

HILDA User Training: Weighting and Imputation

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Weighting

Outline

- Overview
- Steps in weighting
- Benchmarking
- Replicate weights
- Advice on using the weights
- Final remarks

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Overview

Purpose of weights:

- Weighted estimates sum to the population rather than the sample
- Adjusts for
 - Unequal probabilities of selection
 - Unit non-response
 - Wave non-response
- Used in
 - Tabulations (almost always)
 - Regressions (sometimes)

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What weights do not do...

- Weights do not adjust for
 - Stratification
 - Clustering of the sample
- Weights are only part of the picture in analysing data from complex surveys
 - Weights help correct for biases in estimates
 - Standard errors around those estimates need to be calculated assuming a complex design

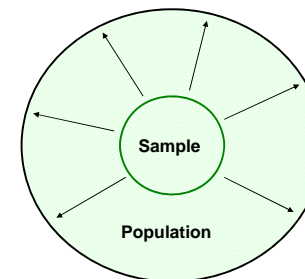
Weights provided

	Household	Enumerated Person	Responding Person
Longitudinal		✓	✓
Cross-sectional	✓	✓	✓

Three main steps

1. Design weights
2. Non-response / attrition adjustment
3. Calibration / benchmarking

Weighting process



- IDEAL WORLD: no non-response
- STEP 1: weight sample up to population by inverse of probability of selection (design weight)

Design weight in HILDA wave 1

$$P(\text{select household}) = P(\text{select CD}) * \\ P(\text{select dwelling} | \text{select CD}) * \\ P(\text{select household} | \text{select dwelling})$$

$$p_{hs} = 488 \frac{\hat{N}_{di} n_{di} n_{hi}}{\sum_j \hat{N}_{dj} N_{di} N_{hi}}$$

where

\hat{N}_{di} = estimated number of dwellings in CD

N_{di} = actual number of dwellings in CD

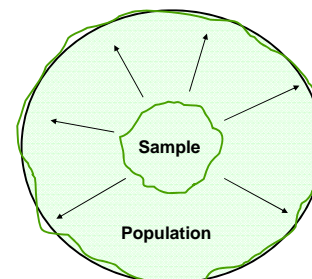
n_{di} = number of dwellings selected in CD

N_{hi} = number of households in dwelling

n_{hi} = number of households selected in dwelling

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Weighting process (c'td)



- REAL WORLD: non-response
- STEP 2: adjust design weight for non-response

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Non-response adjustment in HILDA wave 1 (households)

Internal (collected)

- Security features
 - Locked gate – no intercom access**
 - Locked gate – intercom access**
 - Security guard/doorman/on-site manager/gatekeeper
 - Security door**
 - No trespassing sign
 - Evidence of a dangerous dog*
 - No junk mail sign/no hawkers sign**
 - Bars on windows
- Dwelling type*
- External condition of dwelling**
- Proportion of highrises in area

** sig at 1%, * sig at 5%

External (known about CD)

- Geographic location**
- Proportion of different family and household types
- Median age of persons in the area
- Density of area (population per km²)**
- Proportion of people speaking a language other than English
- Proportion of different dwelling types
- Proportion of people with different employment states
- Average household size
- Median weekly household income**

$$w_{1h} = \frac{1}{p_{hs}} \frac{1}{\hat{p}_{hr}}$$

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Non-response adjustment in HILDA wave 1 (responding persons)

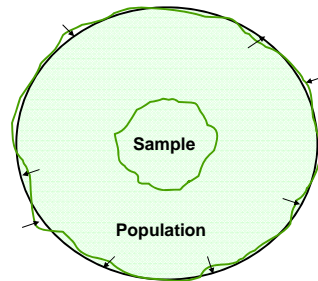
- Geographic location**
- Labour force status**
- Sex**
- Age group**
- Number of adults in HH**
- Number of children in HH**
- Marital status**
- English ability**
- Dwelling type**
- Long term health condition
- Housing tenure

** sig at 1%, * sig at 5%

$$w_{1i} = w_{1hb} \frac{1}{\hat{p}_{ir}}$$

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Weighting process (c'td)



- STEP 3: benchmark to known population totals
 - Also called post-stratification or calibration
 - For HILDA, we use the SAS macro GREGWT (written by ABS Methodology Division) to adjust to multiple benchmarks simultaneously

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Benchmarking in HILDA wave 1

