DK responses in surveys on inflation expectations

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Motivation

Regression model with DK responses

Robust Heckit estimator

Reexamination of Sheen and Wang (2023)

Results

Conclusion

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Missing responses in surveys

Survey questions with many missing responses:

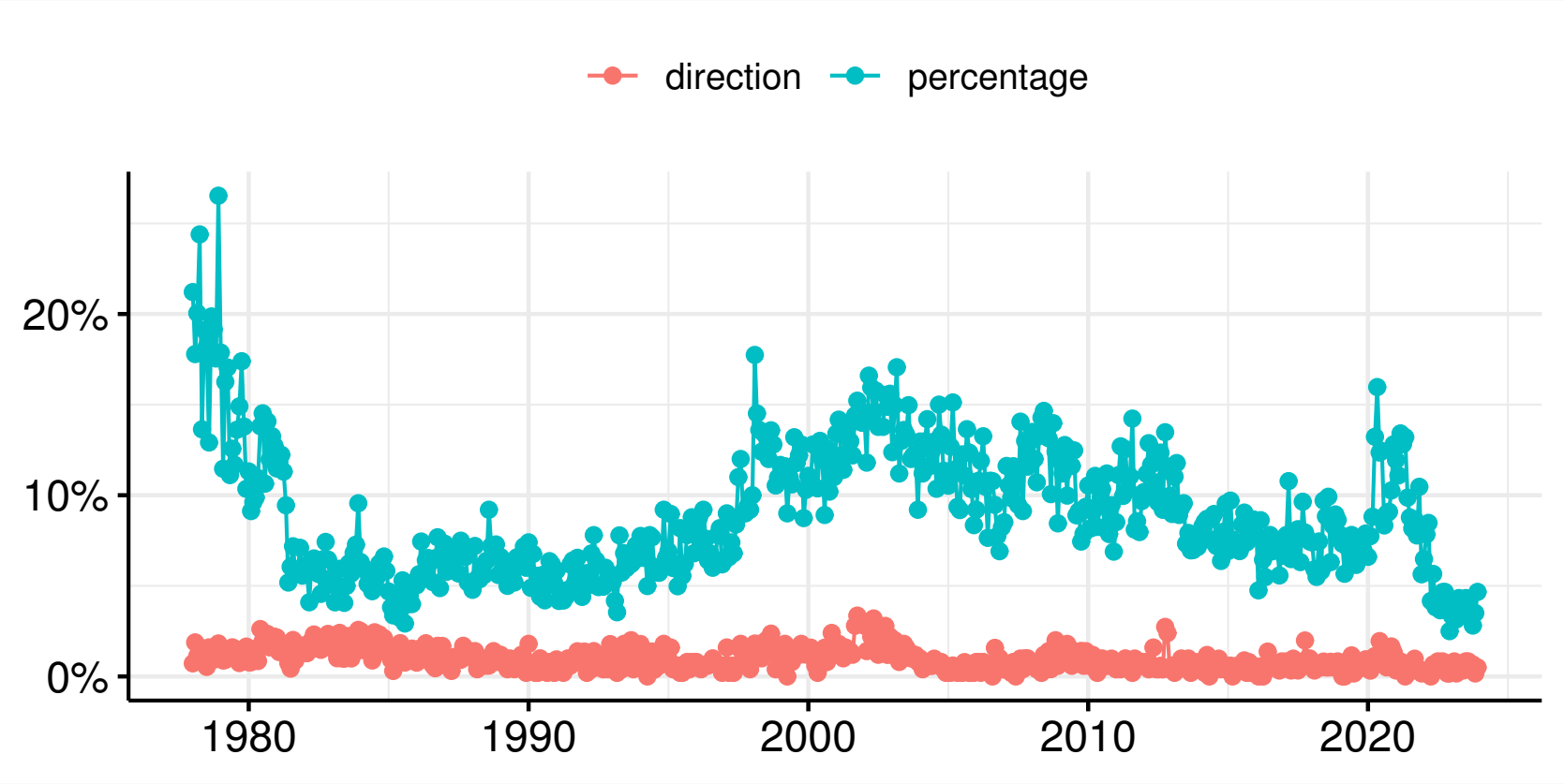
- wage
- voting behavior
- quantitative inflation expectation

