#### **Effective Programming Practices for Economists**

# **Background**

A Primer on Graphs

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# **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 = \{\{x_0, x_1\}, \{x_1, x_2\}, \{x_2, x_3\}\}
```

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

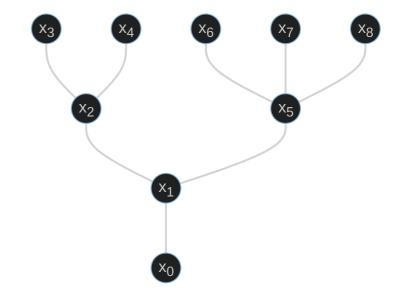
```
N = \{x_0, x_1, x_2, x_3\}
E = \{\{x_1, x_0\}, \{x_1, x_2\}, \{x_2, x_3\}\}
```

#### **Chain (directed)**

```
egin{aligned} N = & \{x_0, x_1, x_2, x_3\} \ E = & \{ & (x_0, x_1), \ & (x_1, x_2), \ & (x_2, x_3) \ \} \end{aligned}
```

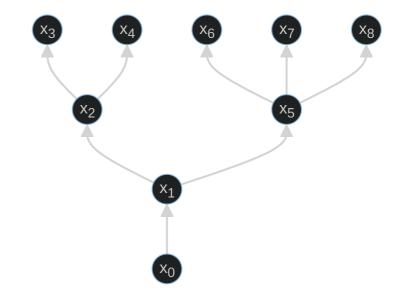
#### **Tree (undirected)**

```
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}
```



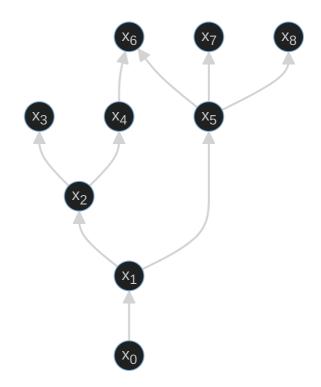
#### Tree (directed, "arborescence")

```
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}
```



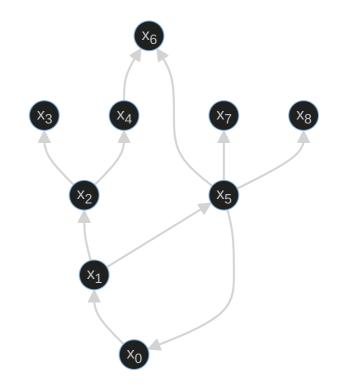
#### **Directed Acyclic Graph (DAG)**

```
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
- **-** ...