

# Practice Question 1

## Causal Inference

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### A. Sketch the Directed Acyclic Graph (DAG)

Sketch (on paper or in R) the following DAG, representing our beliefs that:

- $x_1$  causes  $x_2$
- $x_1$  causes  $x_3$
- $x_2$  causes  $x_3$

### B. Identify the number of open path(s)

How many open path(s) are there?

- A) 0
- B) 1
- C) 2
- D) 3

### C. Identify the number of backdoor path(s)

How many backdoor path(s) are there?

- A) 0
- B) 1
- C) 2
- D) 3

### D. What is the valid adjustment set?

What are the valid adjustment set(s)? (Multiple solutions are possible)

- A)  $\emptyset$
- B)  $\{X_2\}$
- C)  $\{X_1, X_2\}$
- D)  $\{X_2, X_3\}$

### E. Simulate the Data

Simulate the data ( $n = 1000$  with `set.seed(1)`) from the structural equations:

$$\begin{aligned}X_1 &\sim \mathcal{N}(0, 1) \\X_2 &\sim 2X_1 + \mathcal{N}(0, 1) \\X_3 &\sim X_1 - 0.5X_2 + \mathcal{N}(0, 1)\end{aligned}$$

where  $\epsilon_1, \epsilon_2, \epsilon_3 \sim \mathcal{N}(0, 1)$  (i.i.d.)

### F. Test the Correlations

Test the correlations between the variables use  $\alpha = 0.05$ . Tip: You can use `cor.test` from (`stats`) to test marginal dependencies and `pcor.test` from (`ppcor`) to test conditional dependencies.

### G. Recover the DAG

Which correlation(s) are (in)significant from part C? What structure can you infer from the results?

- A) Mediator
- B) Collider
- C) Confounder

### H. Recovered DAG from PC Algorithm

Figure 1 (next page) shows that the `PC-algorithm` did not recover the DAG. Which model assumption is not met?

- A) Positivity
- B) Exchangeability
- C) Faithfulness
- D) Sufficiency
- E) Strong ignorability

### I. Why does the algorithm require this assumption?

### J. In general, we do not worry about violation of this assumption, why?

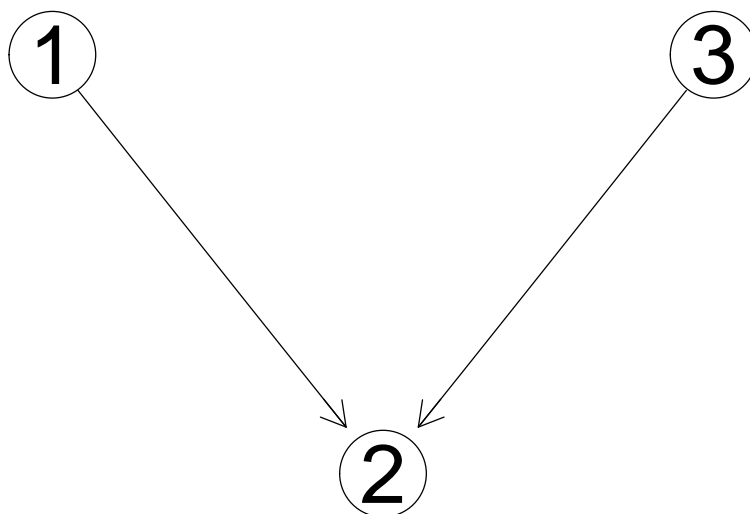


Figure 1: DAG Recovered by PC Algorithm