Types of missing responses:

1. nonresponse
   a) unit nonresponse
   b) item nonresponse
2. DK response

Missing response rates for inflation expectations (Michigan Survey of Consumers)

Proportion of DK responses + item nonresponses



Dealing with DK responses

Recent works (on inflation expectations) discard DK responses in regression analysis:

- Sheen and Wang (2023, Eur. Econ. Rev.)
- Tsiaplias (2021, J. Appl. Econom.)
- Tsiaplias (2020, J. Econ. Dyn. Control)
- Wang, Sheen, Trück, Chao, and Härdle (2020, Macroecon. Dyn.)
- Ehrmann, Pfajfar, and Santoro (2017, Int. J. Cent. Bank.)

$\Longrightarrow$ sample selection bias?

Why discard DK responses?

Possible excuses:

1. They are ignorable $\Longrightarrow$ Needs justification
2. Heckman-type bias correction requires strong assumptions
   - normality
   - homoskedasticity
   - exclusion restriction

   $\Longrightarrow$ Use a robust estimator

Aim of this work

1. Use a robust Heckit estimator to handle DK responses
    - developed by Zhelonkin, Genton, and Ronchetti (2016)
    - available as an R package **`ssmrob`**
2. Reexamine an analysis in Sheen and Wang (2023, EER)
    - Study the influence of monetary condition news on household inflation expectations
    - Use data from the MSC, 2008M12–2015M12 ('zero lower bound' period)
    - Compare OLS, ML, Heckit, and robust Heckit estimates

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Sample selection model

Let

- y^* be the latent numerical response
- d be the (numerical) response dummy

Sample selection model

$$y = \begin{cases} y^* & \text{if } d = 1 \\ \text{NA} & \text{if } d = 0 \end{cases}$$

$$d = [\boldsymbol{x}'\boldsymbol{\alpha} + z > 0]$$

$$y^* = \boldsymbol{x}'\boldsymbol{\beta} + u$$

$$\begin{pmatrix} z \\ u \end{pmatrix} | \boldsymbol{x} \sim \mathrm{N}\left(\mathbf{0}, \begin{bmatrix} 1 & \sigma_{zu} \\ \sigma_{uz} & \sigma_u^2 \end{bmatrix} \right)$$

Sample selection bias

Outcome equation for the selected sample

$$\mathrm{E}(y|d=1,\boldsymbol{x}) = \boldsymbol{x}'\boldsymbol{\beta} + \mathrm{E}(u|z > -\boldsymbol{x}'\boldsymbol{\alpha}, \boldsymbol{x})$$

Consider estimation of $\boldsymbol{\beta}$

- OLS estimator is inconsistent
- ML and Heckit estimators are consistent, but not widely used in the context of "*DK responses in surveys on inflation expectations*"

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Heckit estimator

Moment restrictions:

- Selection equation (probit):

$$\mathsf{E}(s\boldsymbol{x}h(s\boldsymbol{x}'\boldsymbol{\alpha})) = \mathbf{0}$$

  where $s := 2d - 1$ gives the sign, and $h(.) := \phi(.)/\Phi(.)$ gives the inverse Mill's ratio

- Outcome equation (for the selected sample):

$$\mathsf{E}(\boldsymbol{x}(y - \boldsymbol{x}'\boldsymbol{\beta} - \sigma_{uz}h(\boldsymbol{x}'\boldsymbol{\alpha}))d) = \mathbf{0}$$
$$\mathsf{E}(h(\boldsymbol{x}'\boldsymbol{\alpha})(y - \boldsymbol{x}'\boldsymbol{\beta} - \sigma_{uz}h(\boldsymbol{x}'\boldsymbol{\alpha}))d) = 0$$

