BUDT 730

# Data, Models and Decisions

## Lecture 20

Decision Trees (III)

Prof. Sujin Kim

# Learning Objectives

- Single Stage problem
  - Learn how to implement a decision tree via Precision tree
  - Learn how to conduct a sensitivity analysis in Precision Tree
- Decision Tree
  - Understand how to construct a single stage decision tree
  - Learn how probabilities are used in the decision-making process
- Multi-stage problem
  - Understand how to construct a multi-stage decision tree
  - Learn how conditional probabilities are used in the decision-making process

# Precision Tree

PrecisionTree

Decision Trees in Microsoft Excel

# Finding the ‘Best’ Decision

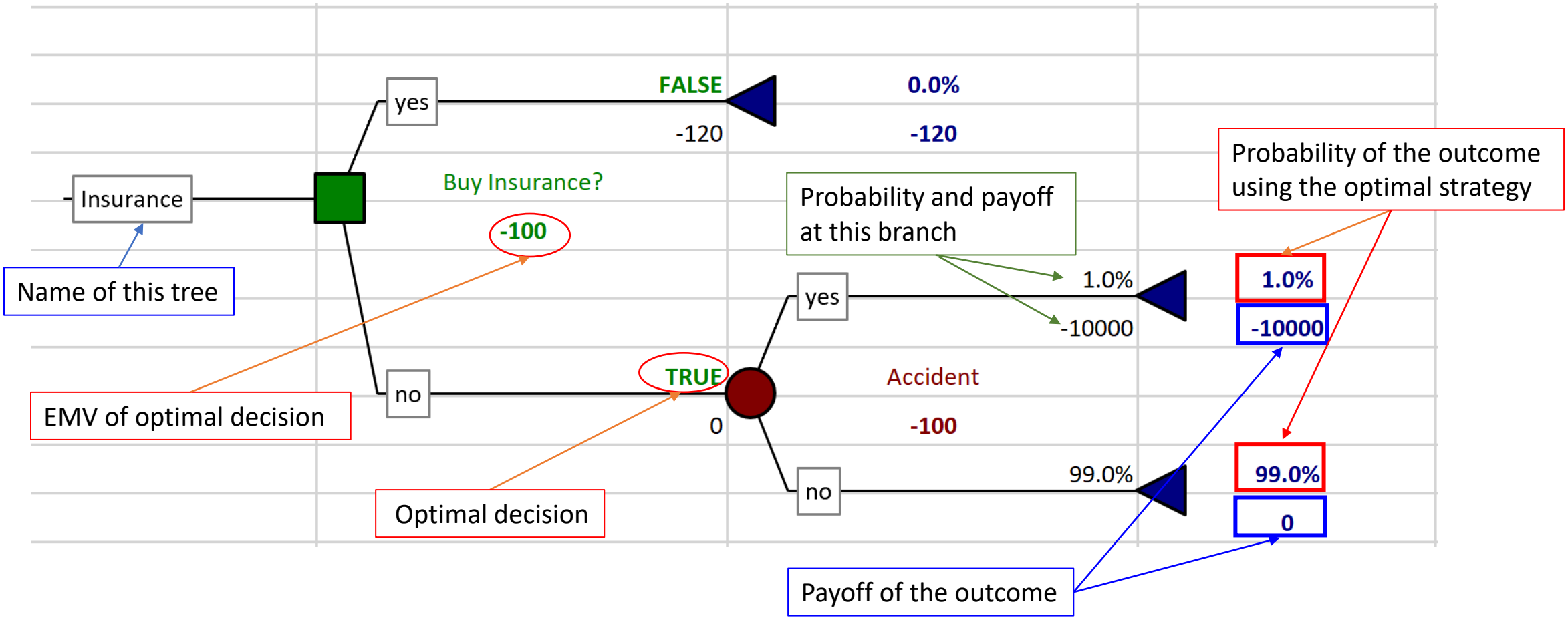
- The best decision is found using *the* ***rollback (folding-back) procedure***
- Start at the end and work your way backwards (from right to the left)

- Precision Tree does this automatically
  - Optimal decision branch is marked TRUE, otherwise FALSE
  - **Policy Suggestion** produces the optimal tree
  - **Risk Profile** summarizes the EMV for each decision as well as the probability of each outcome

# Ann’s Auto Insurance - Part A

1. Decision Tree for EMV maximizer
   - Build a tree
   - Generate an optimal tree
   - Perform a sensitivity analysis
2. Decision Tree for Exponential EU maximizer
   - Build a tree
   - Generate an optimal tree
   - Perform a sensitivity analysis

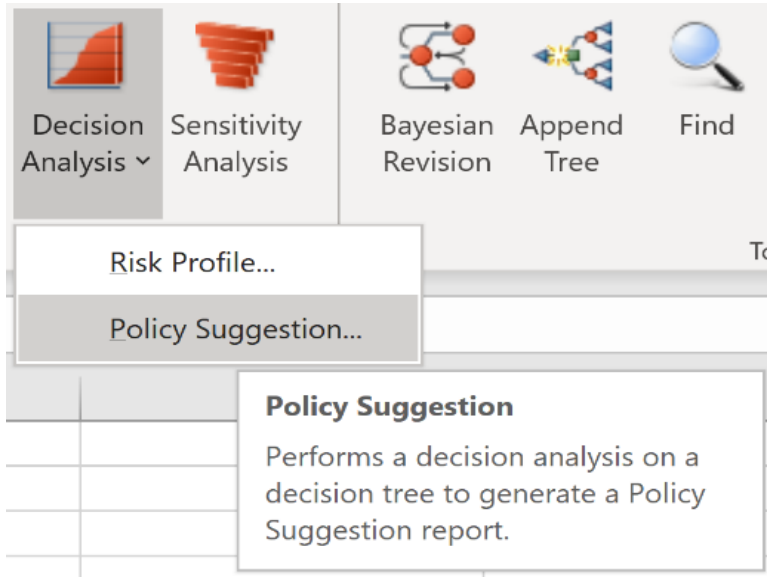
# How to Read Decision Tree?
# Ann's Auto Insurance - Part A: Maximizing EMV

