#### **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)**

```
х3
N = \{x_0, x_1, x_2, x_3\}
E=\{
                                                (x_2)
        \{x_0,x_1\},
         \{x_1,x_2\},
         \{x_2,x_3\}
                                                x_0
```

#### **Chain (undirected)**

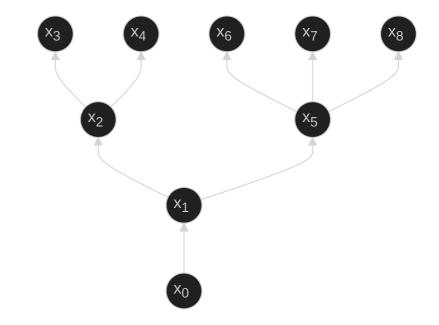
```
х3
N = \{x_0, x_1, x_2, x_3\}
E=\{
                                                (x_2)
        \{x_1,x_0\},
         \{x_1,x_2\},
        \{x_2,x_3\}
                                                x_0
```

# **Chain (directed)**

```
N = \{x_0, x_1, x_2, x_3\}
E= \{
                                                    x<sub>2</sub>
         (x_0,x_1),
         (x_1,x_2),
         (x_2,x_3)
                                                    x_0
```

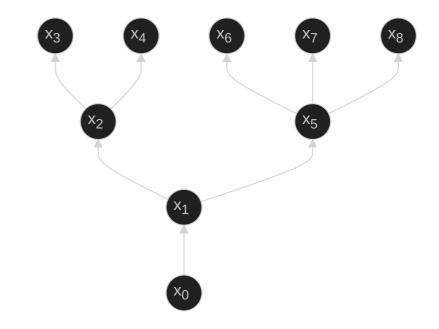
#### **Tree (undirected)**

```
egin{aligned} 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\} \ & \} \end{aligned}
```



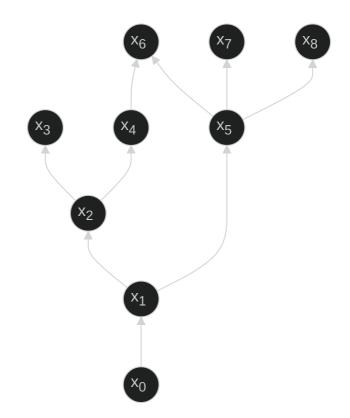
#### Tree (directed, "arborescence")

```
egin{aligned} 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) \ & \} \end{aligned}
```



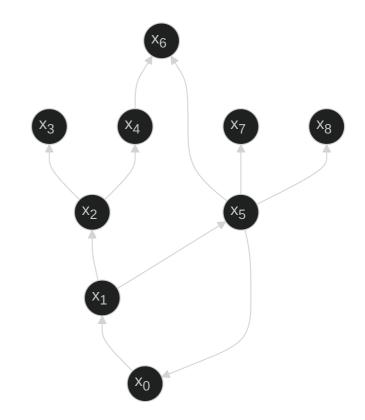
## **Directed Acyclic Graph (DAG)**

```
egin{aligned} 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) \ & \} \end{aligned}
```



# 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
- **-** ...