

# **Effective Programming Practices for Economists**

## **Background**

### **A Primer on Graphs**

Janoś Gabler and Hans-Martin von Gaudecker

# Graph definition

A graph  $G$  is a pair  $(N, E)$  of sets, where  $N$  are nodes and  $E$  are edges:

$$G = (N, E)$$

Edges are

- sets of two nodes (undirected graphs)
- pairs of nodes (directed graphs)

# Chain (undirected)

$$N = \{x_0, x_1, x_2, x_3\}$$

$$E = \left\{ \begin{array}{l} \{x_0, x_1\}, \\ \{x_1, x_2\}, \\ \{x_2, x_3\} \end{array} \right\}$$



# Chain (undirected)

$$N = \{x_0, x_1, x_2, x_3\}$$

$$E = \left\{ \begin{array}{l} \{x_1, x_0\}, \\ \{x_1, x_2\}, \\ \{x_2, x_3\} \end{array} \right\}$$



# Chain (directed)

$$N = \{x_0, x_1, x_2, x_3\}$$

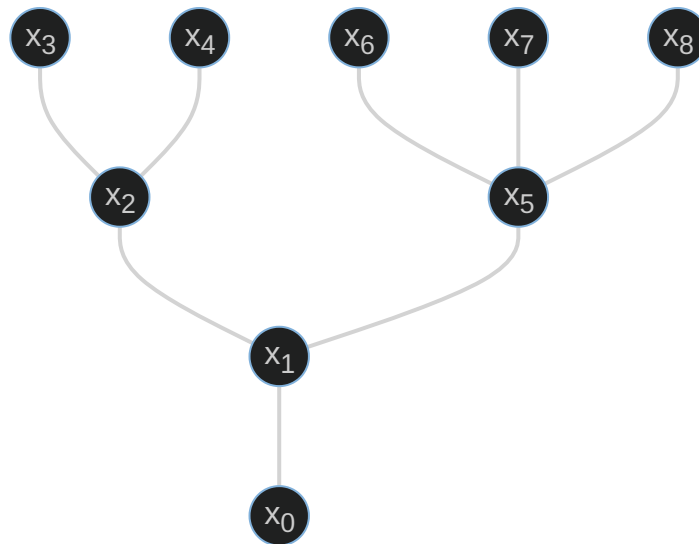
$$E = \left\{ \begin{array}{l} (x_0, x_1), \\ (x_1, x_2), \\ (x_2, x_3) \end{array} \right\}$$



# Tree (undirected)

$$N = \{x_0, x_1, \dots, x_8\}$$

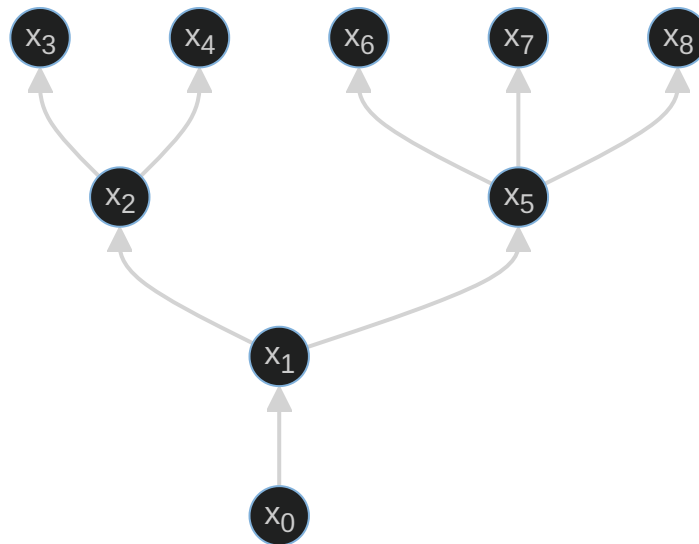
$$E = \left\{ \begin{array}{l} \{x_0, x_1\}, \{x_1, x_2\}, \{x_2, x_3\}, \\ \{x_2, x_4\}, \{x_1, x_5\}, \{x_5, x_6\}, \\ \{x_5, x_7\}, \{x_5, x_8\} \end{array} \right\}$$



