Improved Longitudinal Imputation Method in Survey of Doctorate Recipients

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Strengthening and Expanding the Capacity of the Federal Statistical Ecosystem.

Disclaimer

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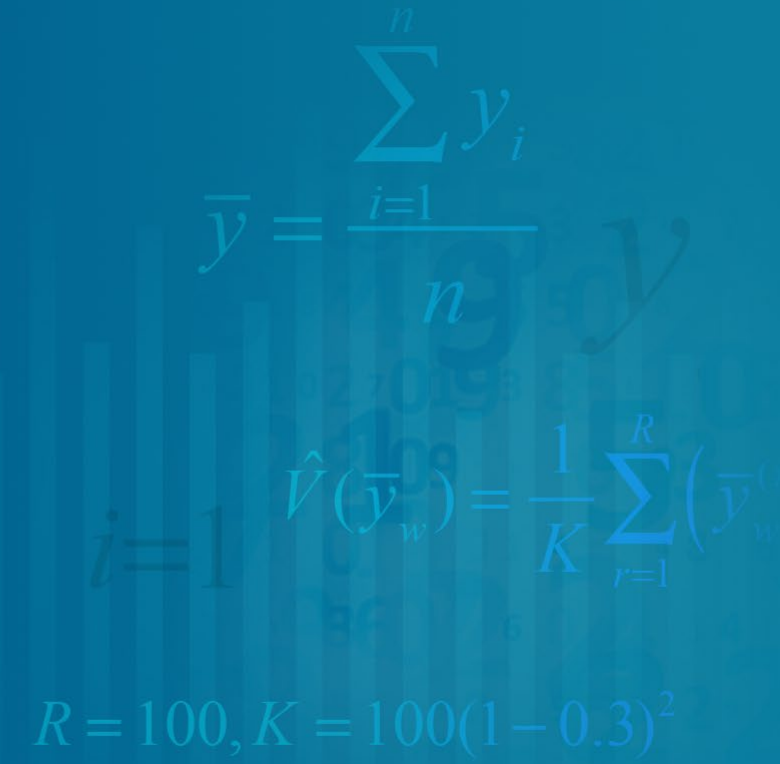
Outline

- Background
- Imputation Process
- Evaluation
- Summary

Background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$\hat{V}(\bar{y}_w) = \frac{1}{K}\sum_{r=1}^{R}$
$R = 100, K = 100(1-0.3)^2$

Survey of Doctorate Recipients

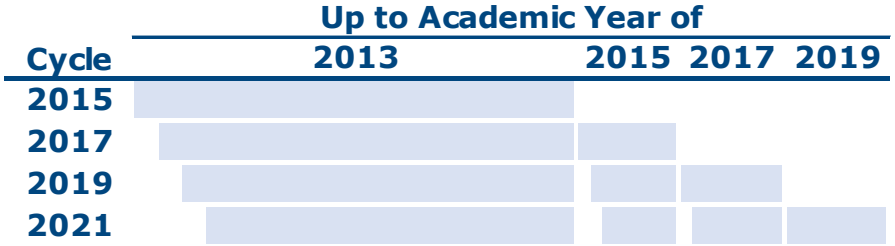
- Biennial survey of U.S. research doctorate holders in science, engineering, and health fields
  - Launched in 1973
  - Conducted by the National Center for Science and Engineering Statistics within National Science Foundation
  - With sponsorship from National Institutes of Health
- Provides demographic, education, and career history information
- Target population contains U.S. research doctorate holders residing in U.S. and out of U.S.

Sample Design

- Refreshed sample for 2015 cycle, extending its coverage and increasing the sample size
- Stratified by field of study, gender, and underrepresented minority status
- Maintains a continuing cohort until aged out
- Replenishes sample with new PhDs in every cycle

→Generating cross-sectional data

and longitudinal data



SDR 2015/2017/2019 Cross-sectional Data

- Sample of 120,000+ doctorate holders
- 80,000+ respondents who responded to critical items
- Weighting compensates for doctorate holders who did not respond
- Imputation addresses item nonresponse

Longitudinal SDR (L-SDR) 2015-2025 Sample

- Sample of ~40,000 doctorate holders
- Drawn from SDR 2015 respondents who were 65 years old or younger as of 2015
- Stratified by
  - Reported employment sector in 2015
  - Age
  - Underrepresented minority status
  - Gender

L-SDR 2015-2019 Data

- ~36,500 who responded in both or either of the 2017 and 2019 cycles
- Weighting compensates for individuals who did not respond in both cycles
- Imputation addresses unit nonresponse in one of 2017 and 2019 cycles
- Limited findings are publicly available[1]

