ESM 204 HW4: A Climate Change Model

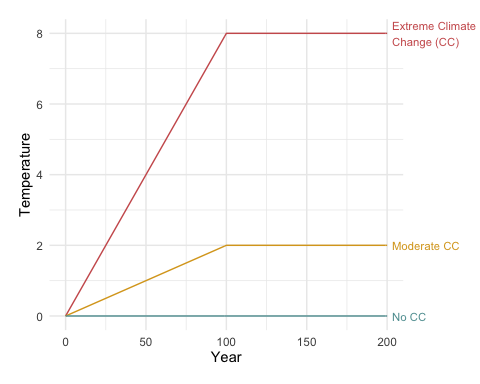
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## 1. Plots

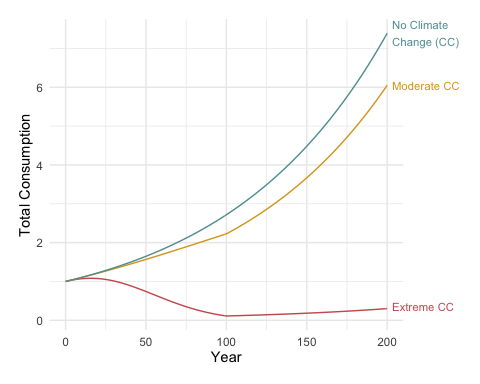
### a) Temperature over time

years <- data.frame(  
 year = seq(from = 0, to = 200, by = 1))  
  
# temperature function  
temp\_fun = function(t, T){  
 temp = pmin(t\*T/100,T)  
 }  
  
temp\_time <- years %>%   
 mutate(none = temp\_fun(t = year, T = 0),  
 moderate = temp\_fun(t = year, T = 2),  
 extreme = temp\_fun(t = year, T = 8)) %>%   
 pivot\_longer(2:4,  
 values\_to = "temp",  
 names\_to = "climate\_change")



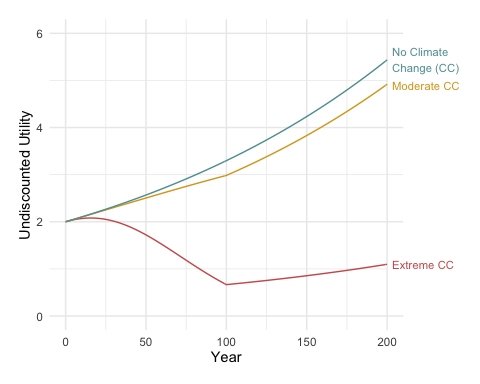
### b) Consumption over time

# economic activity retained function  
econ\_fun <- function(temp, B = 0.05){  
 econ = exp(-B\*temp^2)  
 }  
  
econ\_time <- temp\_time %>%   
 mutate(econ = econ\_fun(temp = temp))  
   
# total consumption function  
consum\_fun <- function(econ, g = 0.01, t){  
 consum = econ\*exp(g\*t)  
 }   
  
consum\_time <- econ\_time %>%   
 mutate(consum = consum\_fun(t = year, econ = econ))



### c) Undiscounted utility over time

# society utility function  
utility\_fun <- function(C, n = 0.5){  
 utility = ((C^(1-n))/(1-n))  
 }  
  
utility\_time <- consum\_time %>%   
 mutate(utility = utility\_fun(C = consum))



## 2. Analysis

### a) Discounted Utility

# discount rate function  
disc\_fun <- function(y = 0.005, n = 0.5, g = 0.01){  
 disc = y + n\*g  
}  
  
# T = 4.4  
disc\_4.4 <- years %>%   
 mutate(temp = temp\_fun(t = year, T = 4.4),  
 econ = econ\_fun(temp = temp),  
 consum = consum\_fun(t = year, econ = econ),  
 utility = utility\_fun(C = consum),  
 disc\_utility = utility/((1 + disc\_fun())^year))  
  
# NPV under T = 4.4   
npv\_4.4 <- sum(disc\_4.4$disc\_utility)  
npv\_4.4

## [1] 198.6612

# T = 0   
disc\_0 <- years %>%   
 mutate(temp = temp\_fun(t = year, T = 0),  
 econ = econ\_fun(temp = temp),  
 consum = consum\_fun(t = year, econ = econ),  
 utility = utility\_fun(C = consum),  
 disc\_utility = utility/((1 + disc\_fun())^year))  
  
# NPV under T = 0   
npv\_0 <- sum(disc\_0$disc\_utility)  
npv\_0

## [1] 255.2734

# percent loss in PV from climate change (T = 4.4)  
L <- ((npv\_0 - npv\_4.4)/npv\_0)\*100  
L

## [1] 22.17709

The present value utility with climate change (T = 4.4) is **198.66**. The present value utility without climate change is **255.27**. The percent loss in present value utility from claimate change (L) is **22.18%**.

### b) Sensitivity Analyses

#### T = 4.84

sens\_T <- years %>%   
 mutate(temp = temp\_fun(t = year, T = 4.84),  
 econ = econ\_fun(temp = temp),  
 consum = consum\_fun(t = year, econ = econ),  
 utility = utility\_fun(C = consum),  
 disc\_utility = utility/((1 + disc\_fun())^year))  
  
npv\_sens\_T <- sum(sens\_T$disc\_utility)  
  
# L with T = 4.84  
L\_sens\_T <- ((npv\_0 - npv\_sens\_T)/npv\_0)\*100  
L\_sens\_T

## [1] 25.79679

# change in L  
L\_sens\_T - L

## [1] 3.619695

Increasing T by 10% results in an **increase** in the percent loss in present value utility (L) by **3.62%**.

