

# Updates to the ipfraking ecosystem

Stanislav Kolenikov  
Abt Associates  
stas\_kolenikov@abtassoc.com

**Abstract.** Kolenikov (2014) introduced package `ipfraking` for weight calibration procedures known as iterative proportional fitting, or raking, of complex survey weights. This article briefly describes the original package, and adds updates to the core program, as well as a host of additional programs that are used to support the process of creating survey weights in the authors' production code.

**Keywords:** st0001, survey, calibration, weights, raking

## 1 Introduction and background

Large scale social, behavioral and health data are often collected via complex survey designs that may involve some or all of stratification, multiple stages of selection and unequal probabilities of selection (Korn and Graubard 1995, 1999). In an ideal setting, varying probabilities of selection are accounted for by using the Horvitz-Thompson estimator of the totals (Horvitz and Thompson 1952; Thompson 1997), and the remaining sampling fluctuations can be further ironed out by post-stratification (Holt and Smith 1979). However, on top of the planned differences in probabilities of obtaining a response from a sampled unit, non-response is a practical problem that has been growing more acute over the recent years (Groves et al. 2001; Pew Research Center 2012). The analysis weights that are provided along with the public use microdata by data collecting agencies are designed to account for unequal probabilities of selection, non-response, and other factors affecting imbalance between the population and the sample, thus making the analyses conducted on such microdata generalizable to the target population.

Earlier, I introduced (Kolenikov 2014) a Stata package called `ipfraking` that implements calibration of survey weights to known control totals to ensure that the resulting weighted data are representative of the population of interest. The process of calibration is aimed at aligning the sample totals of the key variables with those known for the population as a whole. The remainder of this section provides a condensed treatment of estimation with survey data using calibrated weights; full treatment was provided in the original paper.

For a given finite population  $\mathcal{U}$  of units indexed  $i = 1, \dots, N$ , the interests of survey statisticians often lie in estimating the population total of a variable  $Y$

$$T[Y] = \sum_{i \in \mathcal{U}} Y_i \quad (1)$$

A sample  $\mathcal{S}$  of  $n$  units indexed by  $j = 1, \dots, n$  is taken from  $\mathcal{U}$ . If the probability to select the  $i$ -th unit is known to be  $\pi_i$ , then the *probability weights*, or *design weights*,

are given by the inverse probability of selection:

$$w_{1i} = \pi_i^{-1} \quad (2)$$

With these weights, an unbiased (design-based, non-parametric) estimator of the total (1) is (Horvitz and Thompson 1952)

$$t_1[y] = \sum_{j \in \mathcal{S}} \frac{y_j}{\pi_j} \equiv \sum_{j \in \mathcal{S}} w_{1j} y_j, \quad (3)$$

The subindex 1 indicates that the weights  $w_{1i}$  were used in obtaining this estimator. Probability weights protect the end user from potentially informative sampling designs, in which the probabilities of selection are correlated with outcomes, and the design-based methods generally ensure that inference can be generalized to the finite population even when the statistical models used by analysts and researchers are not specified correctly (Pfeffermann 1993; Binder and Roberts 2003).

Often, survey statisticians have auxiliary information on the units in the frame, and such information can be included it at the sampling stage to create more efficient designs. Unequal probabilities of selection are then controlled with probability weights, implemented as `[pw=exp]` in Stata (and can be permanently affixed to the data set with `svyset` command).

In many situations, however, usable information is not available beforehand, and may only appear in the collected data. The census totals of the age and gender distribution of the population may exist, but age and gender of the sampled units is unknown until the survey measurement is taken on them. It is still possible to capitalize on this additional data by adjusting the weights in such a way that the reweighted data conforms to these known figures. The procedures to perform these reweighting steps are generally known as *weight calibration* (Deville and Särndal 1992; Deville et al. 1993; Kott 2006, 2009; Särndal 2007).

Suppose there are several (categorical) variables, referred to as *control variables*, that are available for both the population and the sample (age groups, race, gender, educational attainment, etc.). Weight calibration aims at adjusting the margins, or low level interactions, via an iterative optimization aimed at satisfying the *control totals* for the control variables  $\mathbf{x} = (x_1, \dots, x_p)$ :

$$\sum_{j \in \mathcal{S}} w_{3j} \mathbf{x}_j = T[\mathbf{X}_j] \quad (4)$$

where the right hand side is assumed to be known from a census or a higher quality survey. Deville and Särndal (1992) framed the problem of finding a suitable set of weights as that of constrained optimization with the control equations (4) serving as constraints, and optimization targeted at making the discrepancy between the design weights  $w_{1j}$  and calibrated weights  $w_{3j}$  as close as possible, in a suitable sense.