Household and enumerated person benchmarks (integrated)		
Number	Variable Group	Level
1	Number of adults and children in household	Household
2	State by part of State	Household
3	Sex by age group	Person
4	State by part of State	Person
5	Labour force status	Person
6	Marital status	Person

Responding person benchmarks		
Number	Variable Group	Level
1	Sex by age group	Person
2	State by part of State	Person
3	State by labor force status	Person
4	Marital status	Person
5	Household composition (number of adults and children)	Person

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Longitudinal responding person weight

- Same process for longitudinal weights
 1. Design weight
 2. Adjust for non-response
 3. Benchmark
- Include deaths and overseas movers
- Longitudinal balanced panel from wave 1 to T
 1. & 2.

$$w_{L_{1-T}i} = w_{1ib} \frac{1}{\hat{P}_{ri_{2-T}}}$$

Design weights, non-response and benchmark adjustment for W1

Non-response adjustment for attrition W2 to WT

3. Benchmark $w_{L_{1-T}i}$ to wave 1 person characteristics to give $w_{L_{1-T}ib}$

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Non-response adjustment for attrition

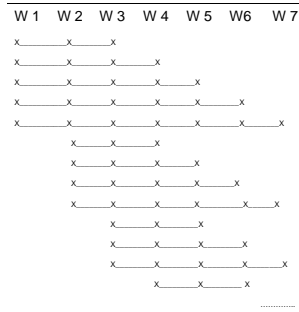
- Person characteristics
 - Age**
 - Sex
 - Marital status**
 - Ability in speaking English
 - Employment status and hours**
 - Number of children the person has
 - Country of birth**
 - Highest level of education achieved**
 - Relationship in household**
 - Health status
 - Likelihood of moving
 - Number of times moved in last 10 years*
 - Whether reference person in household
- Interview situation
 - Cooperation**
 - Assisted interview
 - Difficulties during interview (english, eyesight, hearing, reading)
 - Suspicious**
 - Understanding
 - Influence of others
 - Length of interview*
 - SCQ returned**
- Household characteristics
 - Location (State by part of State)**
 - Remoteness area*
 - SEIFA index of disadvantage**
 - Dwelling type**
 - Dwelling condition*
 - Bedrooms**
 - Number of calls made**
 - Partial household responding**
 - Number of adults**
 - Number of children
 - Household type*
 - Housing tenure*
 - Benefit recipient in household**
 - Household income
 - Interview time in household*
- Household changes
 - Splits**
 - Moved between waves**

** sig at 1%, * sig at 5%

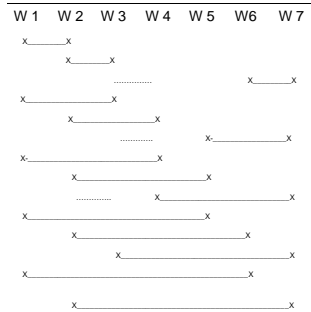
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Balanced panels

Balanced continuous panels



Balanced wave combination panels

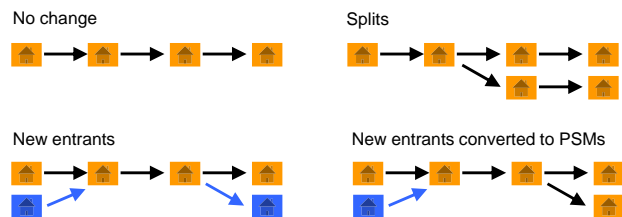


Cross-sectional weights for Wave 2 onwards

- Reminder of following rules
 - W1 household members
 - Continuing Sample Members (CSMs)
 - Follow and interview CSMs and their HHs
 - New sample members
 - Temporary Sample Members (TSMs)
 - TSMs become CSMs when:
 - New baby born/adopted to CSM
 - Parent of new CSM

Adjustment to weights...