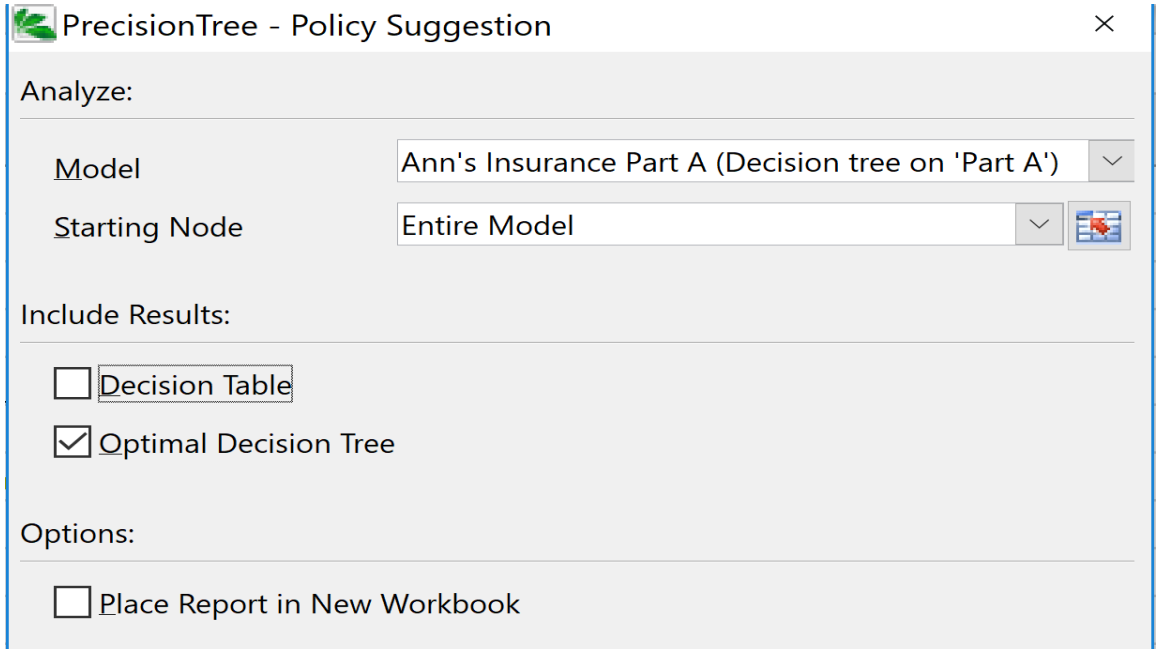


# Decision Tree for Ann's Auto Insurance problem - Part A

Create Optimal decision tree

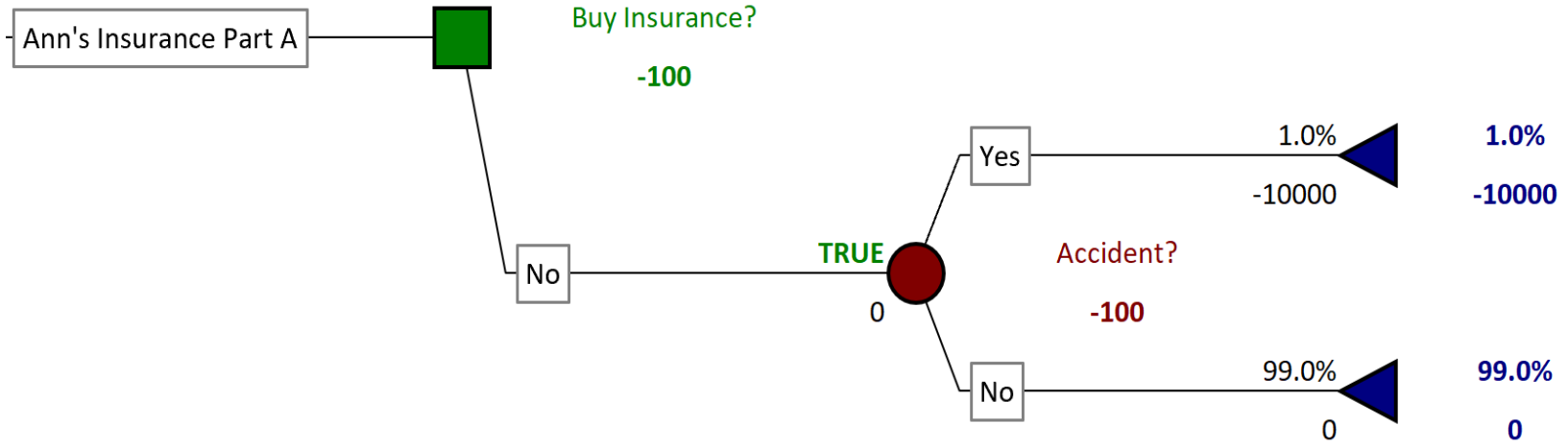
- Go to Decision Analysis -> Policy Suggestion -> Click Optimal Decision Tree