# Tree (directed, "arborescence")

$$N = \{x_0, x_1, \dots, x_8\}$$

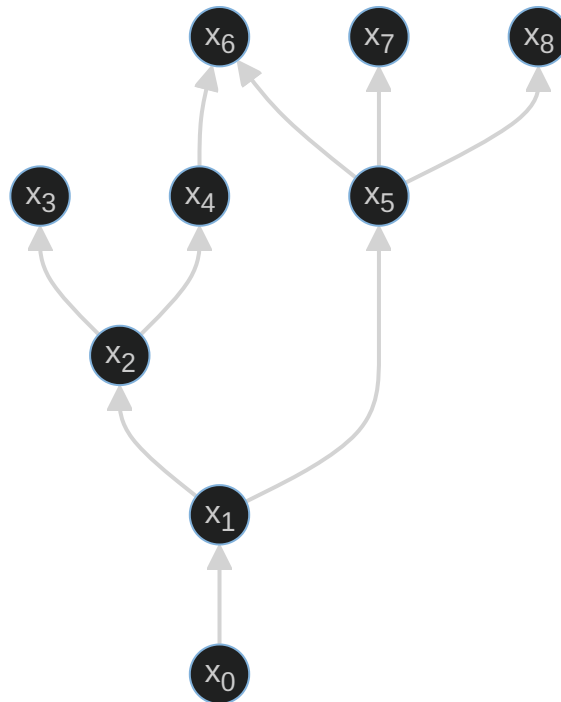
$$E = \left\{ \begin{array}{l} (x_0, x_1), (x_1, x_2), (x_2, x_3), \\ (x_2, x_4), (x_1, x_5), (x_5, x_6), \\ (x_5, x_7), (x_5, x_8) \end{array} \right\}$$



# Directed Acyclic Graph (DAG)

$$N = \{x_0, x_1, \dots, x_8\}$$

$$E = \left\{ \begin{array}{l} (x_0, x_1), (x_1, x_2), (x_2, x_3), \\ (x_2, x_4), (x_1, x_5), (x_5, x_6), \\ (x_5, x_7), (x_5, x_8), (x_4, x_6) \end{array} \right\}$$





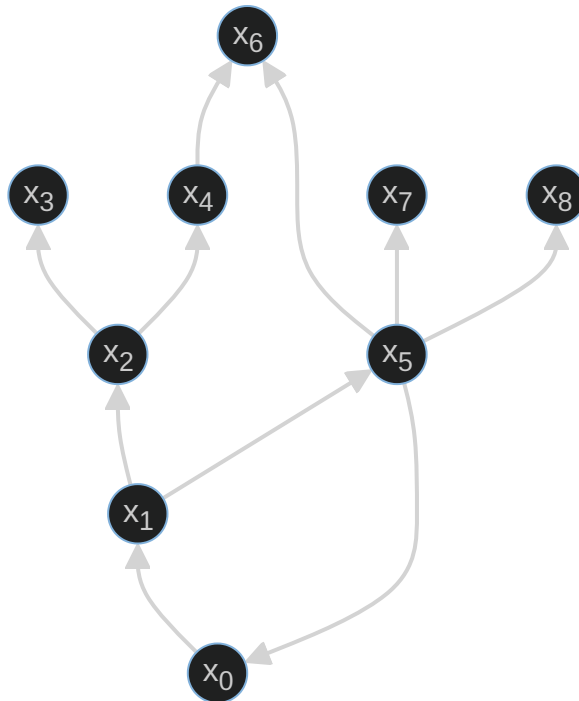
# Directed ~~Acyclic~~ Graph

$$N = \{x_0, x_1, \dots, x_8\}$$

$$E = \{$$

- $(x_0, x_1), (x_1, x_2), (x_2, x_3),$
- $(x_2, x_4), (x_1, x_5), (x_5, x_6),$
- $(x_5, x_7), (x_5, x_8), (x_4, x_6),$
- $(x_5, x_0)$

$$\}$$



# Graph Use Cases

- The file system
- Git
- Reproducible research
- Causal theory
- Behavioural economics
- ...