- ...for new sample members



Special inclusions/exclusions

- Moved overseas or died – still receive a longitudinal weight
- Zero weights
 - Remote areas of Australia excluded from the benchmarking process
 - ABS classification updated after wave 1 – causes some w1 zero weights
 - Affects people who moved to a remote area
 - Non-private dwellings for cross-sectional weights

Benchmarking

- Also called post-stratification or calibration
- Why do it?
 - Sample frame never perfect
 - Non-response adjustment uses modelled probabilities, and also isn't perfect

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Revisions to benchmarks

- **Estimated residential population**
 - Births
 - Deaths
 - Interstate and intrastate migration
 - Overseas migration
 - Census
- **Estimated households**
 - Estimated residential population
 - Census
- **Labour force estimates**
 - Change in estimation methodology
 - Change in benchmarks

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Benchmarking

Household weight benchmarks		
<i>Number</i>	<i>Variable Group</i>	<i>Level</i>
1	Number of Adults and Children in Household	Household
2	State by part of state	Household
3	Sex, Age Group	Person
5	State by part of state	Person
6	Labour Force Status	Person
7	Social Marital Status	Person

Responding person weight benchmarks		
<i>Number</i>	<i>Variable Group</i>	<i>Level</i>
1	Sex by age group	Person
2	State by part of state	Person
3	State by labor force status	Person
4	Marital statue	Person
5	Household composition (number of adults and children)	Person

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Replicate weights

- 45 replicate weights have been provided
 - Essentially replicate the weighting process but on a subset of the data
- Use to calculate standard errors

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Data

Weights		
Population	Weight	Replicate Weights
Responding People (longitudinal)	_lnwtrp	_rwn1 to _rwn45
	_lrt1_tn	_lrt1_tn1 to _lrt1_tn45
	_lrt1tn	_lrt1tn1 to _lrt1tn45
Enumerated People (longitudinal)	_lnwte	_rwn1 to _rwn45
	_let1_tn	_let1_tn1 to _let1_tn45
	_let1tn	_let1tn1 to _let1tn45
Households (cross-sectional)	_hhwth	_rwh1 to _rwh45
Responding People (cross-sectional)	_hhwtrp	_rwrp1 to _rwrp45
Enumerated People (cross-sectional)	_hhwte	_rwe1 to _rwe45
Sample Design Characteristics		
Characteristic	Variable	
Stratum	_hhstrat	
Cluster	_hhraid	

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Advice on using weights

- Means, ratios, totals etc for the population?
 - Must use weights
- Which weight to use depends on which question you are answering
 - How many people live in poor households in 2007?
 - What proportion of people have changed their employment status between 2005 and 2007?
- Static versus change
 - Cross-section versus longitudinal weights

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Using weights in regression models?

- If use weights in models
 - Guards against
 - i) mis-specification of model holding in the population, and
 - ii) informative sample designs
 - BUT estimates tend to have larger standard errors
- Run with and without
 - If substantial differences, reconsider specification – what additional information is in the weights that is not in your model?
 - If no difference, use model without weights as will tend to have lower standard errors

Further info

Pfeffermann, D. (1993), 'The Role of Sampling Weights When Modeling Survey Data', *International Statistical Review*, Vol. 61, No. 2, pp. 317-337.

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Only part of the story...

- Complex sample design, eg HILDA has
 - Stratification
 - Systematic selection
 - Households clustered in areas
 - People clustered in households
 - Unequal probabilities of selection
- Weights used to calculate estimates
- When calculating standard errors, need
 - Strata, cluster, weights
 - Replicate weights (replicates sample design on subset of data – HILDA has 45 replicates)

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Methods of complex SE calculation

- Method categories:
 - Linearisation techniques
 - Resampling
- User manual recommends two:
 - Taylor Series Linearisation
 - Delete a group Jackknife

Delete-a-group Jackknife

- Method of producing replicate weights for the sample
- 45 replicates provided for all weights on the dataset.
- Takes into account the complex design of the survey and the way it has evolved from wave 1
- Simple formula for the variance using the replicate weights

$$Var(\hat{x}) = \left(\frac{R-1}{R} \right) \sum_{r=1}^R (\hat{x}^{(r)} - \hat{x})^2$$

Delete-a-group Jackknife – replicates

- Aim to mirror the overall sample design within each replicate group
- Ordered CD's systematically allocated to a replicate group
 - CD 1 to 45 allocated to replicate group 1 to 45 then repeated
- Allocated group of CD's dropped from each replicate
 - Replicate group size 44/45 of main sample
- Replicate group undergoes weighting process
 - units in dropped CD's receive zero weight

Taylor Series linearisation

- Use Taylor's Theorem to create a linear approximation to a non-linear statistic
- Calculate the variance of the linear approximation
- Benefits
 - Well developed theory
 - Can be applied in general sample designs
 - Software readily available