# Decision Tree for Ann's Auto Insurance problem - Part A

Optimal Decision Tree

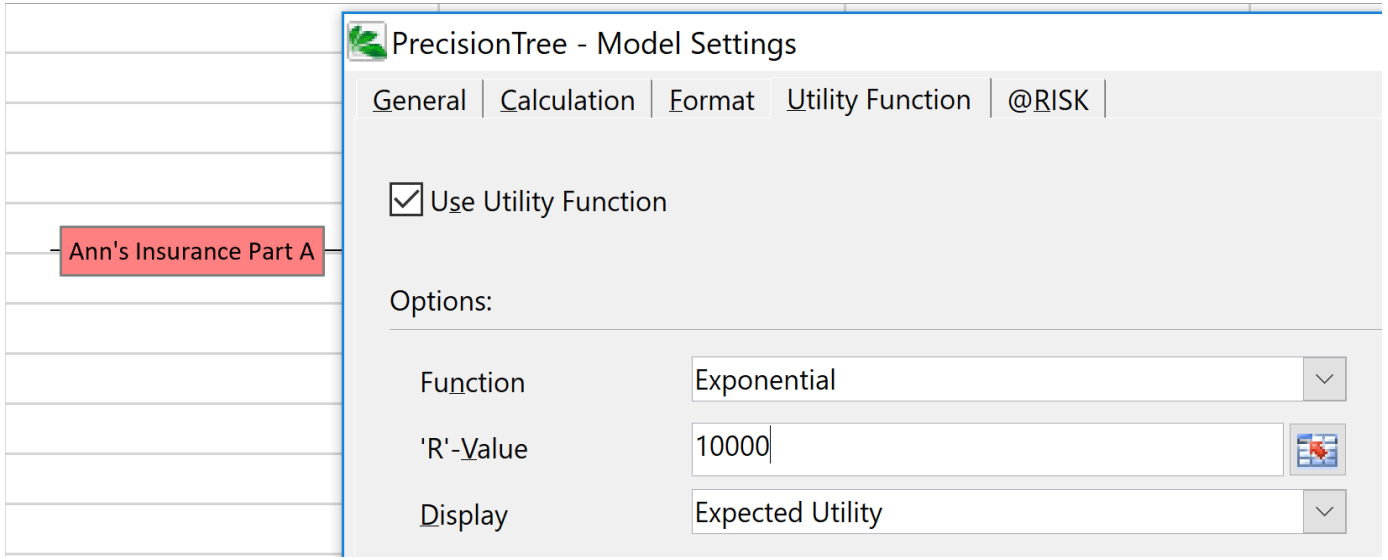


# Decision Tree for Ann's Auto Insurance problem - Part A

## EU Maximizer

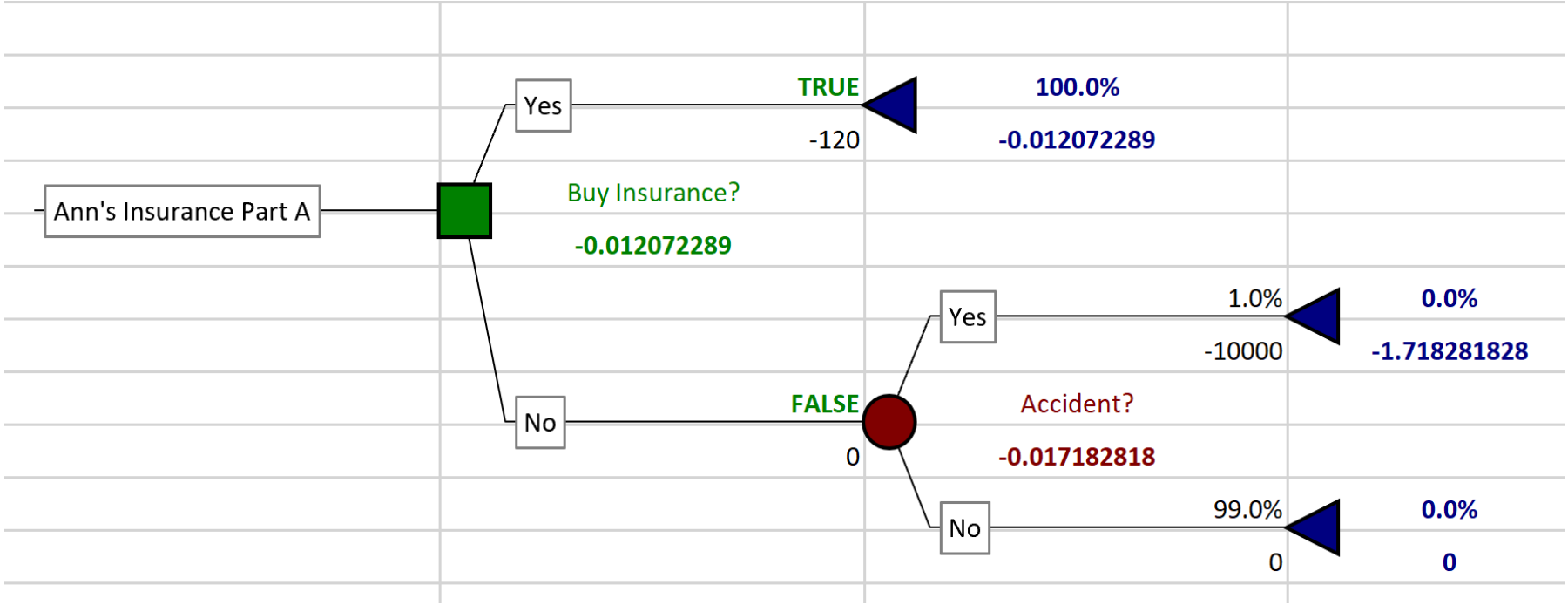
Suppose Ann's risk attitude is best represented by an exponential utility function with a risk tolerance R = $10,000. Build a decision tree for this problem.

1. Click the name of the tree. Click 'Utility Function' tab.



# Decision Tree for Ann's Auto Insurance problem - Part A

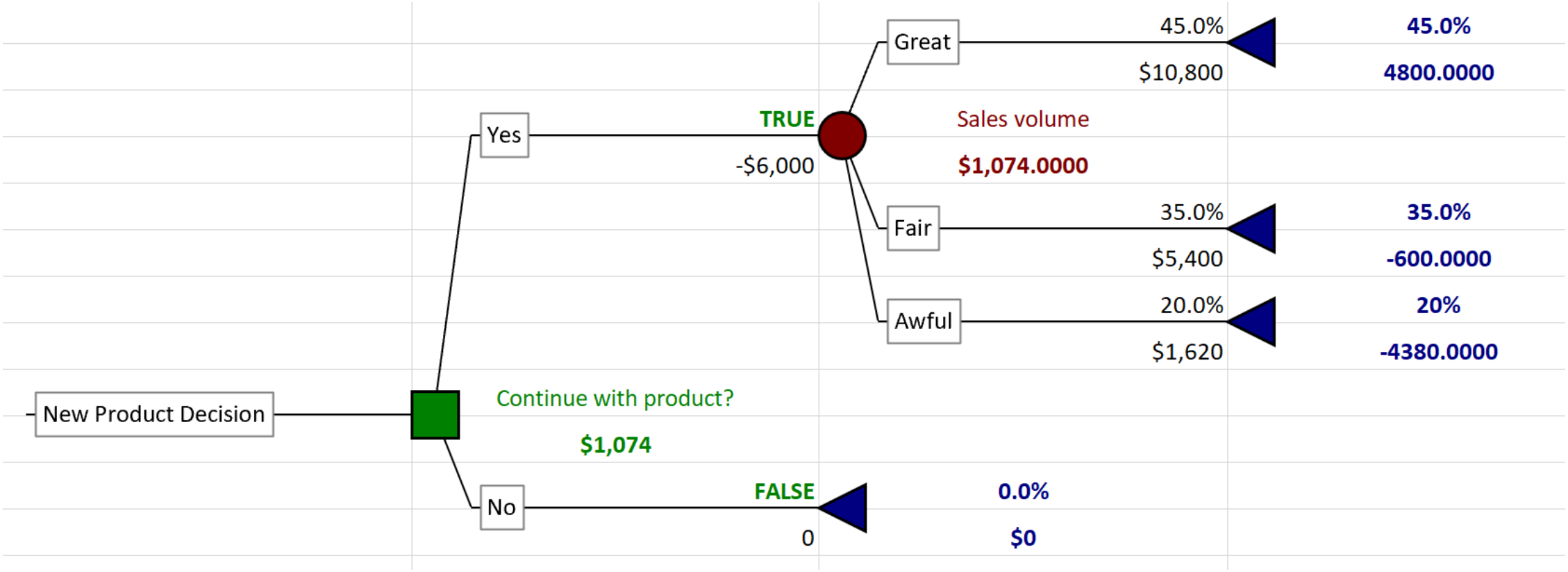
## EU Maximizer



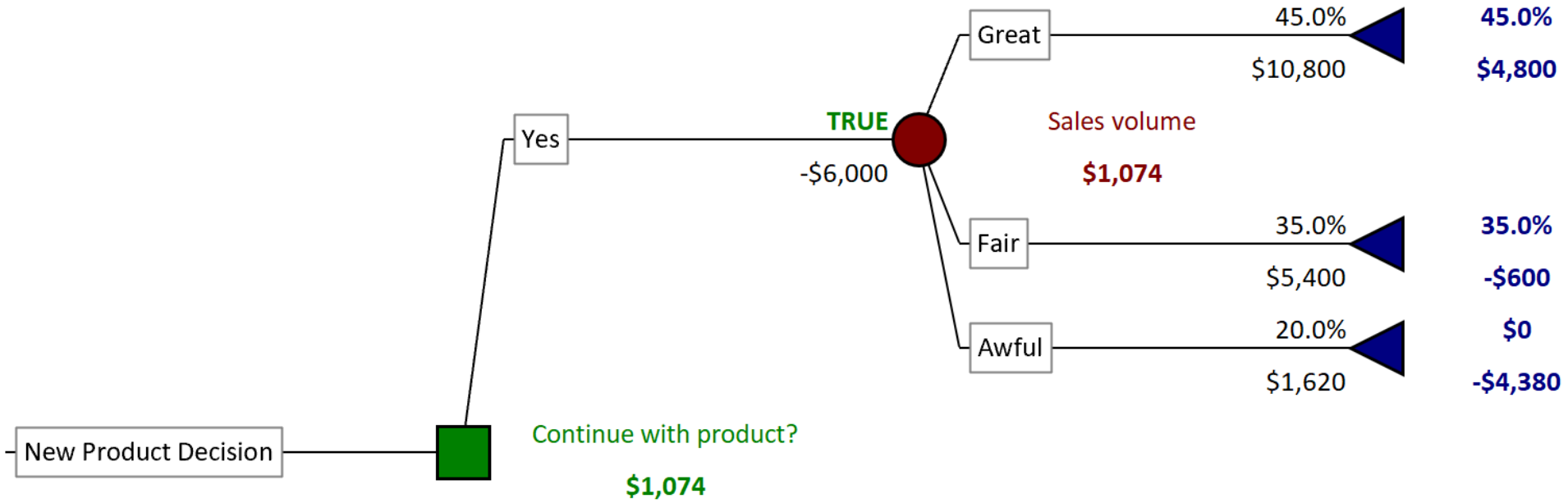
# In-Class Exercise (Quiz 13)