In package `ipfraking` (Kolenikov 2014), I implemented a popular calibration algorithm, known as *iterated proportional fitting*, or as *raking*, which consists of iterative

updating (post-stratification) of each of the margins. (For an in-depth discussion of distinctions between raking and post-stratification, see Kolenikov (2016).) Since 2014, the continuing code development resulted in additional features that this update documents.

## 2 Updates to ipfraking program and package

Below, I provide full syntax, and list the new features in a dedicated section.

### 2.1 Syntax of ipfraking

```
ipfraking [if] [in] [weight] , ctotal(matname [matname ...]) [
  generate(newvarname) replace double iterate(#) tolerance(#)
  ctrltolerance(#) trace nodivergence trimhiabs(#) trimhirel(#)
  trimloabs(#) trimlorel(#) trimfrequency(once|sometimes|often) double
  meta nograph ]
```

Note that the weight statement [**pw**=varname] is required, and must contain the initial weights.

#### Required options

ctotal(matname [matname ...]) supplies the names of the matrices that contain the control totals, as well as meta-data about the variables to be used in calibration.

#### □ Technical note

The row and column names of the control total matrices (see [P] **matrix rownames**) should be formatted as follows.

- **rownames**: the name of the control variable
- **colnames**: the values the control variables takes
- **coleq**: the name of the variable for which total is computed; typically it is identically equal to 1.

□

generate(newvarname) contains the name of the new variable to contain the raked weights.

**replace** indicates that the weight variable supplied in the [**pw**=varname] expression should be overwritten with the new weights.

One and only one of **generate**() or **replace** must be specified.

**Linear calibration**

`linear` requests linear calibration of weights.

**Options to control convergence**

`tolerance(#)` defines convergence criteria (the change of weights from one iteration to next). The default is  $10^{-6}$ .

`iterate(#)` specifies the maximum number of iterations. The default is 2000.

`nodivergence` overrides the check that the change in weights is greater at the current iteration than in the previous one, i.e., ignores this termination condition. It is generally recommended, especially in calibration with simultaneous trimming.

`ctrltolerance(#)` defines the criterion to assess the accuracy of the control totals. It does not impact iterations or convergence criteria, but rather only triggers alerts in the output. The default value is  $10^{-6}$ .

`trace` requests a trace plot to be added.

**Trimming options**

`trimhiabs(#)` specifies the upper bound  $U$  on the greatest value of the raked weights. The weights that exceed this value will be trimmed down, so that  $w_{3j} \leq U$  for every  $j \in \mathcal{S}$ .

`trimhirel(#)` specifies the upper bound  $u$  on the adjustment factor over the baseline weight. The weights that exceed the baseline times this value will be trimmed down, so that  $w_{3j} \leq uw_{1j}$  for every  $j \in \mathcal{S}$ .

`trimloabs(#)` specifies the lower bound  $L$  on the smallest value of the raked weights. The weights that are smaller than this value will be increased, so that  $w_{3j} \geq L$  for every  $j \in \mathcal{S}$ .

`trimlorel(#)` specifies the lower bound  $l$  on the adjustment factor over the baseline weight. The weights that are smaller than the baseline times this value will be increased, so that  $w_{3j} \geq lw_{1j}$  for every  $j \in \mathcal{S}$ .

`trimfrequency(keyword)` specifies when the trimming operations are to be performed. The following keywords are recognized:

`often` means that trimming will be performed after each marginal adjustment.

`sometimes` means that trimming will be performed after a full set of variables has been used for post-stratification. This is the default behavior if any of the numeric trimming options above are specified.

`once` means that trimming will be performed after the raking process is declared to have converged.

The numeric trimming options `trimhiabs(#)`, `trimhirel(#)`, `trimloabs(#)`, `trimlore1(#)` can be specified in any combination, or entirely omitted to produce untrimmed weights. By default, there is no trimming.

### Miscellaneous options

`double` specifies that the new variable named in `generate()` option should be generated as double type. See [D] **data types**.

`meta` puts information taken by `ipfraking` as inputs and produced throughout the process into characteristics stored with the variable specified in `generate()` option. See details in Section 2.2.

`nograph` omits the histogram of the calibrated weights, which can be used to speed up `ipfraking` (e.g., in replicate weight production).

## 2.2 New features of ipfraking

Since the first publication, the following features and options were added.