Sample design issues

- Taylor Series
 - Software packages assume a stratified cluster design
 - Doesn't take into account benchmarking effects or systematic selection
- Replicate groups don't correctly reflect the sample design
 - Cluster size needs to be taken into account
 - Systematic selection skips

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More information

- Technical papers
 - Wave 1 weighting
 - Wave 2 weighting
 - HILDA Standard Errors User Guide
 - Guide to Standard Errors for Cross-sectional estimates (Wave 1)

melbourneinstitute.com/hilda/data/technical_papers.html

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Imputation

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Overview

- Three types of non-response:
 - item non-response
 - wave non-response
 - unit non-response
- Level: person and household
- Imputation: A method of 'completing' data
- Allows for improved data use

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Overview (c'td)

- What do we impute in Release 9:
 - Income
 - Wealth
 - Wave 2 and wave 6 special module
 - Home value (every wave)
 - Expenditure
 - Ad-hoc
 - Date of birth, wave 2 employment status

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Size of missing data problem- Income

Variable	W1	W2	W3	W4	W5	W6	W7	W8	W9
Financial year income (non-zero cases only)									
<i>Wages and salaries</i>	7.9	6.9	5.5	3.8	4.5	4.6	5.1	4.6	5.9
<i>Aust Gov't pensions</i>	1.4	1.7	1.0	1.5	1.1	0.9	1.0	1.9	3.6
<i>Aust Gov't allowances</i>	3.0	2.1	2.1	2.6	2.0	0.9	1.2	1.9	4.6
<i>Foreign govt pensions</i>	0.5	2.7	0.0	0.5	2.4	0.5	1.0	2.2	2.3
<i>Business income</i>	29.1	28.6	27.4	19.4	21.6	18.6	19.8	19.0	20.3
<i>Interest income</i>	19.5	18.6	13.9	11.0	11.3	12.8	11.6	11.2	14.4
<i>Dividends and royalties</i>	14.6	14.5	11.9	9.2	10.2	11.3	11.3	11.3	13.5
<i>Rent income</i>	20.3	14.7	14.9	11.3	10.5	10.3	10.2	10.5	11.1
<i>Private pensions</i>	6.3	4.6	3.2	4.1	4.8	3.9	4.1	4.0	4.9
<i>Private transfers</i>	8.0	22.9	15.5	14.4	20.7	13.4	18.5	20.1	18.6
Total FY income	15.7	14.9	12.1	9.6	10.7	10.3	10.4	10.6	12.3

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Size of missing data problem- Wealth(w2,6)

Person-level wealth			Household-level wealth			
	W2	W6		W2	W6	W6 band
<i>Joint bank accounts</i>	9.8	6.0	<i>Children's bank accounts</i>	6.2	4.6	
<i>Own bank accounts</i>	4.6	3.3	<i>Business value</i>	20.1	17.5	7.8
<i>Superannuation, retirees</i>	20.1	19.7	<i>Cash investments</i>	11.6	12.3	7.1
<i>Superannuation, not retired</i>	17.3	27.5	<i>Equity investments</i>	15.3	13.3	4.4
<i>HECS debt</i>	10.6	7.6	<i>Collectibles</i>	14.0	15.1	8.1
<i>Joint credit card debt</i>	10.1	7.6	<i>Home value</i>	7.6	4.2	
<i>Own credit card debt</i>	3.6	3.1	<i>Other property value</i>	4.6	0.5	
<i>Other Debt</i>	2.4	1.8	<i>Life insurance</i>	24.9	28.5	16.9
			<i>Trust funds</i>	35.7	35.8	26.7
			<i>Vehicles: Value</i>	2.3	1.5	
			<i>Business debt</i>	22.9	11.6	8.1
			<i>Home: All debt</i>	7.6	4.2	
			<i>Other property: Debt</i>	7.1	5.9	

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Size of the missing data problem (Home value)

- Home Value

	W1	W2	W3	W4	W5	W6	W7	W8	W9
Home value (households) (non-zero cases only)									
Home value	5.9	7.6	5.6	4.0	3.3	4.2	2.6	3.0	3.6

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Size of missing data problem - Expenditure

