

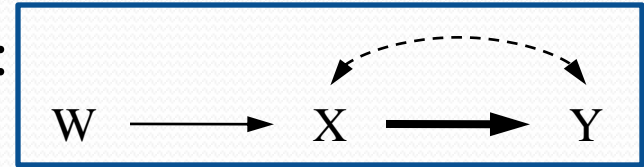
## Extending the Use of Instrumental Variables for the Identification of Direct Causal Effects in SEMs

- Problem: Identify direct causal effect  $X \rightarrow Y$  in linear Structural Equation Models (SEMs)

- Previous result: Use **instrumental variable**  $W$ , if:

- Graphical criteria is satisfied, e.g.:

- $W$  is **not a descendant of  $X$  or  $Y$**



- Direct effect  $X \rightarrow Y = \sigma_{wy.z} / \sigma_{wx.z}$
- However, we cannot identify some direct effects  $X \rightarrow Y$  using this graphical criteria
- Question: Can we use  $W$  as an instrumental variable, even if  $W$  is **a descendant of  $X$  or  $Y$** ?

## Extending the Use of Instrumental Variables for the Identification of Direct Causal Effects in SEMs

- New result: W, **a descendant of X**, can be used as an “**path-specific instrumental variable**”, if:

- New graphical criteria is satisfied, e.g.:
- Total effect **X→W** is identifiable:  $\tau_{WX}$

- Direct effect  $X \rightarrow Y =$

$$(\sigma_{WY.Z} - \sigma_{YX.Z} \tau_{WX}) / (\sigma_{WX.Z} - \sigma_{XX.Z} \tau_{WX})$$

- As a result, we can identify some direct effects  $X \rightarrow Y$  using this new graphical criteria

- Future work: Solution of W, **a descendant of Y**, as an “path-specific instrumental variable”

