

## In-Class Exercise 3

For this in-class exercise, work with your group of 2-3 people, to answer the following questions. These questions are not necessarily easy and sometimes they will not have a clear “correct” answer. The goal is to get you thinking about the material we’ve learned. Some of these questions may require you to discuss and debate with your group members to come up with an answer or can cover topics that we have not yet covered in class.

Be prepared to share your answers with the class and add to the discussion.

After class submit your a do-file with your answers in comments to Moodle for grading. You will be graded as a group on your submission. Only one group member needs to submit the assignment, but make sure add all group member names.

### Bayesian Networks in Macroeconomics

You would like to understand the relationship between tax cuts, business sentiment, investment, and GDP growth. You believe that tax cuts lead to investment that boosts GDP growth. But investor sentiment is also an important factor that drives investment. You decide to model this using a Bayesian network.

#### **i** Hint

Review the lecture on Bayesian networks and the examples we went through in class.

In these questions, I give you the necessary probabilities in words. To aid in solving the problems, you should turn these words into probabilities.

For example, if I say “a tax cut has led to GDP growth 80% of the time,” you can write this as  $P(Y | T) = .8$ .

#### **Problem 1**

Suppose to make things simpler, you assume that the only factor that increases GDP growth is tax cuts. Draw a Bayesian network that represents this relationship. Then show how the joint probability distribution can be broken down or “decomposed” using the structure of the network.

#### **Problem 2**

Suppose your prior is that the probability that Congress passes a tax cut is 0.3. You know that in the past, a tax cut has led to GDP growth 80% of the time. But you also know that even without a tax cut, GDP growth happens 20% of the time. You know that the probability that Congress passes a tax cut is 0.3.

 Warning

In this example, it looks like a tax cut leading to GDP growth and no tax cut leading to GDP growth sums to 1. This is just a coincidence!

Let's say we got new information from the Fed, and they say that GDP growth is happening. What is the probability that Congress passed a tax cut?

### Problem 3

Now let's make the model more complicated by adding investment and sentiment. Assume that tax cuts influences investment, and sentiment also influences investment. Investment then influences GDP growth. Draw the Bayesian network that represents this relationship.

### Problem 4

Using the structure of the network, show how the joint probability distribution can be turned into a product of conditional probabilities.

### Problem 5

We're going to assume that sentiment "blows the wind." It's just a coin flip whether sentiment is high or low, independent of anything else. You also know that the probability that Congress passes a tax cut is 0.3.

Explain why, using the law of total probability and the structure of the network, we can write the probability of GDP growth given a tax cut as:

$$P(Y = 1 | T = 1) = P(I = 1 | T = 1)P(Y = 1 | I = 1) + P(I = 0 | T = 1)P(Y = 1 | I = 0)$$

### Problem 6

You find out that GDP growth is happening ( $Y = 1$ ). Based on past data, GDP grows 90% of the time. What is the probability that a tax cut was passed, given that GDP growth is happening?

 Hint

Just because sentiment and investment aren't explicitly mentioned in the problem, doesn't mean you won't need to use them.

### Problem 7

Reflect on the results from f. What happened and why? Try to give me an intuitive explanation based on the structure of the network.