	2015	2017	2019
L-SDR 2015-2019 Sample	Y_{15}	Y_{17}	Y_{19}
	Y_{15}		Y_{19}
	Y_{15}	Y_{17}	
	Y_{15}		

Weighting →

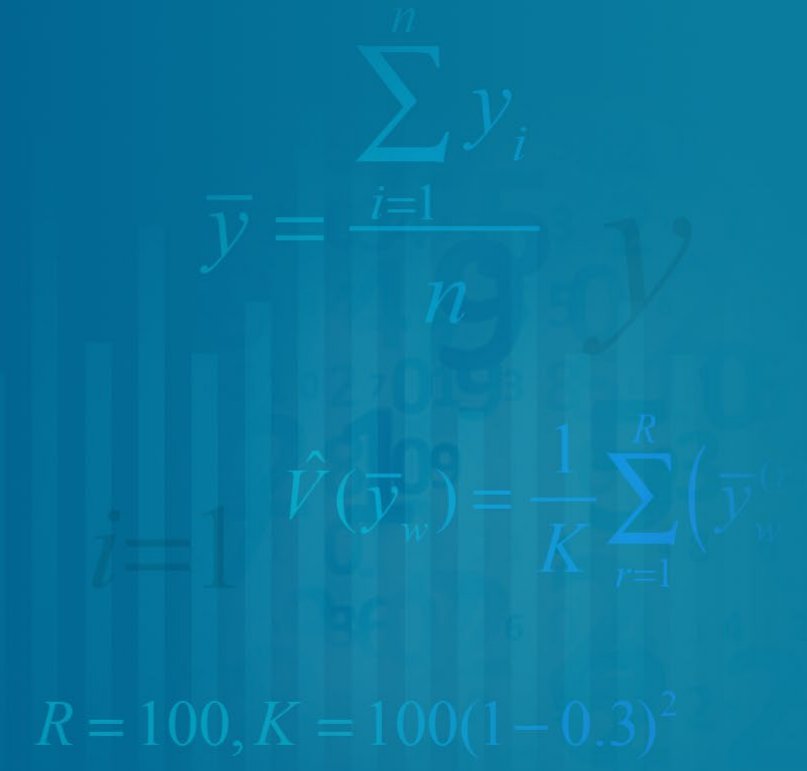
2015	2017	2019
Y_{15}	Y_{17}	Y_{19}
Y_{15}		Y_{19}
Y_{15}	Y_{17}	

Imputation →

Y_{15}	Y_{17}	Y_{19}	L-SDR 2015-2019 Data
Y_{15}	$Y_{17,imp}$	Y_{19}	
Y_{15}	Y_{17}	$Y_{19,imp}$	

[1]https://ncses.nsf.gov/pubs/nsf22326#section11241

Imputation Process



Imputation Implemented | L-SDR 2015-2019 Data

	Phase 1 Imputation	Phase 2 Imputation
Nonresponse (NR) type	Item NR	Unit NR of 1 cycle
Respondents	Cross-sectional	Longitudinal
Imputation Method	Hot-deck	Hot-deck

Information usage	Phase 1 Imputation	Phase 2 Imputation
Demographic	√	√
Cross-sectional	√	--
Longitudinal	√ limited	√ **systematically**

Phase 1 | Imputation for Cross-sectional Data

- Hot-deck imputation replaces each missing value with a randomly selected observed response in its imputation cell containing "similar" individuals
- Imputation cells defined by crossing cross-sectional, demographic, and longitudinal variables closely related to the variable to be imputed

ID	Gender	Age	Employed in 2019			
			Raw	Donor ID	Donor value	Imputed
1	Male	30-45	Yes			Yes
2	Male	30-45		1	Yes	Yes
3	Male	46-60	Yes			Yes
4	Male	46-60	No			No
5	Male	46-60	No			No
6	Male	46-60		5	No	No
7	Female	30-45	Yes			Yes
8	Female	30-45	No			No
9	Female	30-45		7	Yes	Yes
10	Female	46-60	No			No

Phase 2 | Imputation for Longitudinal Data

- Hot-deck imputation with imputation cells defined by longitudinal variables first and selected demographic variables
- Treat imputed data for other cycles as reported

ID	Employed in 2015	Employed in 2017	Gender	Age	Employed in 2019			
					Raw	Donor ID	Donor value	Imputed
1	Yes	Yes	Male	30-45	Yes			Yes
2	Yes	Yes	Male	30-45		1	Yes	Yes
3	Yes	Yes	Male	46-60	Yes			Yes
4	Yes	No	Male	46-60	No			No
5	Yes	No	Male	46-60	No			No
6	No	No	Male	46-60		5	No	No
7	Yes	Yes	Female	30-45	Yes			Yes
8	Yes	No	Female	30-45	No			No
9	No	No	Female	30-45		7	Yes	Yes
10	No	No	Female	46-60	No			No

