



## Study background

- Endogeneity or reverse causality in regression analysis results in biased estimation of the effects of independent variables on the dependent variable and leads to inaccurate interpretations, i.e., regression coefficients.
- Endogeneity in the water-related behavioural study is rarely discussed.

## Methods

- Instrument variable (IV), also called second-stage regression, approach was used.
- Control variable: a combination of several socio-economic characteristics.
- Endogenous explanatory variables: Perception of risk, attitude, and norms (RAN).
- Instrument variables: Variables related to institutional quality of the countries, based on the World Governance Indicators (WGI) of the World Bank.
- Dependent (outcome) variable: Household water treatment (HWT) adoption.

## Dataset

Eight datasets of previous HWT studies were used:

(Location, reference; total samples; % use HWT)

- Indonesia (1); Daniel et al., 2020; 282; 63%.
- Indonesia (2); Daniel et al., 2020; 164; 72%.
- Nepal; Daniel et al., 2019; 351; 21%.
- Chad; Lilje et al., 2015; 473; 28%.
- Ethiopia; Sonogo et al., 2013; 92; 91%.
- Burundi; Sonogo & Mosler, 2016; 700; 9%.
- Zimbabwe; Mosler et al., 2013; 480; 23%.
- Bolivia; Tamas, 2009; 194; 29%.

## Illustration of endogeneity or reverse causality in the water-related behavior

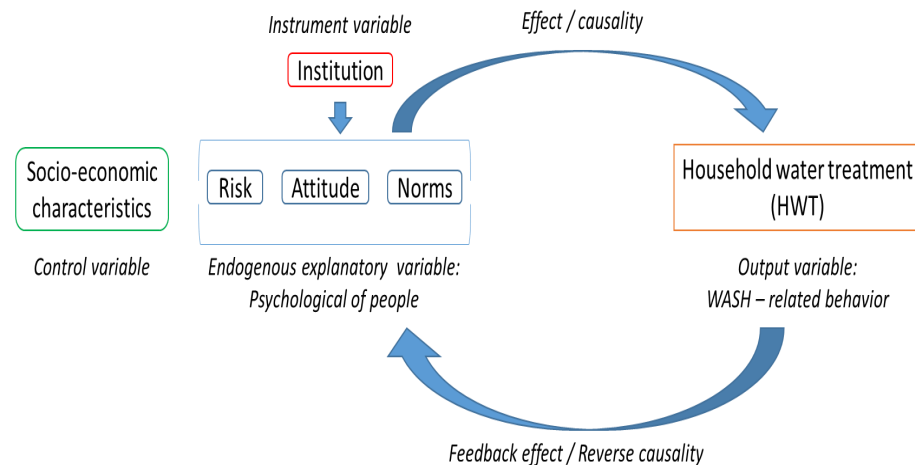


Table 1. Unweighted logistic regression of HWT adoption

Standard logistic regression		Logistic regression with instrument variable approach	
Independent variables	B (β)	Independent variables	B (β)
SEC	0.489* (1.631)	SEC	0.483 (1.621)*
Risk	0.124** (1.132)	Risk	0.197 (1.218)*
Attitude	0.758* (2.134)	<i>Attitude</i>	1.203 (3.331)*
Norms	0.790* (2.203)	<i>Norm</i>	1.104 (3.018)*
Pseudo R <sup>2</sup> = 0.300		Pseudo R <sup>2</sup> = 0.210	
*significant <0.001; **significant <0.01; <i>Attitude</i> and <i>Norm</i> are predicted psychological factors from the first-stage regression.			

## Results and discussion

- (1) *Attitude* and *norms* were endogenous (The Wald tests,  $\chi^2 = 49.04$  and  $126.80$ , respectively;  $p < 0.001$ ).
- (2) WGI were weak instruments for *risk*, therefore, *risk* was treated as exogenous variable.
- (3) Good institutions' performance, i.e. higher scores of WGI indicators, positively stimulated the psychology of HWT adoption.
- (4) The effect of *attitude* and *norms* on HWT adoption was underestimated by the standard logistic regression, i.e.  $B = 0.758$  and  $0.790$ , respectively (Table 2) in standard logistic regression, compared to  $B = 1.203$  (59% higher) and  $1.104$  (40% higher), respectively, (Table 1) in the second-stage regression or when *attitude* and *norms* were treated as endogenous variables.
- (5) Psychological factor *risk* seems to be less important when compared to attitude and norm in influencing the HWT adoption.
- (6) Institutional quality cannot be used as instruments for prevalent psychology if the case study is located in the same area, because all respondents then have the same institutional environment, which is its major limitation

## Conclusion

Endogeneity exists in water-related behavioural studies. Therefore, regression analysis should not be used and IV approach can be an alternative if good instruments for psychological factors can be found.

## Acknowledgements

We are very grateful to Prof. Joachim Mosler, Dr. Jonathan Lilje, Dr. Ina Sonogo, Dr. Andrea Tamas for sharing their research datasets with us.