M-estimator

Estimating functions:

$$\psi_1(z;\theta) := sxh(sx'\alpha)$$

$$\psi_2(z;\theta) := \begin{pmatrix} x \\ h(x'\alpha) \end{pmatrix} (y - x'\beta - \sigma_{uz} h(x'\alpha))d$$

where $z := (d, s, y, x')'$ and $\theta := (\alpha', \beta', \sigma_{uz})'$

Let

$$\psi(z;\theta) := \begin{pmatrix} \psi_1(z;\theta) \\ \psi_2(z;\theta) \end{pmatrix}$$

M-estimator of θ solves

$$\frac{1}{n} \sum_{i=1}^{n} \psi\left(z_i; \hat{\theta}\right) = 0$$

(=Heckit estimator of β)

Robustness

- An estimator is robust to outliers if its influence function is bounded
- Influence function of an M-estimator:

$$\mathrm{IF}(z) \propto \psi(z; \theta)$$

- For the Heckit estimator, $\mathrm{IF}(.)$ is unbounded; hence NOT robust

Bounded-influence estimator

- Bound $\boldsymbol{\psi}(.;\boldsymbol{\theta})$ to obtain a robust estimator
- Huber function:

$$\Psi(z) := \begin{cases} z & \text{for } |z| \leq K \\ \mathbf{sgn}(z)K & \text{for } |z| > K \end{cases}$$

- Apply a Huber function to the standardized prediction error
- Bound covariates if necessary
- Implementation is easy using `ssmrob` package for R

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Sheen and Wang (2023, EER)

- Study the influence of monetary condition news on SR and LR household inflation expectations
- Use data from the MSC, 2008M12–2015M12 ('zero lower bound' period)
- Estimate a regression equation for the percentage of inflation by OLS, ignoring nonresponses
- Find that monetary condition news was insignificant

Inflation expectations in the MSC

Q1: Direction

px1q1 prices up/down next year
px5q1 prices up/down next 5 years

Q2: Size (only if up/down to Q1)

px1q2 prices % up/down next year
px5q2 prices % up/down next 5 years

Percentage

px1 price expectations 1yr recoded
px5 price expectations 5yr recoded

Sheen and Wang (2023) mistakenly use **px1q2**/**px5q2** instead of **px1**/**px5**

Regressors

Micro

MPN	news: monetary condition
IN	news: inflation
ytl	income quartiles
age	age of respondent
female	female dummy
hsize	household size
edu	education of respondent

Macro

IP	industrial production (growth rate at $t-1$)
UR	unemployment rate (at $t-1$)
CPI	consumer price index (growth rate at $t-1$)

Sample selection

We follow Sheen and Wang (2023):

- Use only wave 2 inflation expectations on the LHS to include lagged (wave 1) inflation expectations on the RHS
- Exclude respondents with missing news/demographic variables

Sample size

		wave 1	
horizon	wave 2	observed	missing
1 year	observed	**13426**	960
	missing	734	417
5 year	observed	**13234**	997
	missing	789	517

Exclusion restriction

- Higher inflation uncertainty may increase the likelihood of DK responses, but not the level of inflation expectations
- Include the absolute change of the CPI inflation rate in the previous month in the selection equation
- Correct sign, but insignificant
- Still better to include

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Classical estimation

Classical estimation:

- Compare OLS, ML, and Heckit estimates
- Use `sampleSelection` package for R

Parameters of interest:

1. Coefficient on MPN
2. Coefficient on the bias correction term (IMR)

Classical estimation (SR)

Outcome equation for **px1**			
	OLS	ML	Heckit
MPN	0.17 (0.20)	0.17 (0.20)	0.22 (0.21)
IN	0.65 (0.18)***	0.65 (0.18)***	0.64 (0.19)***
Lpx1	0.24 (0.01)***	0.24 (0.01)***	0.25 (0.01)***
MPN:Lpx1	0.04 (0.04)	0.04 (0.04)	0.04 (0.04)
IN:Lpx1	0.08 (0.03)*	0.08 (0.03)*	0.09 (0.03)**
	⋮		
rho		−0.01 (0.05)	−0.72
invMillsRatio			−2.77 (2.00)
Num. obs.	13426	14160	14160
Censored		734	734