- Create the decision tree for ACME using Precision Tree
  - Use ‘New Product_Single Stage_template.xslx’

# New Product Decision at ACME



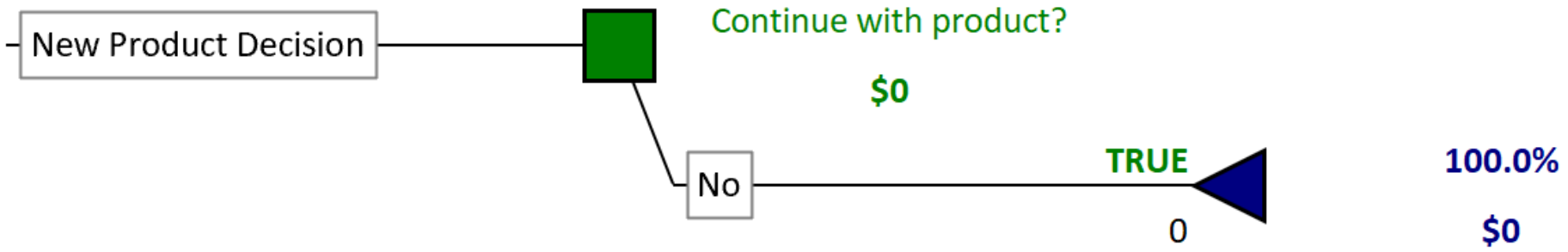
# New Product Decision at ACME: Optimal Tree – EMV maximizer




Should ACME finish development and then market the product, or should it stop development at this point and abandon the product?

> **Yes!**

# New Product Decision at ACME:
# Optimal tree with exponential utility: $u(x) = 1 - e^{-x/5000}$




Should ACME finish development and then market the product, or should it stop development at this point and abandon the product?

**> No !**

# Final Exam

## Thursday, December 16, 1:30-3:30pm, VMH 1212

- A **seat map** will be posted in the morning of December 15.
- Coverage: Lecture 7-21 (from hypothesis test to decision tree), IA4, IA5, IA6 and TA2. Relevant quizzes.
- You are allowed to have one sheet of paper with notes (double-sided).
- Scratch papers for calculations will be given in the exam.
- Both notes and scratch papers will be collected after the exam.
- You are NOT allowed to use the book or other notes.
- You need to use Respondus lockdown browser to take the exam.
- You can also use a scientific calculator. You can also use the calculator in lockdown browser.
- The practice final exam will be posted under 'Module' later this week.
- Extra office hours: Tuesday, Dec 14, 10 am-12pm VMH - 1333 - ATK Classroom

# Sensitivity Analysis for Decision Trees

# Sensitivity Analysis for Decision Trees

- Some input parameters will be estimates with some level of uncertainty
- It is important to analyze how sensitive our decisions (and EMV or EU) are to various input parameters
- Precision Tree offers several built-in tools to perform one- and two-way sensitivity analysis of decision trees
  - Based on expected value or expected utility
  - Multiple visualizations: sensitivity graph, **strategy region**, tornado graph, spider graph

# Ann's Auto Insurance Part A – Sensitivity Analysis

- Perform one-way sensitivity analysis, varying **probability of accident** from 1% to 2% (with 11 steps), and show the strategy region
  - As the probability increases, the EMV _____
  - How about the optimal decision?
- Perform one-way sensitivity analysis, varying **cost of policy** from $80 - $150 (with 8 steps), and show the strategy region
  - As the cost of policy decreases, the EMV _____
  - How about the optimal decision?

- Perform two-way sensitivity analysis, varying **cost of policy** from $80 - $150 and varying **probability of accident** from 1% to 2%, and show the strategy region

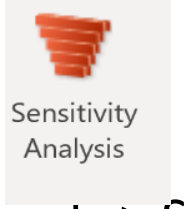
# Ann's Auto Insurance Part A – Sensitivity Analysis

- Perform one-way sensitivity analysis, varying **probability of accident** from 1% to 2% (with 11 steps), and show the strategy region
  - As the probability increases, the EMV ___decreases_____
  - How about the optimal decision? switch from 'No (not buying)' to 'Yes (buying)'
- Perform one-way sensitivity analysis, varying **cost of policy** from $80 - $150 (with 8 steps), and show the strategy region
  - As the cost of policy decreases, the EMV ___ increases _____
  - How about the optimal decision? switch from 'No (not buying)' to 'Yes (buying)'

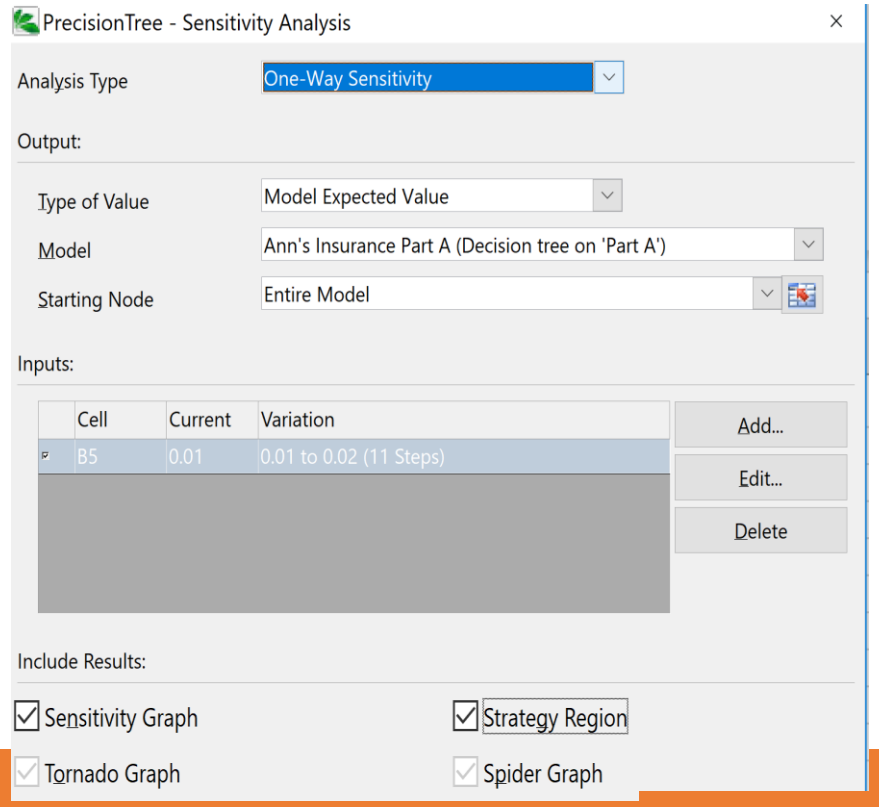
- Perform two-way sensitivity analysis, varying **cost of policy** from $80 - $150 and varying **probability of accident** from 1% to 2%, and show the strategy region

