Carbon Calculator Calculations

Output matrix definitions:

FD = Final Demand (000's USD)

Z = Transaction Matrix

X = Total Output

A = "Technical Coefficient"

Q = Production Based Emissions Intensity Matrix (Gg/000's USD)

I = Identity Matrix

L = Leontief Matrix

P_sgp = Production based emissions by sector for Singapore in the given year (Gg CO2eq)

P_emis_total = Total Singaporean production based non-direct emissions

E = Consumption based emissions intensity matrix (Gg/000's USD)

C = consumption based emissions matrix (Gg/000's USD)

C_sgp = Consumption based emissions by sector for Singapore in the given year (Gg CO2eq)

Data Exploration

Set up environment, read in data

```
setwd("/Users/sophiejanaskie/Documents/data-driven-yale/carbon-calculator/")
wd <- getwd()

# read in Singapore Eora Tables

# final demand matrix (Y or FD)
# Household Final Consumption, Non-Profit Institutions Serving Households,Government Final Consumption,
FD <- read.csv("Eora26_2012_pp/Eora26_2012_pp_FD.csv", header=FALSE)

# production-based emissions matrix (Q)
# PB emissions to the environment
Q <- read.csv("Eora26_2012_pp/Eora26_2012_pp_Q.csv", header=FALSE)

# direct emissions matrix (QY)
# PB emissions released during use phase, Tier 0
Pd <- read.csv("Eora26_2012_pp/Eora26_2012_pp_QY.csv", header=FALSE)

# transaction matrix (intermediates)
# 26 consumption categories for all 189 countries
Z <- read.csv("Eora26_2012_pp/Eora26_2012_pp_T.csv", header=FALSE)

# value added
VA <- read.csv("Eora26_2012_pp/Eora26_2012_pp_VA.csv", header=FALSE)
```

```
# labels
FDlab <- read.delim("Eora26_2012_pp/labels_FD.txt", header=FALSE)
Qlab <- read.delim("Eora26_2012_pp/labels_Q.txt", header=FALSE)
Zlab <- read.delim("Eora26_2012_pp/labels_T.txt", header=FALSE)
VAlab <- read.delim("Eora26_2012_pp/labels_VA.txt", header=FALSE)
```

Data Cleaning

```
# specify where Singapore is in Eora Matrix
sgp_col=3927
sgp_row=907

# remove discrepancy entries from T and FD matrices
Z_disc <- Z[,4915]

FD_disc <- matrix(0, nrow=4914, ncol=1)

for(i in 1:length(FD_disc)) {
  FD_disc[i]=sum(FD[i,1134:1140])
}

Z_disc <- as.numeric(Z_disc)
FD_disc <- as.numeric(FD_disc)

# reassign Z and FD without the last row and column

Z = Z[,1:length(Z)-1]
Z = Z[1:length(Z),]

FD = FD[1:4914,1:1134]

# keep only the row with total CO2eq emissions in the production based emissions matrix (P), and trim d

CO2eq_row = 1856
P = Q[CO2eq_row,1:4915]
```

```
# sum final demand categories into 1 FD column per country
FD_country <- matrix(0, nrow=4914, ncol=189)

k=1
for(i in 1:length(FD)) {
  for(j in seq(from=1,to=length(FD),by=6)) {
    FD_country[i,k]=sum(FD[i,j:j+5])
    k=k+1
  }
  k=1
}
```

Calculations

Vector of total outputs, X

```
X <- matrix(0,nrow=length(Z),ncol=1)

for(i in 1:length(Z)) {
  X[i,1] = sum(Z[i,]) + sum(FD[i,]) + Z_disc[i] + FD_disc[i]
}
```

```
Z_m <- data.matrix(Z, rownames.force=NA)
FD_m <- data.matrix(FD, rownames.force=NA)
```

Technology Matrix, A

```
A <- matrix(0,nrow=length(Z),ncol=length(Z))

for(i in 1:length(Z)) {
  for(j in 1:length(Z)) {
    A[i,j] = Z_m[i,j] / X[j,1]
  }
}
```

Calculate production based emissions intensity (Q)

```
PB <- matrix(0,nrow=1, ncol=length(Z))

for(i in 1:length(Z)) {
  PB[1,i] = P[1,i]/X[i]
}

# assigns the 26 Singaporean sectors in P to P_sgp
P_sgp = P[1,sgp_col:(sgp_col+25)]
colnames(P_sgp) <- Zlab[sgp_col:(sgp_col+25),4]
rownames(P_sgp) <- "carbon"

PB_sgp = PB[1,sgp_col:(sgp_col+25)]
PB_sgp <- matrix(PB_sgp)
rownames(PB_sgp) <- Zlab[sgp_col:(sgp_col+25),4]

P_emis_total = sum(P_sgp[1,1:length(P_sgp)])

Pop = 5607000

P_cap = P_emis_total/Pop
```

Leontief Inverse (L)

```
I <- diag(length(Z))
diff <- I-A
L <- solve(diff)
```

Calculate consumption based emissions intensity matrix (E)

Transform PB emissions intensity matrix to CB emissions intensity matrix

```
# entire E
E = PB%*%L

# singaporean E
E_sgp = E[1,sgp_col:(sgp_col+25)]
E_sgp <- matrix(E_sgp)
rownames(E_sgp) <- Zlab[sgp_col:(sgp_col+25),4]
colnames(E_sgp) <- "carbon intensity (CO2/$)"
```

Transform E to C (CB emissions inventory) using final demand

```
C = E%*%FD_m
```

Calculate Singaporean consumption based emissions intensity matrix (E_sgp)

```
# isolate singaporean final demand
FD_sgp <- FD[sgp_col:(sgp_col+25),sgp_row:(sgp_row+6)]

# sum FD_sgp into one column
FD_sgp_sum <- matrix(0,nrow=26,ncol=1)

for(i in 1:26) {
  FD_sgp_sum[i]=sum(FD_sgp[i,])
}

# insert into FD column, with zeros everywhere else
FD_sgp_final <- matrix(0,nrow=4914,ncol=1)
FD_sgp_final[sgp_col:(sgp_col+25),1] <- FD_sgp_sum

# calculate singaporean consumption based emissions
C_sgp = C[,sgp_row:(sgp_row+5)]
```

Export to csv

```
write.csv(E, file="CB_emissions_intensity_E.csv")
write.csv(E_sgp, file="CB_emissions_intensity_SINGAPORE.csv")
```