Variable	Wave								
	1	2	3	4	5	6	7	8	9
Responding persons									
<i>Usual payments/repayments per month (collected in the HQ)</i>									
Rent	0.3	0.4	0.4	0.3	0.3	0.4	0.5	0.5	0.6
First mortgage	1.9	1.5	1.4	1.3	1.2	0.9	1.2	1.4	1.7
Second mortgage	0.7	0.5	0.5	0.5	0.5	0.5	0.6	0.6	1.0
<i>Weekly household expenditure (collected in the HQ)</i>									
Work-related child care, term-time (school aged)	0.3	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0.2
Work-related child care, holidays (school aged)	0.3	0.2	0.1	0.1	0.1	0.0	0.1	0.0	0.2
Work-related child care (not yet at school)	0.1	0.2	0.0	0.1	0.0	0.0	0.1	0.0	0.2
Non-work-related child care (school aged)	-	0.4	0.0	0.2	0.1	0.0	0.1	0.1	0.8
Non-work-related child care (not yet at school)	-	0.1	0.0	0.1	0.1	0.0	0.2	0.2	0.9
All groceries	1.2	-	1.0	0.9	0.9	-	-	-	-
Groceries for food and drink	2.0	-	1.7	1.2	1.2	-	-	-	-
Meals eaten outside	0.9	-	1.0	0.9	0.8	-	-	-	-

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Size of missing data problem - Expenditure

Variable	Wave								
	1	2	3	4	5	6	7	8	9
Responding persons									
<i>Annualised household expenditure (collected in the SCQ)</i>									
Groceries	-	-	-	-	15.1	14.5	16.5	18.0	18.7
Alcohol	-	-	-	-	15.9	15.4	17.1	18.8	19.3
Cigarettes and tobacco	-	-	-	-	16.4	16.2	17.8	19.0	19.7
Public transport and taxis	-	-	-	-	16.5	16.9	18.3	19.5	20.0
Meals eaten out	-	-	-	-	15.1	15.1	16.8	18.4	19.2
Leisure activities	-	-	-	-	15.9	-	-	-	-
Motor vehicle fuel	-	-	-	-	15.6	14.6	16.6	18.4	19.1
Men's clothing and footwear	-	-	-	-	-	15.7	17.5	19.1	19.7
Women's clothing and footwear	-	-	-	-	-	16.4	18.1	19.3	20.1
Children's clothing and footwear	-	-	-	-	-	17.2	18.3	20.1	20.8
Clothing and footwear	-	-	-	-	16.6	-	-	-	-
Telephone rent and calls	-	-	-	-	16.0	-	-	-	-
Telephone rent and calls, internet charges	-	-	-	-	-	14.7	16.7	18.2	19.0
Holiday and holiday travel costs	-	-	-	-	15.8	15.1	17.3	18.9	19.4

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Methods

- Income and expenditure
 - Nearest neighbour regression method
 - Population carry-over
 - Little & Su method
- Wealth
 - Nearest neighbour regression method
 - Little & Su method
- Age, wave 2 employment status
 - Hot deck method

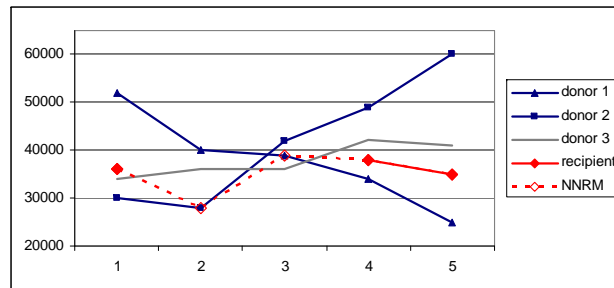
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Nearest neighbour regression method

- Cross-sectional method
- Process:
 - Use data from respondents to create a multiple regression model
 - Calculate the predicted values for both donors and non-respondents.
 - Order the predicted values and choose the NN to a non-respondents
 - Donor's actual value used to impute missing value
- Restrict donors to imputation classes
- Donor used maximum of 2 times

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Nearest neighbour regression method



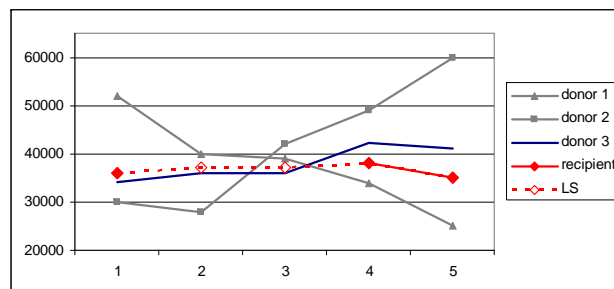
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Little and Su method