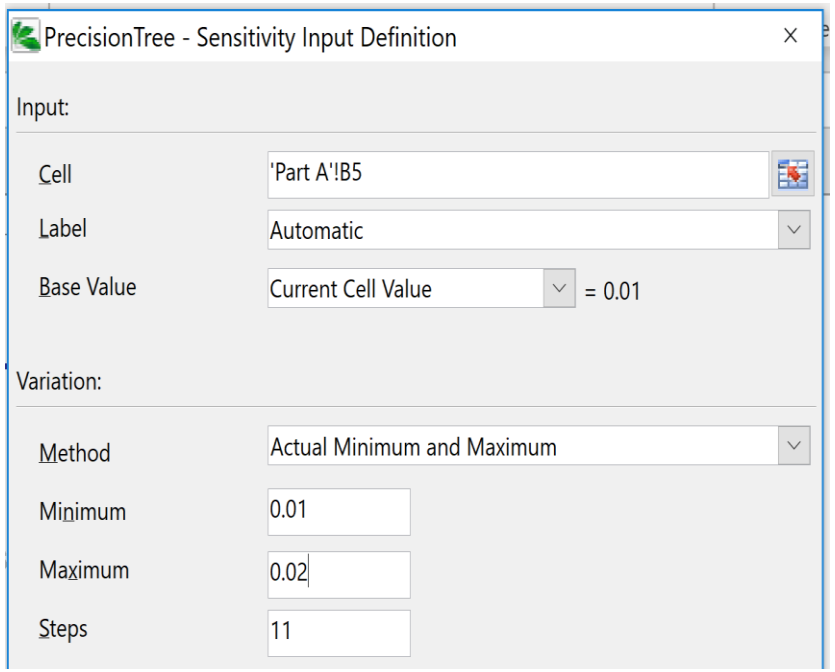
# Ann's Auto Insurance Part A – Sensitivity Analysis

- Click 'Sensitivity Analysis'

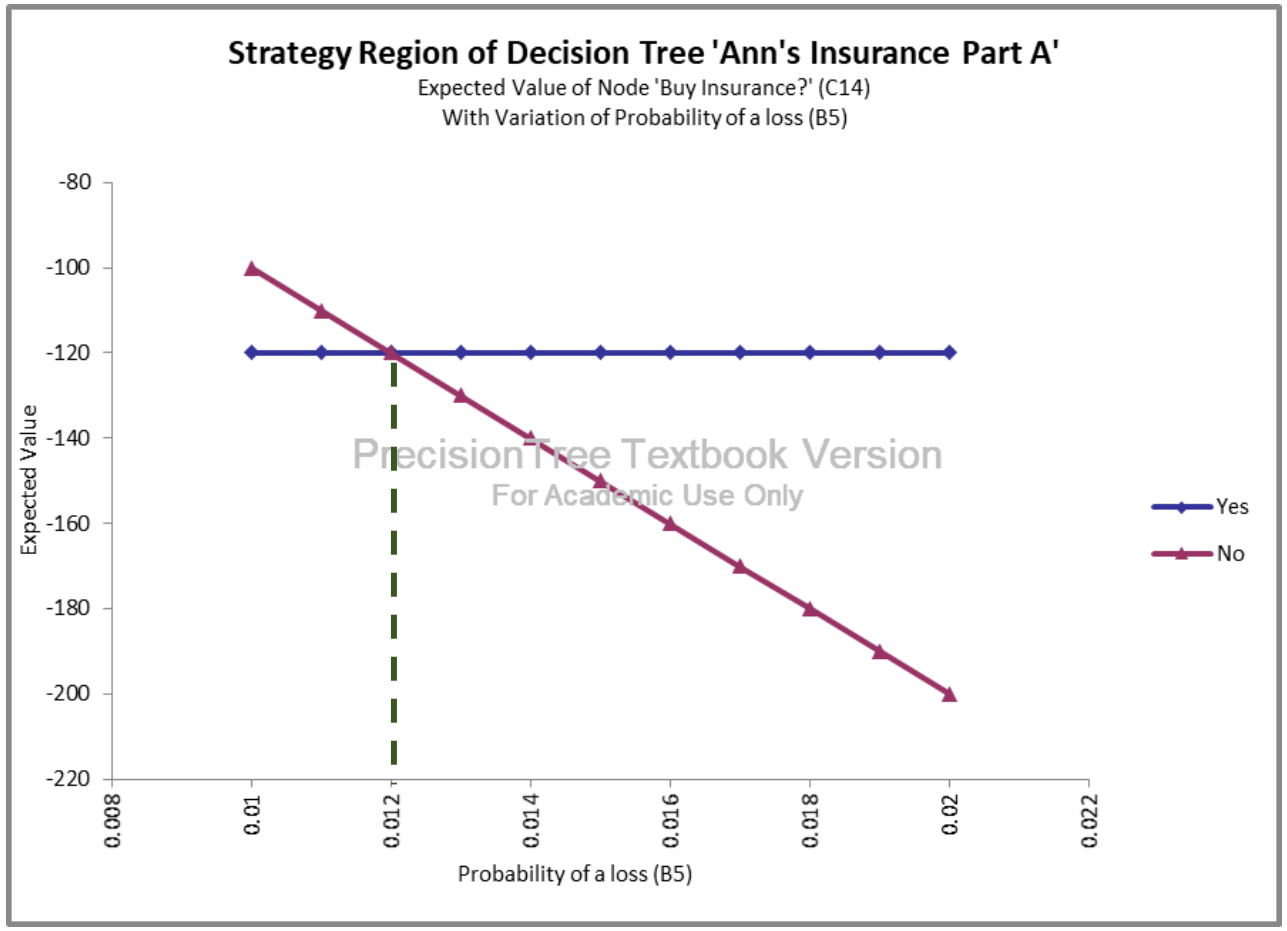



- One-Way Sensitivity-> Add Input -> Select the cell (B5) -> set up the range-> click 'Sensitivity Graph' and 'Strategy Region'->Click