Reporting of results and errors by `ipfraking` was improved in several directions.

1. The discrepancy for the worst fitting category is now being reported.
2. The number of trimmed observations is reported.
3. If `ipfraking` determines that the categories do not match in the control totals received from `ctotals()` and those found in the data, a full listing of categories is provided, and the categories not found in one or the other are explicitly shown.

Linear calibration (Case 1 of Deville and Särndal (1992)) is provided with `linear` option. The weights are calculated analytically:

$$w_{j,\text{lin}} = w_{1j}(1 + \mathbf{x}'_j \lambda). \quad \lambda = \left( \sum_{j \in S} w_{1j} \mathbf{x}_j \mathbf{x}'_j \right)^{-1} (T[\mathbf{X}_j] - t_1[y]) \quad (5)$$

This works very fast, but has an undesirable artefact of producing negative weights, as the range of weights is not controlled. (As raking works by multiplying the currents weights by positive factors, if the input weights are all positive, the output weights will be positive as well.) Negative weights are not allowed by the official `svy` commands or commands that work with `[pweights]`. In author's experience, running linear weights first, pulling up the negative and small positive weights (`replace weight = 1 if weight <= 1`) and re-raking using the "proper" iterative proportional fitting runs faster than raking from scratch. An example of linearly calibrated weights is given below in Section 5.

Option `meta` saves more information in characteristics of the calibrated weight variables. Using Example 3 from Kolenikov (2014) with trimming options, we have:

```

. capture drop rakedwgt3
. ipfraking [pw=finalwgt], gen( rakedwgt3 ) ///
>   cttotal( ACS2011_sex_age Census2011_region Census2011_race ) ///
>   trimhiabs(200000) trimloabs(2000) meta

Iteration 1, max rel difference of raked weights = 14.95826
Iteration 2, max rel difference of raked weights = .21474256
Iteration 3, max rel difference of raked weights = .02754514
Iteration 4, max rel difference of raked weights = .00511347
Iteration 5, max rel difference of raked weights = .00095888
Iteration 6, max rel difference of raked weights = .00018036
Iteration 7, max rel difference of raked weights = .00003391
Iteration 8, max rel difference of raked weights = 6.377e-06
Iteration 9, max rel difference of raked weights = 1.199e-06
Iteration 10, max rel difference of raked weights = 2.254e-07
The worst relative discrepancy of 3.0e-08 is observed for race == 3
Target value = 20053682; achieved value = 20053682
Trimmed due to the upper absolute limit: 5 weights.

Summary of the weight changes

```

	Mean	Std. dev.	Min	Max	CV
Orig weights	11318	7304	2000	79634	.6453
Raked weights	22055	18908	4033	200000	.8573
Adjust factor	2.1486		0.9220	18.9828	

```

. char li rakedwgt3[]
rakedwgt3[source]:      finalwgt
rakedwgt3[objfcn]:      2.25435521346e-07
rakedwgt3[maxctrl]:     3.00266822363e-08
rakedwgt3[converged]:   1
rakedwgt3[worstcat]:    3
rakedwgt3[worstvar]:    race
rakedwgt3[command]:     [pw=finalwgt], gen( rakedwgt3 ) cttotal( ACS2011_sex_age Census2011_region ..
rakedwgt3[trimloabs]:   trimloabs(2000)
rakedwgt3[trimhiabs]:   trimhiabs(200000)
rakedwgt3[trimfrequency]: sometimes
rakedwgt3[hash1]:       2347674164
rakedwgt3[mat3]:        Census2011_race
rakedwgt3[over3]:       race
rakedwgt3[totalof3]:    _one
rakedwgt3[Census2011_race]: 7.48567503861e-09
rakedwgt3[mat2]:        Census2011_region
rakedwgt3[over2]:       region
rakedwgt3[totalof2]:    _one
rakedwgt3[Census2011_region]: 3.00266822363e-08
rakedwgt3[mat1]:        ACS2011_sex_age
rakedwgt3[over1]:       sex_age
rakedwgt3[totalof1]:    _one
rakedwgt3[ACS2011_sex_age]: 4.13778410340e-09
rakedwgt3[note1]:       Raking controls used: ACS2011_sex_age Census2011_region Census2011_race
rakedwgt3[note0]:       1

```

The following characteristics are stored with the newly created weight variable (see [P] **char**).

