sum(MRHbox[i,])
    RF[i] <- RadForc(CO2conc[i], RF0, CO20)
    atmtemp[i] <- ST(atmtemp[i-1], oceantemp[i-1], RF[i], STpar)[[1]]
    oceantemp[i] <- ST(atmtemp[i-1], oceantemp[i-1], RF[i], STpar)[[2]]
    impact[i,] <- impactcc(atmtemp[i], impactpar, 0, 1, 1)
    if (t > 2010) {
        population[i,] <- population[i-1,] * (1 + popgrowth)
        popgrowth <- popdecline * popgrowth
        TFPgrowth <- TFPdecline * TFPgrowth
    }
    if (t > 1960) {
        capital[i,] <- invest(capital[i-1,], output[i-1,], savings, depreciation)
        TFP[i,] <- TFP[i-1,] * (1 + TFPgrowth)
    }
    if (t >= 1960) {
        output[i,] <- pmax(0.3 * population[i,], CobbDouglas(TFP[i,], capital[i,], population[i,], lamb
        outputpc[i,] <- output[i,] / population[i,] * 1000
        consumption[i,] <- (1 - savings) * output[i,]
        impact[i,] <- impactcc(atmtemp[i], impactpar, impelas, outputpc[i,], outputpc2010)
    }
    if (t == 2015) {
        emred[i,1] <- 0.0
        for (j in 2:NReg) {
            emred[i,j] <- emred[i,1] * unitabcost[1] / unitabcost[j] * output[i-1,1] / output[i-1,j] * (
        }
    }
    if (t > 2015) {
        emred[i,1] <- pmin(0.99, emred[i-1,1] * (1 + globalDR[i-1]))
        for (j in 2:NReg) {
            emred[i,j] <- pmin(0.99, emred[i,1] * unitabcost[1] / unitabcost[j] * output[i-1,1] / outpu
        }
    }
    if (t > 2010) {
        energyint[i,] <- AEEI * energyint[i-1,]
        emissint[i,] <- ACEI * emissint[i-1,]
        energy[i,] <- energyint[i,] * output[i,]
        CO2emitbau[i,] <- emissint[i,] * energy[i,]
        CO2emit[i,] <- CO2emitbau[i,] * (1 - emred[i,])
        CO2global[i] <- CO2global[i-1] * sum(CO2emit[i,]) / sum(CO2emit[i-1,]) + perturbation[i]
```

```
        discountrate[i,] <- PRTP + RRA * (consumption[i,] / consumption[i-1,] - 1)
        globalDR[i] <- PRTP + RRA * (sum(consumption[i,]) / sum(consumption[i-1,]) - 1)
    }
    if (t > 2015) {
        relabcost[i,] <- unitabcost * emred[i,]^2 + 0.001 * permitprice[i] * permittrade[i,] / output[i
        totabcost[i,] <- relabcost[i,] * output[i,]
        margabcost[i,] <- 2 * unitabcost * emred[i,] * output[i,] / CO2emit[i,] * 1000
    }
}
```

Step 5 - create copies of variables and induce a perturbation

```
output0 <- output
CO2conc0 <- CO2conc
atmtemp1 <- atmtemp
impact0 <- impact
dr0 <- discountrate
perturb[266] <- 1
```

Step 6 - run MLIAM05

```
for (t in (StartYear+1):EndYear) {
    i <- t - StartYear + 1
    MRHbox[i,] <- MRH(MRHbox[i-1,], CO2global[i-1], MRHlife, MRHshare, CO2convert)
    CO2conc[i] <- sum(MRHbox[i,])
    RF[i] <- RadForc(CO2conc[i], RF0, CO20)
    atmtemp[i] <- ST(atmtemp[i-1], oceantemp[i-1], RF[i], STpar)[[1]]
    oceantemp[i] <- ST(atmtemp[i-1], oceantemp[i-1], RF[i], STpar)[[2]]
    impact[i,] <- impactcc(atmtemp[i], impactpar, 0, 1, 1)
    if (t > 2010) {
        population[i,] <- population[i-1,] * (1 + popgrowth)
        popgrowth <- popdecline * popgrowth
        TFPgrowth <- TFPdecline * TFPgrowth
    }
    if (t > 1960) {
        capital[i,] <- invest(capital[i-1,], output[i-1,], savings, depreciation)
        TFP[i,] <- TFP[i-1,] * (1 + TFPgrowth)
    }
    if (t >= 1960) {
        output[i,] <- pmax(0.3 * population[i,], CobbDouglas(TFP[i,], capital[i,], population[i,], lamb
        outputpc[i,] <- output[i,] / population[i,] * 1000
        consumption[i,] <- (1 - savings) * output[i,]
        impact[i,] <- impactcc(atmtemp[i], impactpar, impelas, outputpc[i,], outputpc2010)
    }
    if (t == 2015) {
        emred[i,1] <- 0.0
        for (j in 2:NReg) {
            emred[i,j] <- emred[i,1] * unitabcost[1] / unitabcost[j] * output[i-1,1] / output[i-1,j] * (
        }
    }
    if (t > 2015) {
        emred[i,1] <- pmin(0.99, emred[i-1,1] * (1 + globalDR[i-1]))
        for (j in 2:NReg) {
```

```
            emred[i,j] <- pmin(0.99, emred[i,1] * unitabcost[1] / unitabcost[j] * output[i-1,1] / outpu
        }
    }
    if (t > 2010) {
        energyint[i,] <- AEEI * energyint[i-1,]
        emissint[i,] <- ACEI * emissint[i-1,]
        energy[i,] <- energyint[i,] * output[i,]
        CO2emitbau[i,] <- emissint[i,] * energy[i,]
        CO2emit[i,] <- CO2emitbau[i,] * (1 - emred[i,])
        CO2global[i] <- CO2global[i-1] * sum(CO2emit[i,]) / sum(CO2emit[i-1,]) + perturbation[i]
        discountrate[i,] <- PRTP + RRA * (consumption[i,] / consumption[i-1,] - 1)
        globalDR[i] <- PRTP + RRA * (sum(consumption[i,]) / sum(consumption[i-1,]) - 1)
    }
    if (t > 2015) {
        relabcost[i,] <- unitabcost * emred[i,]^2 + 0.001 * permitprice[i] * permittrade[i,] / output[i
        totabcost[i,] <- relabcost[i,] * output[i,]
        margabcost[i,] <- 2 * unitabcost * emred[i,] * output[i,] / CO2emit[i,] * 1000
    }
}
```

Step 7 - calculate Social Cost of Carbon

```
discountfactor <- matrix(0, nrow = NYear, ncol = NReg)
for (i in 1:NReg) {
  discountfactor[266, i] <- 1
}
for (i in (267:NYear)) {
  discountfactor[i, ] <- discountfactor[i-1, ] / (1 + dr0[i-1, ])
}

addrelimp <- impact0 - impact
addabsimp <- addrelimp * output / 100
SCC <- discountfactor * addabsimp
SCC <- 1000 * sum(SCC)

globaveinc <- sum(output[266, ]) / sum(population[266, ])
equityweight <- output[266, ] / population[266, ]
equityweight <- equityweight / globaveinc
equityweight <- equityweight^RRA

globalSCC <- sum(equityweight * SCC)
```