Motivation

- Phase 1 imputation sometimes created longitudinal transitional patterns that were not reported
  - Employment sectors

2015	2017	2019
4 year university	→ 2 year college	→ self-employed
Non-US government	→ 2 year college	→ state/local government

  - Influential cases with large changes in salary between cycles

→ Improve donor matching in cross-sectional imputation to align two imputation phases through **systematic usage of historically reported data** in Phase 1 imputation for cross-sectional data while keeping Phase 2 imputation the same

Proposed Phase 1 Imputation Approach

- For Phase 1 imputation, form three imputation groups

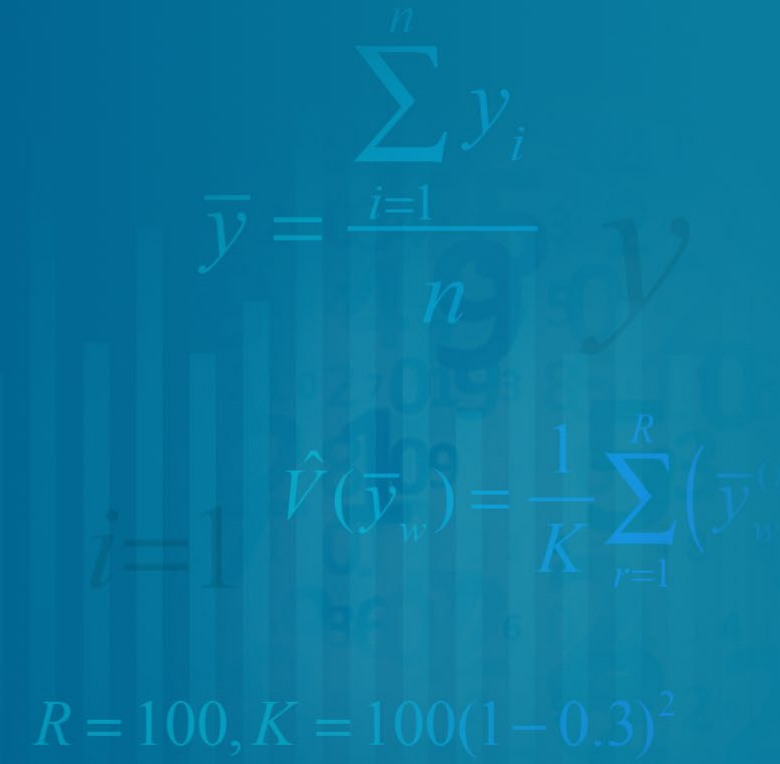
Item reported?			Imputation group 1		Imputation group 2		Imputation group 3	
2015	2017	2019	Recipients	Donors	Recipients	Donors	Recipients	Donors
Yes	Yes	Yes		√		√		√
No	Yes	Yes				√		√
Yes	No	Yes						√
No	No	Yes						√
Yes	Yes	No	√					
No	Yes	No			√			
Yes	No	No					√	
No	No	No					√	

No= Did not respond or was not sampled in the cycle

Proposed Phase 1 Imputation Approach

- Update imputation cell formation by systematically using longitudinal variables in imputation groups 1 & 2
  - **Time of doctorate award**
  - **Reported values in previous cycles (up to 2)**
  - Cross-sectional or demographic variables currently used

Evaluation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Evaluation | Cross-sectional Results

- Applied to proposed Phase 1 imputation approach to employment section in SDR 2019 data while keeping Phase 2 imputation approach the same
- Compared marginal distributions of variables subject to imputation using goodness-of-fit chi-square tests
  - No significant differences out of ~100 variables
- Compared estimates in cells with 100+ respondents of 20 detailed statistical tables
  - <1% estimates with significant differences

