Identifying Direct Causal Effects Under Unmeasured Confounding

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Introduction

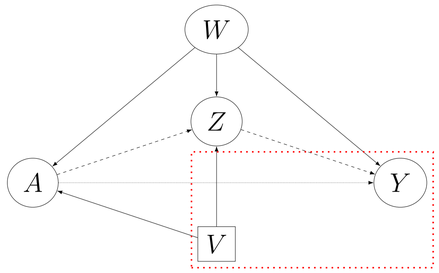
This is the background.

Statistical Problem

State the causal and statistical models, and estimand.
The causal target parameter is

$$\Psi^F(P_{U,X,0}) = \int_{w,z} \mathbb{E}[Y(1,z) - Y(0,z) \mid W = w] \, p_Z(z \mid A = 0, w) p_W(w) \, dz \, dw \, .$$

Identification



(A1) No unmeasured endogenous pathways:
$f_Y(Z, A, W, V, U_Y) \equiv f_Y(Z, A, W, U_Y)$.

(A2) Conditional expectation equivalence:
$\mathbb{E}(Y \mid Z, A = 1, W, V) \equiv \mathbb{E}(Y \mid Z, A = 1, W)$

Theorem

Under assumptions A1 and A2, $\Psi^F(P_{U,X,0})$ is identified by

$$\Psi(P_0) = \mathbb{E}_{P_0}\mathbb{E}_{P_0}\{\mathbb{E}_{P_0}(Y \mid W, A = 1, Z) - \mathbb{E}_{P_0}(Y \mid W, A = 0, Z) \mid A = 0, W\} \, .$$

Inference

Existing estimation and testing approaches are compatible with with this relaxed identification strategy.

Examples include the targeted maximum likelihood estimator of Zheng and van der Laan [2012] and the one-step estimator based on the efficient influence function of $\Psi(P)$ [Tchetgen Tchetgen and Shpitser, 2011]. These nonparametric estimators are multiple-robust and asymptotically linear under non-restrictive assumptions.

These estimators are implemented in the `medoutcon` `R` package.

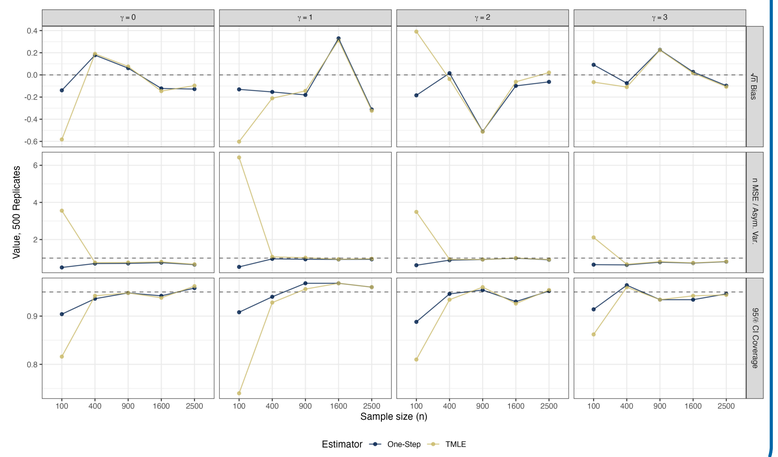
Funding

Thank you for paying my bills.

Simulation Study

We consider the following data-generating process:

$$\begin{aligned} W_1 &\sim \text{Unif}(-1, 1), \; W_2, V \sim N(0, 1) \\ A|W, V &\sim \text{Bern}\left((1 + \exp\{-W_1 - W_2 - V\})^{-1}\right) \\ Z|A, W, V &\sim \text{Bern}\left((1 + \exp\{-W_1 - W_2 - \gamma V - 3A\})^{-1}\right) \\ Y|Z, A, W, V &\sim N(3A + W_1 + W_2 + Z, 1) \, . \end{aligned}$$



Conclusions

Here are the important takeaways.

References

Wenjing Zheng and Mark J. van der Laan. Targeted maximum likelihood estimation of natural direct effects. *The International Journal of Biostatistics*, 8 (1):1–40, 2012. doi: doi:10.2202/1557-4679.1361. URL https://doi.org/10.2202/1557-4679.1361.

Eric J Tchetgen Tchetgen and Ilya Shpitser. Semiparametric estimation of models for natural direct and indirect effects. Working Paper 129, Harvard University, 2011. URL https://biostats.bepress.com/harvardbiostat/paper129/.

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