Classical estimation (LR)

Outcome equation for **px5**			
	OLS	ML	Heckit
MPN	−0.13 (0.19)	−0.13 (0.19)	−0.03 (0.22)
IN	0.53 (0.15)***	0.53 (0.15)***	0.58 (0.18)**
Lpx5	0.29 (0.01)***	0.29 (0.01)***	0.32 (0.01)***
MPN:Lpx5	0.06 (0.05)	0.06 (0.05)	0.05 (0.05)
IN:Lpx5	−0.07 (0.03)	−0.07 (0.03)	−0.06 (0.04)
	⋮		
rho		−0.01 (0.05)	−1.30
invMillsRatio			−4.13 (1.42)**
Num. obs.	13234	14023	14023
Censored		789	789

Robust estimation

Why are the ML and Heckit estimates different?

$\Longrightarrow$ Model misspecification

Possible consequences:

1. Only Heckit is consistent
2. Both ML and Heckit are inconsistent

Robustness check:

- Compare classical and robust Heckit estimates
- Use `ssmrob` package for R
- Set $K = 100$ (classical) or $K = 1.345$ (robust)

Robust estimation (SR)

Outcome equation for **px1**		
	classical ($K = 100$)	robust ($K = 1.345$)
MPN	0.22 (0.25)	0.12 (0.19)
IN	0.64 (0.19)***	0.60 (0.14)***
Lpx1	0.25 (0.01)***	0.24 (0.02)***
MPN:Lpx1	0.04 (0.06)	0.04 (0.06)
IN:Lpx1	0.09 (0.05)	0.04 (0.05)
	⋮	
IMR1	−2.78 (2.49)	0.61 (6.23)
Num. obs.	14160	14160
Censored	734	734

Robust estimation (LR)

Outcome equation for **px5**		
	classical ($K = 100$)	robust ($K = 1.345$)
MPN	−0.03 (0.30)	0.15 (0.22)
IN	0.58 (0.21)**	0.43 (0.19)*
Lpx5	0.32 (0.02)***	0.31 (0.02)***
MPN:Lpx5	0.05 (0.10)	−0.01 (0.06)
IN:Lpx5	−0.06 (0.06)	−0.04 (0.06)
	⋮	
IMR1	−4.13 (1.92)*	−3.90 (3.54)
Num. obs.	14023	14023
Censored	789	789

Findings

1. For both SR and LR inflation expectations, OLS and ML estimates are almost identical
   $\Longrightarrow$ No sample selection bias (?)
2. ML and Heckit estimates somewhat differ. For LR expectations, the bias correction term is significant
   $\Longrightarrow$ Sample selection bias
3. Classical and robust Heckit estimates somewhat differ
   $\Longrightarrow$ Robust estimate is more reliable
4. Monetary condition news remains insignificant
   $\Longrightarrow$ Support the conclusion of Sheen and Wang (2023)

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Summary

- One should not simply ignore "*DK responses in surveys on inflation expectations*." Use a sample selection model.
- ML and Heckit estimates may differ, perhaps because of model misspecification.
- Use a robust Heckit estimator for a robustness check (in the true sense).

Remaining issues

1. Global misspecification
   - Our model may not be even approximately correct
   - Need a (robust) semi/non-parametric estimator
2. DK responses in the regressors
   - Can include them using DK dummies
     $\Longrightarrow$ conditional heteroskedasticity
   - Need a (robust) generalized Heckit estimator
3. Unit nonresponses
   - Need additional information, e.g., regional nonresponse rates
4. Qualitative information in DK responses
   - Can combine data on the direction and percentage of inflation to improve inference

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