Lab 7: Parking Garage Case Study

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using Revise  
using ParkingGarage

and also regular packages

using Plots  
using Distributions  
Plots.default(; margin=5Plots.mm)

# Uncertainty Analysis

## Generate SOWs

I use the same n\_years of 20, and a discount\_rate of 0.12. However I will take 10,000 samples of a normal distribution for the demand growth rate centered at 80 with a standard deviation of 40 cars/yr. This is a bit of a broad range of uncertainty, but I justify it by saying that we’re in an an important era of technological innovation with electric vehicles, which may affect future car demand positively or negatively.

demand\_growth\_dist = Normal(80.0, 40.0)  
demand\_growth\_samples = [rand(demand\_growth\_dist) for \_ in 1:10\_000]  
  
# first I'll use 10 of these to make sure the algorithm works  
# later updated to 2000, similar to paper. more samples caused convergence closer to the other line.  
demand\_growth\_vals = first(demand\_growth\_samples, 2000)  
sows = [ParkingGarageSOW(; demand\_growth\_rate=rate, n\_years=20, discount\_rate=0.12) for rate in demand\_growth\_vals];

## Calculate NPVs

Consider my sampled SOWs and the base case SOW.

n\_levels = 2:12  
policies = [StaticPolicy(i) for i in n\_levels]  
  
results = []  
  
for policy in policies  
 # take the mean of all SOWs for the current level (policy) and add it to the results  
 result\_allsow = [simulate(sow, policy) for sow in sows]  
 push!(results, mean(result\_allsow))  
end  
  
# base case SOW  
sow = ParkingGarageSOW(; demand\_growth\_rate=80.0, n\_years=20, discount\_rate=0.12)  
profits = [simulate(sow, policy) for policy in policies]

11-element Vector{Float64}:  
 -27.058158053279776  
 -15.68143250815078  
 -4.854706963021782  
 1.8348006621072135  
 4.724790888196209  
 4.969673743944295  
 3.209429999782052  
 0.053278672927992765  
 -4.161041957923412  
 -9.11202757306442  
 -14.578783366801865

Plot the results on top of the original plot.

# base plot  
plot(  
 n\_levels,  
 profits;  
 ylabel="NPV Profits [Million USD]",  
 xlabel="Number of levels",  
 legend=true,  
 size=(800, 400),  
 marker=:circle,  
 xticks=n\_levels,  
 label="Traditional NPV",  
)  
# new plot  
plot!(  
 n\_levels,  
 results;  
 ylabel="NPV Profits [Million USD]",  
 xlabel="Number of levels",  
 marker=:circle,  
 xticks=n\_levels,  
 label="Recognizing Uncertainty"  
)  
hline!([0], label="0 NPV")

# Adapative Comparisons

Compare single SOW fixed policy to adaptive policy.

# generate adaptive policy SOW  
adaptive\_policies = [AdaptivePolicy(i) for i in n\_levels]  
adaptive\_profits = [simulate(sow, policy) for policy in adaptive\_policies]  
  
# compare results  
# base plot  
plot(  
 n\_levels,  
 profits;  
 title="Single-SOW Adaptive vs. Fixed Policy",  
 ylabel="NPV Profits [Million USD]",  
 xlabel="Number of levels",  
 legend=true,  
 size=(800, 400),  
 marker=:circle,  
 xticks=n\_levels,  
 label="Fixed Policy",  
)  
# new plot  
plot!(  
 n\_levels,  
 adaptive\_profits;  
 ylabel="NPV Profits [Million USD]",  
 xlabel="Number of levels",  
 marker=:circle,  
 xticks=n\_levels,  
 label="Adaptive Policy"  
)  
hline!([0], label="0 NPV")

Compare multi-SOW adaptive policy to fixed policy

adaptive\_results = []  
  
for policy in adaptive\_policies  
 # take the mean of all SOWs for the current level (policy) and add it to the results  
 result\_allsow = [simulate(sow, policy) for sow in sows]  
 push!(adaptive\_results, mean(result\_allsow))  
end  
  
plot(  
 n\_levels,  
 results;  
 title="Multi-SOW Adaptive vs. Fixed Policy",  
 ylabel="NPV Profits [Million USD]",  
 xlabel="Number of levels",  
 legend=true,  
 size=(800, 400),  
 marker=:circle,  
 xticks=n\_levels,  
 label="Fixed Policy",  
)  
# new plot  
plot!(  
 n\_levels,  
 adaptive\_results;  
 ylabel="NPV Profits [Million USD]",  
 xlabel="Number of levels",  
 marker=:circle,  
 xticks=n\_levels,  
 label="Adaptive Policy"  
)  
hline!([0], label="0 NPV")

Clearly, under uncertainty, the adaptive approach makes the most sense. I think a key assumption in this is that building a 2 level parking garage could feasibly support a lot of future building. If I repeated this I’d include a caveat that you can only adapt so much, or build so much on your original investment based on your previous foundation.