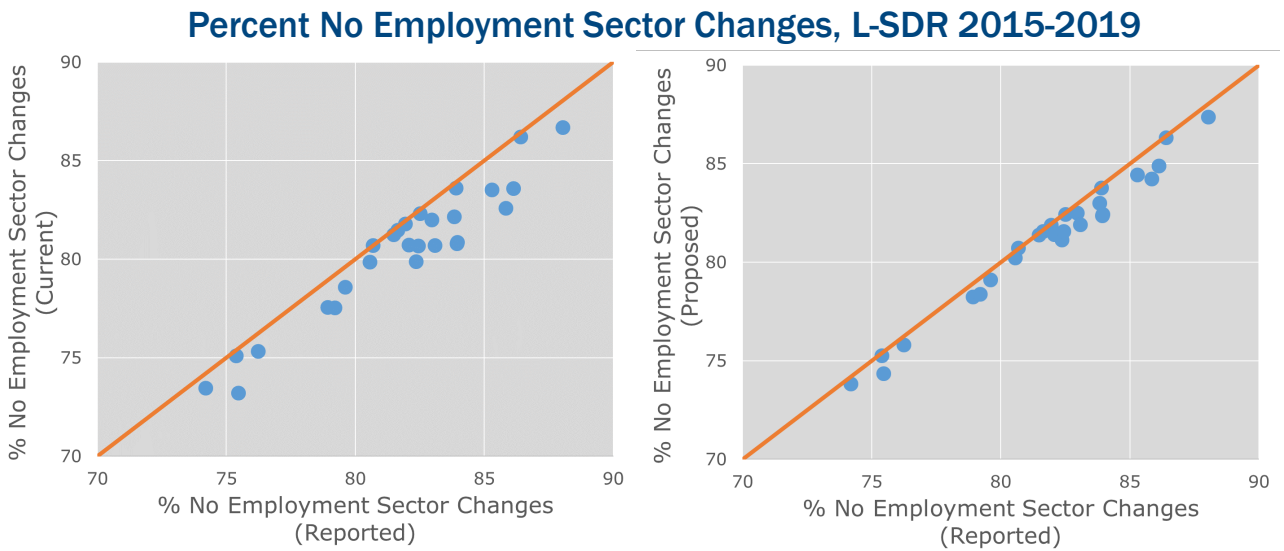
Evaluation | Longitudinal Pattern

- Examined longitudinal patterns
  - Closer to those among respondents who responded in 2015, 2017, 2019
  - New longitudinal patterns rarely introduced by imputation (5% → <1%)
  - Changes in salary more aligned with reported data

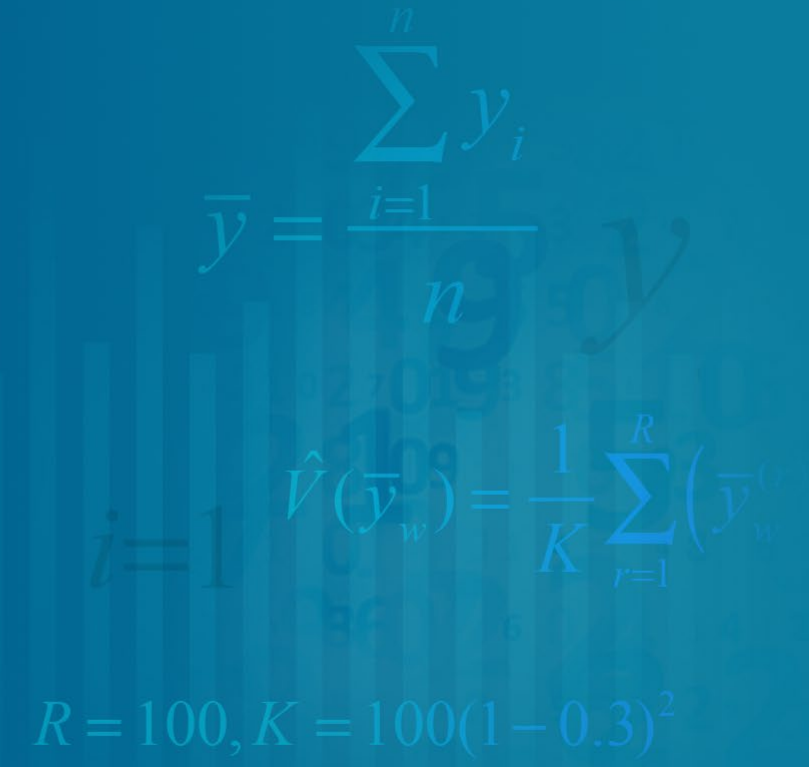
Average ratio of Salary in 2019 to	Reported	Reported + Imputed	
		Current	Proposed
2015	1.12	1.15	1.13
2017	1.07	1.08	1.07

Evaluation | Longitudinal Estimates - Preliminary

- Examined longitudinal estimates by various domain
  - More aligned with estimates based on reported cases



Summary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Summary

- New imputation approach to improve donor matching process
  - Aligned data matching strategies of both imputation phases
  - Reduced chances of creating erroneous longitudinal patterns
  - Longitudinal estimates closer to estimates among reported cases
  - Minimal impact on cross-sectional estimates

- More to come!

Thank You

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