- Longitudinal method
- The method adjusts for how the person differs from the sample average in a wave, and also how the wave differs from the average of the other waves.
- Used for repeat measures on a single variable
 - Needs at least one wave non-missing
- Use the single donor for ALL waves requiring imputation
- Donor chosen from similar age range

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Little and Su method



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Population carry-over

- Longitudinal method
- Before applying the Little and Su method when imputing income (for non-respondents) and expenditure
- Carry the information forward or backward
 - using complete cases to decide the probability with which
 - the last wave value is carried forward or
 - the next wave value is carried backwards
- Only carry over whether zero or non-zero

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Other imputation

- Age imputation:
 - Simple hot deck method
 - Imputation class: sex, household size, relationship in households, household type, partner age and parent age.
- Wave 2 employment status
 - Employment status of non-respondents
 - Derive from wave 3 response to the calendar questions
 - Hot deck imputation

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Longitudinal households

- Longitudinal households:
 - Households are linked longitudinally for imputation purpose
- Indicator variables:
 - *_hhlink*: household linkage indicator for home value imputation
 - *_hwlink*: household linkage indicator for wealth imputation (household link between wave 2 and 6)
 - *_hxylink*: household linkage indicator for expenditure imputation

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Datasets

- Dataset includes
 - Original variables
 - Imputed variables
 - Imputation flag
- All imputed variables have the suffix 'i'
- All imputation flag variables have the suffix 'f'
- Up to the user if they want to use it

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More information

- Technical papers
 - Imputation methods (income and wealth)
 - Expenditure imputation
 - Evaluation of alternative income imputation methods

melbourneinstitute.com/hilda/data/technical_papers.html
melbourneinstitute.com/hilda/data/discussion_papers.html

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Questions?

Where to go for help...

- User Manual
- Technical papers (survey methodology, weighting, imputation, data quality)
- Questionnaires (waves 1-11)
- HILDA website: melbourneinstitute.com/hilda/
- HILDA team: hilda-inquiries@unimelb.edu.au

Appendix

Things to watch out for

Responding vs enumerated

- Not every adult in responding household provided an interview
- Identified by: `_hhresp >=63` and `_hhresp <=68`
- Need to be mindful of this when calculating total household information from person file (eg number of people in household receiving benefits)

Skips

- Skips are identified by `-1`
- Check questionnaire for skips
- For example,
 - A3 (whether English is first language) in W1 only asked if not born in Australia
 - If constructing variable for whether English is first language, then need to include those born in Australia

Positive and negative variables

- Income can be negative for
 - Business income
 - Rental income
 - Total income
- Wealth can be negative for:
 - Household net wealth
 - Home equity
 - Other property equity
 - Total property equity
 - Business equity
- Provided as two variables
 - positive and negative components
- Subtract negative from positive (after treating missing values if necessary)
- For example: `abifip - abifin`

Multiple variables available

- For example, labour force status
 - HF – 1 person in HH, simple questions
 - PQ – derived variable
 - PQ income section – wage and salary earner
 - SCQ – hours worked

Calendar

- Structure

	Occurs	July	Aug	Sept	Oct	Nov	Dec
Study	1	111	111	111	111	100	000
Job 1	1	000	111	111	000	000	000
Job 2	1	000	000	000	000	111	111
Job 3	0	-1-1-1	-1-1-1	-1-1-1	-1-1-1	-1-1-1	-1-1-1

- Tips for use

- List calendar variables
- Turn data into spells
- Calendar finish generally in month/week prior to ivw

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Caution...

Do not combine data from different releases!

- Each release contains all data in prior waves
- Manage the different releases you receive by
 - Overwriting
 - Storing in new spot
- See User Manual for indication of changes
 - Eg: cleaning, correcting derivations, new variables

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Derived Variables

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Relationships in households

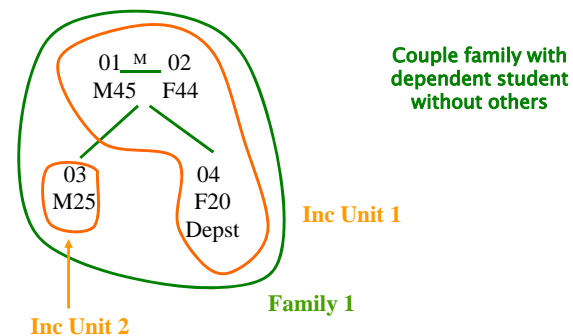
- Complete relationship grid for everyone in the household (complex to use and **NO** order to how people are listed in HH)
- Derived variables from grid:
 - Relationship in household (*_hhrih*)
 - Family identifier (*_hhfam*)
 - Income unit identifier (*_hhIU*)
 - Family type (*_hhfty*)
 - Household type (*_hhType*)