#### g = 0.011

sens\_g <- years %>%   
 mutate(temp = temp\_fun(t = year, T = 4.4),  
 econ = econ\_fun(temp = temp),  
 consum = consum\_fun(t = year, econ = econ, g = 0.011),  
 utility = utility\_fun(C = consum),  
 disc\_utility = utility/((1 + disc\_fun(g = 0.011))^year))  
  
npv\_sens\_g <- sum(sens\_g$disc\_utility)  
  
# L with g = 0.011  
L\_sens\_g <- ((npv\_0 - npv\_sens\_g)/npv\_0)\*100  
L\_sens\_g

## [1] 22.14822

# change in L   
L\_sens\_g - L

## [1] -0.02887278

Increasing g by 10% results in a **decrease** in the percent loss in present value utility (L) by **0.03%**.

#### n = 0.55

sens\_n <- years %>%   
 mutate(temp = temp\_fun(t = year, T = 4.4),  
 econ = econ\_fun(temp = temp),  
 consum = consum\_fun(t = year, econ = econ),  
 utility = utility\_fun(C = consum, n = 0.55),  
 disc\_utility = utility/((1 + disc\_fun(n = 0.55))^year))  
  
npv\_sens\_n <- sum(sens\_n$disc\_utility)  
  
# L with n = 0.55  
L\_sens\_n <- ((npv\_0 - npv\_sens\_n)/npv\_0)\*100  
L\_sens\_n

## [1] 17.66265

# change in L   
L\_sens\_n - L

## [1] -4.514441

Increasing n by 10% results in a **decrease** in the percent loss in present value utility (L) by **4.51%**.

#### B = 0.055

sens\_b <- years %>%   
 mutate(temp = temp\_fun(t = year, T = 4.4),  
 econ = econ\_fun(temp = temp, B = 0.055),  
 consum = consum\_fun(t = year, econ = econ),  
 utility = utility\_fun(C = consum),  
 disc\_utility = utility/((1 + disc\_fun())^year))  
  
npv\_sens\_b <- sum(sens\_b$disc\_utility)  
  
# L with B = 0.055  
L\_sens\_b <- ((npv\_0 - npv\_sens\_b)/npv\_0)\*100  
L\_sens\_b

## [1] 23.93861

# change in L   
L\_sens\_b - L

## [1] 1.761522

Increasing B by 10% results in an **increase** in the percent loss in present value utility (L) by **1.76%**.

### c)

Assuming n = 0.5,

# Without discounting  
  
U\_4.4 <- sum(disc\_4.4$utility)  
U\_0 <- sum(disc\_0$utility)  
  
theta = (U\_4.4/U\_0)^2  
theta

## [1] 0.4926615

# With discounting  
  
U\_4.4\_disc <- sum(disc\_4.4$disc\_utility)  
U\_0\_disc <- sum(disc\_0$disc\_utility)  
  
theta\_disc = (U\_4.4\_disc/U\_0\_disc)^2  
theta\_disc

## [1] 0.6056405

Without considering discounting, the

= **0.493**. With discounting,

= **0.606**.

### d)

# T = 2 (prob = 0.2)  
d\_2 <- years %>%   
 mutate(temp = temp\_fun(t = year, T = 2),  
 econ = econ\_fun(temp = temp),  
 consum = consum\_fun(t = year, econ = econ),  
 utility = utility\_fun(C = consum),  
 disc\_utility = utility/((1 + disc\_fun())^year))  
  
# Without discounting  
U\_2 <- sum(d\_2$utility)  
  
# With discounting  
U\_2\_disc <- sum(d\_2$disc\_utility)  
  
# T = 4 (prob = 0.5)  
d\_4 <- years %>%   
 mutate(temp = temp\_fun(t = year, T = 4),  
 econ = econ\_fun(temp = temp),  
 consum = consum\_fun(t = year, econ = econ),  
 utility = utility\_fun(C = consum),  
 disc\_utility = utility/((1 + disc\_fun())^year))  
  
# Without discounting  
U\_4 <- sum(d\_4$utility)  
  
# With discounting  
U\_4\_disc <- sum(d\_4$disc\_utility)  
  
# T = 6 (prob = 0.3)  
d\_6 <- years %>%   
 mutate(temp = temp\_fun(t = year, T = 6),  
 econ = econ\_fun(temp = temp),  
 consum = consum\_fun(t = year, econ = econ),  
 utility = utility\_fun(C = consum),  
 disc\_utility = utility/((1 + disc\_fun())^year))  
  
# Without discounting  
U\_6 <- sum(d\_6$utility)  
  
# With discounting  
U\_6\_disc <- sum(d\_6$disc\_utility)

# expected theta  
# without discounting  
U\_exp <- U\_2\*0.2 + U\_4\*0.5 + U\_6\*0.3  
theta\_exp <- (U\_exp/U\_0)^2  
theta\_exp

## [1] 0.5147023

# with discounting  
U\_exp\_disc <- U\_2\_disc\*0.2 + U\_4\_disc\*0.5 + U\_6\_disc\*0.3  
theta\_exp\_disc <- (U\_exp\_disc/U\_0)^2  
theta\_exp\_disc

## [1] 0.08489526