<code>command</code>	The full command as typed by the user
<code>matrix name</code>	The relative matrix difference from the corresponding control total, see [D] <b>functions</b>
<code>trimhiabs, trimloabs, trimhirel, trimlorel, trimfrequency</code>	Corresponding trimming options, if specified
<code>maxctrl</code>	the greatest <code>mreldif</code> between the targets and the achieved weighted totals
<code>objfcn</code>	the value of the relative weight change at exit
<code>converged</code>	whether <code>ipfraking</code> exited due to convergence (1) vs. due to an increase in the objective function or reaching the limit on the number of iterations (0)
<code>source</code>	weight variable specified as the <code>[pw=]</code> input
<code>worstvar</code>	the variable in which the greatest discrepancy between the targets and the achieved weighted totals ( <code>maxctrl</code> ) was observed
<code>worstcat</code>	the category of the <code>worstvar</code> variable in which the greatest discrepancy was observed

For the control total matrices  $\# = 1, 2, \dots$ , the following meta-information is stored.

<code>mat#</code>	the name of the control total matrix
<code>totalof#</code>	the multiplier variable (matrix' <code>coleq</code>
<code>over#</code>	the margin associated with the matrix (i.e., the categories represented by the columns)

Also, `ipfraking` stores the notes regarding the control matrices used, and which of the margins did not match the control totals, if any. See [D] **notes**.

## 2.3 Utility programs

The original package `ipfraking` provided two additional utility programs, `mat2do` and `xls2row`. An additional utility program `whatsdeff` was added to compute the design effects and margins of error, common tasks associated with describing survey weights. Specifically, the Transparency Initiative of the American Association for Public Opinion Research (AAPOR 2014) requires that

For probability samples, the estimates of sampling error will be reported, and the discussion will state whether or not the reported margins of sampling error or statistical analyses have been adjusted for the design effect due to weighting, clustering, or other factors.

`whatsdeff weight_variable [ if ] [ in ] , [ by(varlist) ]`

The utility program `whatsdeff` calculates the apparent design effect due to unequal weighting,  $DEFF_{UWE} = 1 + CV_w^2 = 1 + r(\text{Var})/(r(\text{mean}))^2$  from `summarize`

*weight\_variable*. Additionally, it reports the effective sample size,  $n/\text{DEFF}_{\text{UWE}}$ , and also returns the margins of error for the sample proportions that estimate the population proportions of 10% and 50%.

```
. webuse nhanes2, clear
. whatsdeff finalwgt
```

Group	Min	Mean	Max	CV	DEFF	N	N eff
Overall	2000.00	11318.47	79634.00	0.6453	1.4164	10351	7307.97

```
. return list
scalars:
      r(N) = 10351
      r(MOE10) = .0068792766212984
      r(MOE50) = .0114654610354974
      r(Neff_Overall) = 7307.97435325364
      r(DEFF_Overall) = 1.416397964696134
. whatsdeff finalwgt, by(sex)
```

Group	Min	Mean	Max	CV	DEFF	N	N eff
sex							
Male	2000.00	11426.14	79634.00	0.6578	1.4326	4915	3430.94
Female	2130.00	11221.12	61534.00	0.6333	1.4010	5436	3880.01
Overall	2000.00	11318.47	79634.00	0.6453	1.4164	10351	7307.97

```
. return list
scalars:
      r(N) = 10351
      r(MOE10) = .0068792766212984
      r(MOE50) = .0114654610354974
      r(Neff_Overall) = 7307.97435325364
      r(DEFF_Overall) = 1.416397964696134
      r(Neff_Female) = 3880.00710397866
      r(DEFF_Female) = 1.40102836266093
      r(Neff_Male) = 3430.938195872213
      r(DEFF_Male) = 1.432552765279559
```

## 2.4 New programs in the package

Two new programs are added to the package: `ipfraking_report` and `wgtcellcollapse`, and are documented in the subsequent sections of this article. The former provides reports on the raked weights, including summaries of the unweighted data, data with the input weights, and data with the raked weights. The latter creates a mostly automated flow of collapsing weighting cells that are too detailed (and hence have low sample sizes).

## 3 Excel reports on raked weights: `ipfraking_report`

```
ipfraking_report using filename , raked_weight(varname) [
  matrices(namelist) by(varlist) xls replace force ]
```



The utility command `ipfraking_report` produces a detailed report describing the raked weights, and places it into `filename.dta` file (or, if `xls` option is specified, both `filename.dta` and `filename.xls` files).