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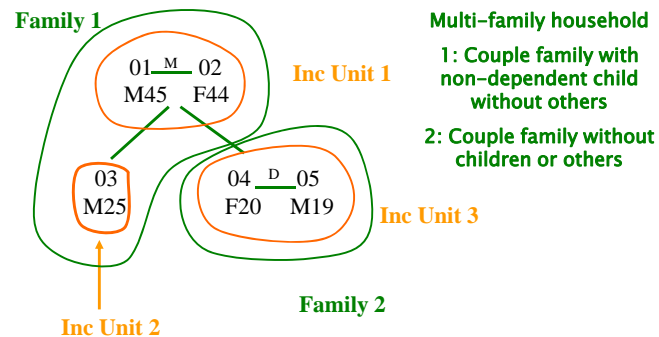
Relationships in households (c'td)

- Household->Family->Income unit->Person
- Household
 - Reside in same dwelling and make common provision for food and other essentials for living
- Key links in family units
 - Married/de facto relationship
 - Parent-child relationship
- Also for income units
 - Age of children

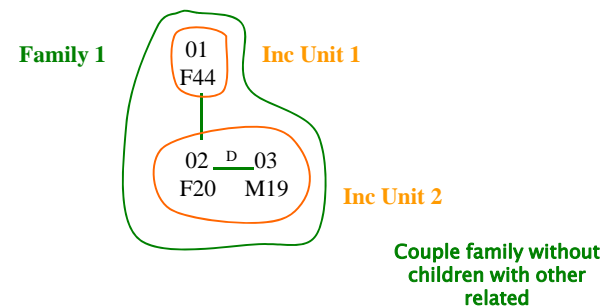
Family example 1



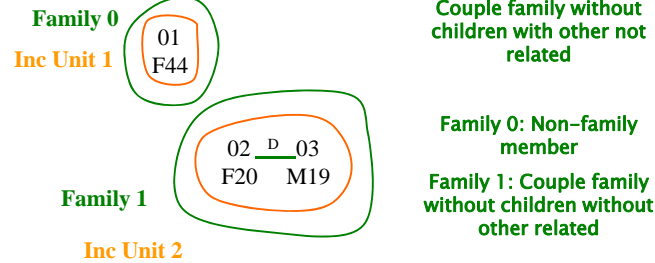
Family example 2



Family example 3



Family example 4



Construction of family type description

Type of core unit	Type of most dependent child	Type of others attached to family
<ul style="list-style-type: none"> Couple family Lone parent 	<ul style="list-style-type: none"> Without children With child < 15 With dependent student With non-dependent child 	<ul style="list-style-type: none"> Without others With others related (eg, aunts, uncles, grandparents)
<ul style="list-style-type: none"> Other related family 	<ul style="list-style-type: none"> Without children 	<ul style="list-style-type: none"> Without others
<ul style="list-style-type: none"> Lone person 		
<ul style="list-style-type: none"> Non-family 		

Construction of household type

Type of core unit	Type of most dependent child	Type of others attached to family
<ul style="list-style-type: none"> Couple family Lone parent 	<ul style="list-style-type: none"> Without children With child < 15 With dependent student With non-dependent child 	<ul style="list-style-type: none"> Without others With others related (eg, aunts, uncles, grandparents) With others not related
<ul style="list-style-type: none"> Other related family 	<ul style="list-style-type: none"> Without children 	<ul style="list-style-type: none"> Without others With others not related
<ul style="list-style-type: none"> Lone person 		
<ul style="list-style-type: none"> Group household 		
<ul style="list-style-type: none"> Multi-family household 		

Household and family type

- Household type = family type, except for:
 - Multifamily HH
 - Group households (family number = 0, all non-family members, separate income units)
 - HH with 'other not-related'

History variables

- W1: background from all respondents
- W2+: update from continuing respondents, plus background from new respondents
- W2 history variables
 - W1 background + update for continuing
 - W2 background for new
- W3 history variables
 - W2 history + update for continuing
 - W3 background for new

History variables (c'td)