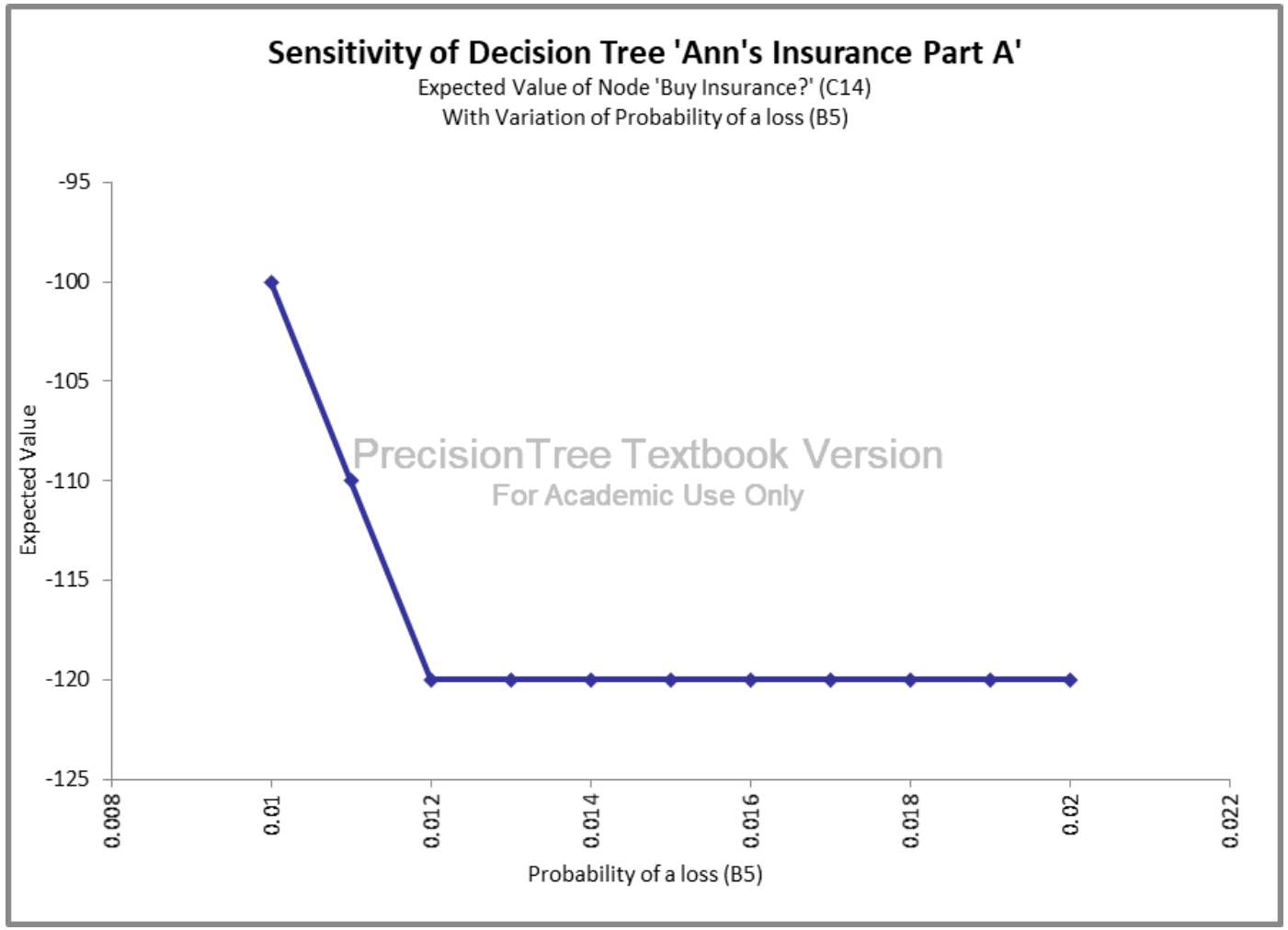



# **Sensitivity analysis on probability of accident:** Strategy Region




| Strategy Region Data | | | | | | |
|---|---|---|---|---|---|---|
| | Input | | Yes | | No | |
| | Value | Change (%) | Value | Change (%) | Value | Change (%) |
| #1 | 0.01 | 0.00% | -120 | -20.00% | -100 | 0.00% |
| #2 | 0.011 | 10.00% | -120 | -20.00% | -110 | -10.00% |
| #3 | 0.012 | 20.00% | -120 | -20.00% | -120 | -20.00% |
| #4 | 0.013 | 30.00% | -120 | -20.00% | -130 | -30.00% |
| #5 | 0.014 | 40.00% | -120 | -20.00% | -140 | -40.00% |
| #6 | 0.015 | 50.00% | -120 | -20.00% | -150 | -50.00% |
| #7 | 0.016 | 60.00% | -120 | -20.00% | -160 | -60.00% |
| #8 | 0.017 | 70.00% | -120 | -20.00% | -170 | -70.00% |
| #9 | 0.018 | 80.00% | -120 | -20.00% | -180 | -80.00% |
| #10 | 0.019 | 90.00% | -120 | -20.00% | -190 | -90.00% |
| #11 | 0.02 | 100.00% | -120 | -20.00% | -200 | -100.00% |

# **Sensitivity analysis on probability of accident:**
Sensitivity graph



# Sensitivity Analysis on cost of policy on cost of policy:
## Strategy Region

Inputs:

| | Cell | Current | Variation |
|---|---|---|---|
| ☐ | B5 | 0.01 | 0.01 to 0.02 (11 Steps) |
| ☑ | E3 | 120 | 80 to 150 (8 Steps) |

Add... Edit... Delete

PrecisionTree - Sensitivity Input Definition

Input:

Cell: E3

Label: Automatic

Base Value: Current Cell Value = 120

Variation:

Method: Actual Minimum and Maximum

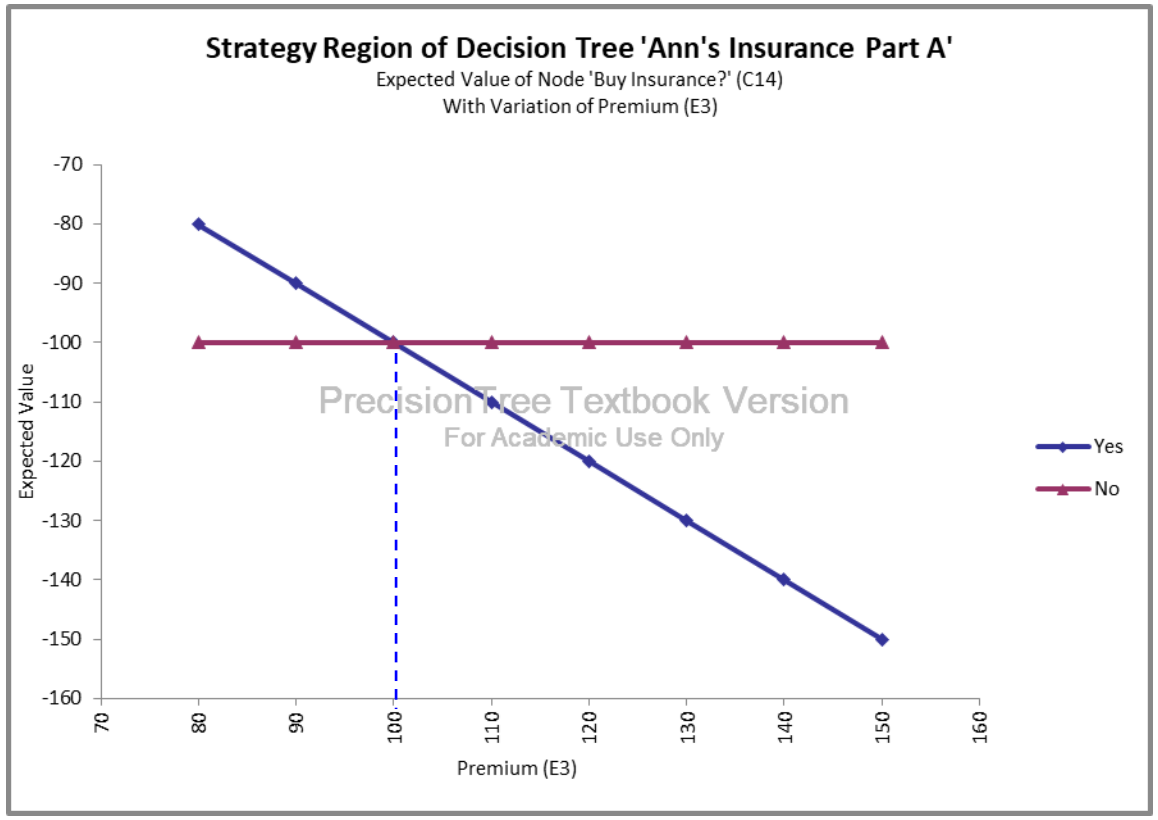
Minimum: 80

Maximum: 150

Steps: 8

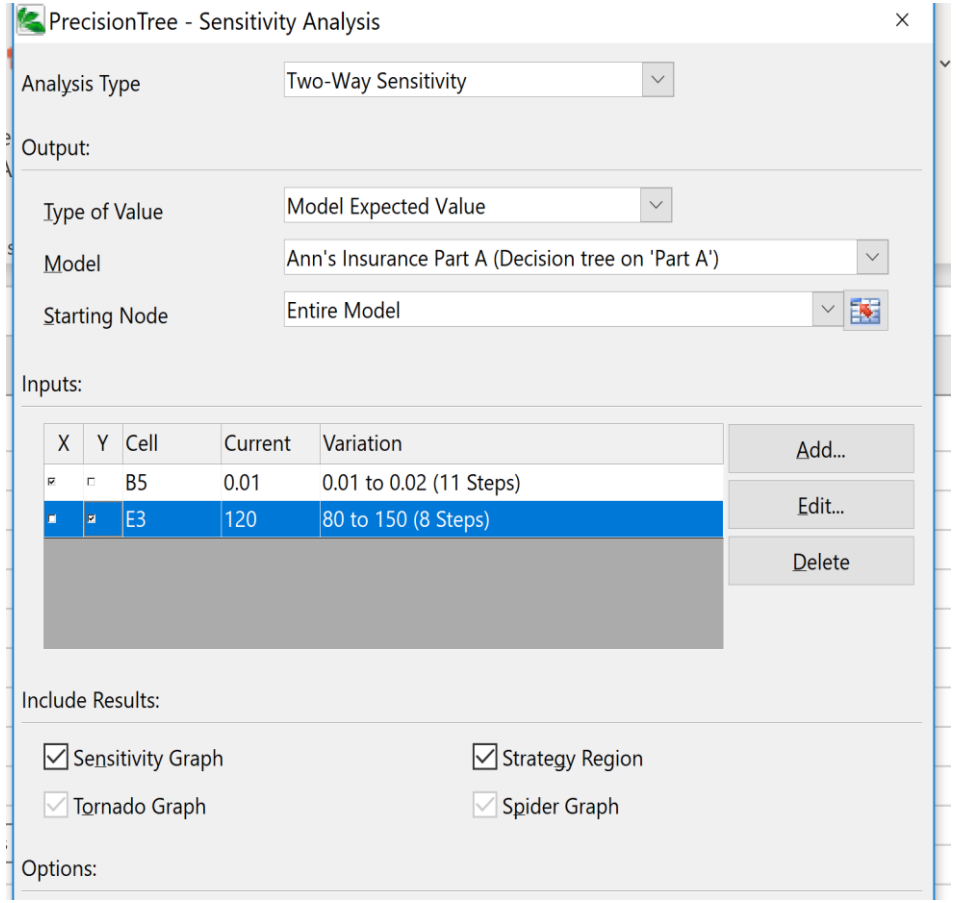
OK Cancel

How much is Ann willing to pay for the insurance?

