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 $Y$*?

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- **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 $X \rightarrow W$ is identifiable: $\tau_{wx}$
- **Direct effect** $X \rightarrow Y =
  \frac{(\sigma_{wy.z} - \sigma_{yx.z} \tau_{wx})}{(\sigma_{wx.z} - \sigma_{xx.z} \tau_{wx})}$
- 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”

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