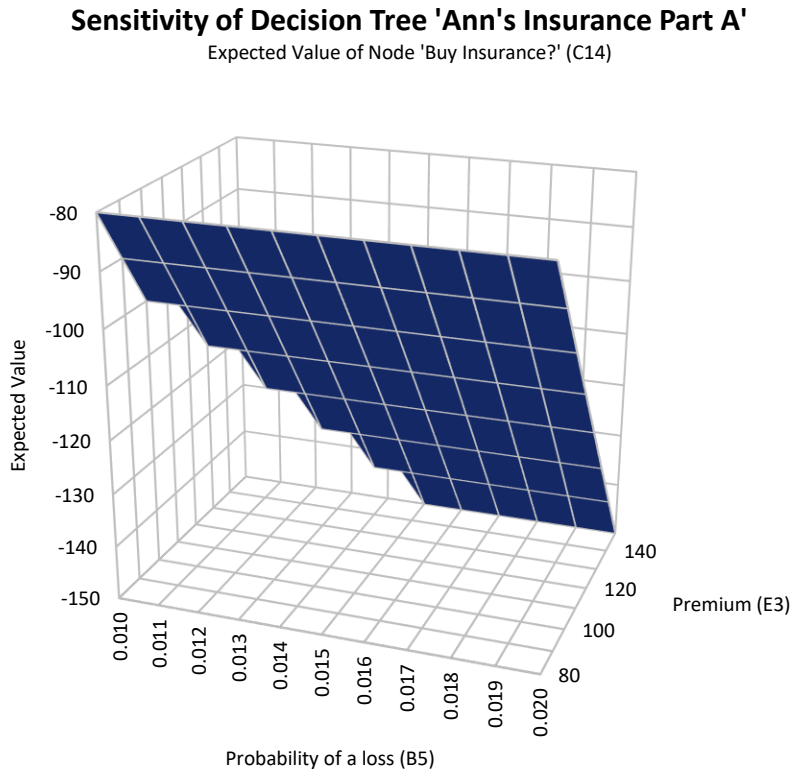


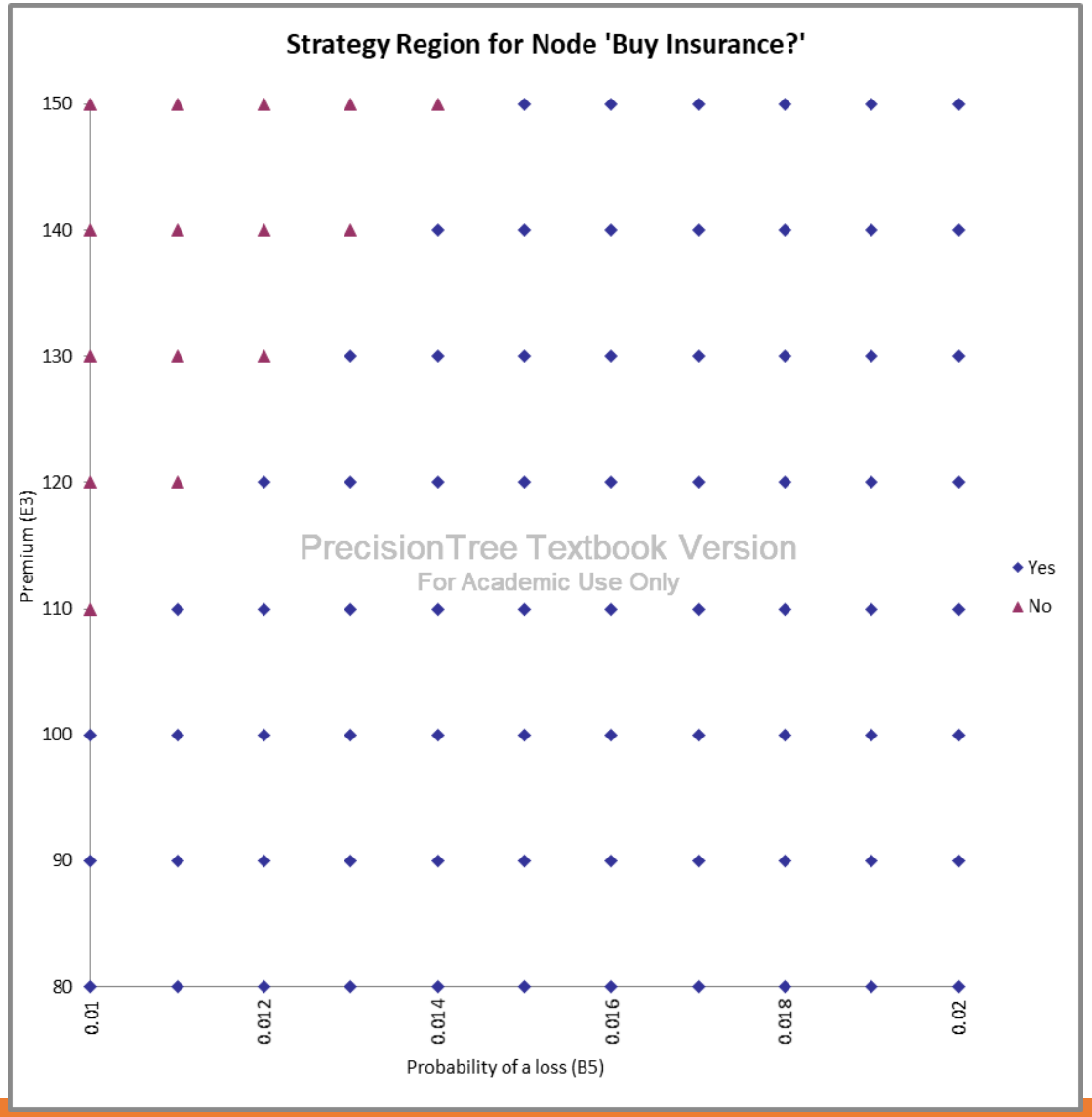
# Ann's Auto Insurance Part A – Sensitivity Analysis on **probability of accident and cost of policy**

- Two-Way Sensitivity -> Add Input -> Select the cell (E3) -> set up the range



# Sensitivity Analysis on **probability of accident and cost of policy**



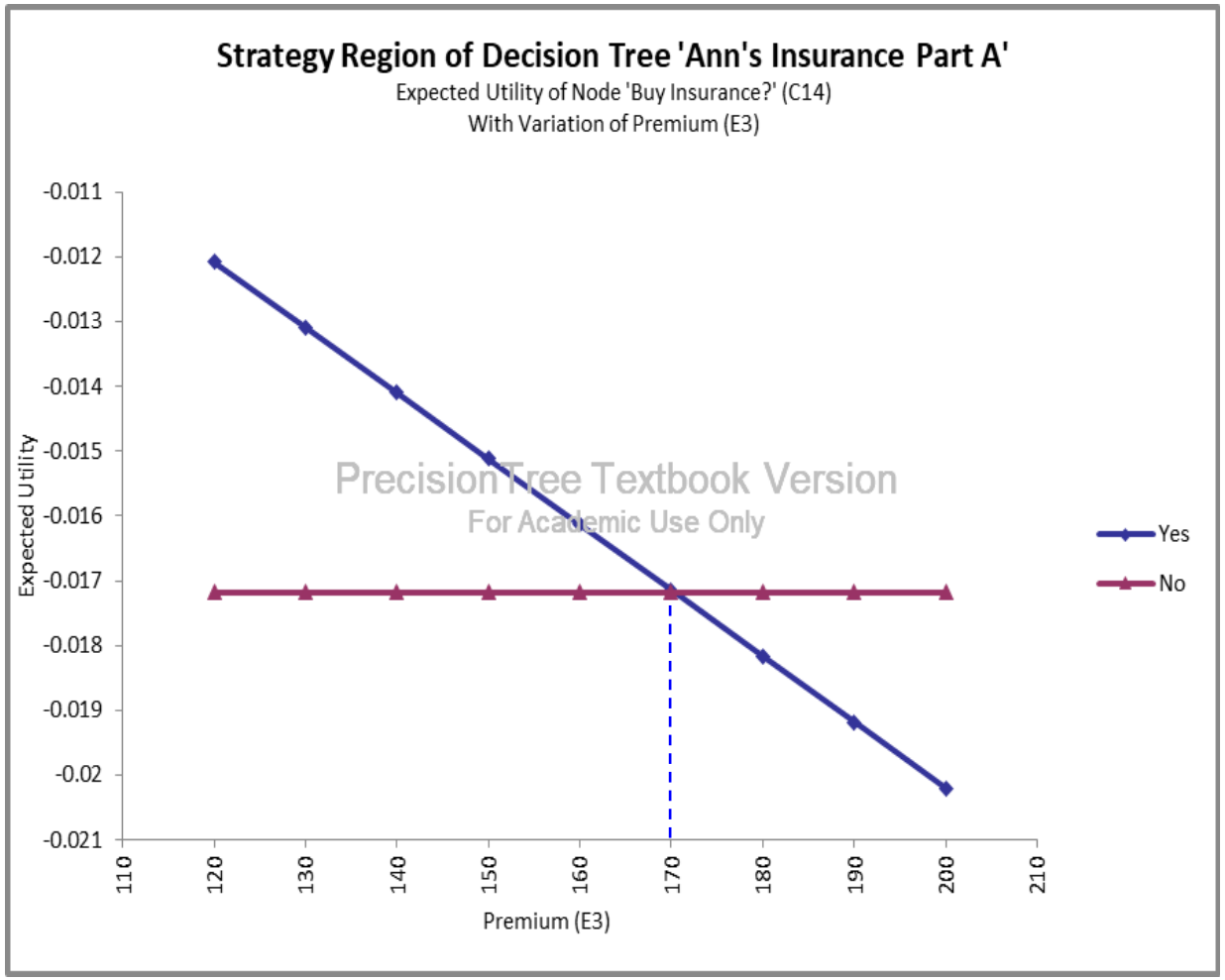



# Sensitivity Analysis on **cost of policy**

**EU Maximizer**

- Perform one-way sensitivity analysis, varying **cost of policy** from $120 - $200 (with 9 steps), and show the strategy region

How much is Ann willing to pay for the insurance?



# Next …

- Multistage Decision Tree:
  - Build a decision tree for Ann's insurance problem
  - Sensitivity Analysis on Ann's insurance
  - New Product Decision at ACME