Along the way, `ipfraking_report` runs a regression of the log raking ratio  $w_{3j}/w_{1j}$  on the calibration variables. This regression is expected to have  $R^2$  very close to 1, and the regression coefficients provide insights regarding which categories received greater vs. smaller adjustments.

```
. ipfraking_report using rakedwgt3-report, raked_weight(rakedwgt3) replace by(_one)
Margin variable sex_age (total variable: _one; categories: 11 12 13 21 22 23).
Margin variable region (total variable: _one; categories: 1 2 3 4).
Margin variable race (total variable: _one; categories: 1 2 3).
Auxiliary variable _one (categories: 1).
file rakedwgt3-report.dta saved
```

Source	SS	df	MS	Number of obs	=	10,351
				F(10, 10340)	>	99999.00
Model	2086.13859	10	208.613859	Prob > F	=	0.0000
Residual	.78315703	10,340	.000075741	R-squared	=	0.9996
				Adj R-squared	=	0.9996
Total	2086.92175	10,350	.201634952	Root MSE	=	.0087

__000003	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
sex_age						
11	.0644365	.0002775	232.21	0.000	.0638925	.0649804
12	.4545577	.0003154	1441.25	0.000	.4539395	.455176
13	.6782466	.0002804	2418.71	0.000	.6776969	.6787963
22	.3966406	.0003049	1300.84	0.000	.3960429	.3972383
23	.7304392	.0002726	2679.97	0.000	.7299049	.7309734
region						
NE	-.4455127	.0002536	-1756.49	0.000	-.4460099	-.4450155
MW	-.4428144	.0002335	-1896.53	0.000	-.4432721	-.4423567
W	-.6672675	.0002407	-2772.21	0.000	-.6677393	-.6667957
race						
Black	.3360321	.0002848	1180.08	0.000	.3354739	.3365902
Other	1.613276	.0006303	2559.34	0.000	1.612041	1.614512
_cons	.5864801	.0002455	2388.48	0.000	.5859988	.5869614

Raking adjustments for sex\_age variable:

the smallest was 1.798 for category 21 (21)

the greatest was 3.732 for category 23 (23)

Raking adjustments for region variable (1=NE, 2=MW, 3=S, 4=W):

the smallest was 0.922 for category 4 (W)

the greatest was 1.798 for category 3 (S)

Raking adjustments for race variable (1=white, 2=black, 3=other):

the smallest was 1.798 for category 1 (White)

the greatest was 9.023 for category 3 (Other)

It looks like `ipfraking` had to work harder to adjust the weights of older females, and especially other race individuals.

### 3.1 Options of `ipfraking_report`

`raked.weight(varname)` specifies the name of the raked weight variable to create the report for. This is a required option.

`matrices(namelist)` specifies a list of matrices (formatted as the matrices supplied to `ctotal()` option of `ipfraking`) to produce weighting reports for. In particular, the variables and their categories are picked up from these matrices; and the control totals/proportions are compared to those defined by the weight being reported on.

`by(varlist)` specifies a list of additional variables for which the weights are to be tabulated in the raking weights report. The difference with the `matrices()` option is that the control totals for these variables may not be known (or may not be relevant). In particular, `by(_one)`, where `_one` is identically one, will produce the overall report.

`xls` requests exporting the report to an Excel file.

`replace` specifies that the files produced by `ipfraking_report` (i.e., the `.dta` and the `.xls` file if `xls` option is specified) should be overwritten.

`force` requires that a variable that may be found repeatedly (between the calibration variables supplied originally to `ipfraking`, the variables found in the independent total `matrices()`, and the variables without the control totals provided in `by()` option) is processed every time it is encountered. (Otherwise, it is only processed once.)

### 3.2 Variables in the raking report

The raking report file contains the following variables.

Variable name	Definition
<code>Weight_Variable</code>	The name of the weight variable, <code>generate()</code>
<code>C_Total_Margin_Variable_Name</code>	The name of the control margin, <code>rowname</code> of the corresponding <code>ctotal()</code> matrix
<code>C_Total_Margin_Variable_Label</code>	The label of the control margin variable
<code>Variable_Class</code>	The role of the variable in the report: Raking margin: a variable used as a calibration margin (picked up automatically from the <code>ctotal()</code> matrix, provided <code>meta</code> option was specified) Other known target: supplied with <code>matrices()</code> option of <code>ipfraking_report</code> Auxiliary variable: additional variable supplied with <code>by()</code> option of <code>ipfraking_report</code>
<code>C_Total_Arg_Variable_Name</code>	The name of the multiplier variable
<code>C_Total_Arg_Variable_Label</code>	The label of the multiplier variable

Variable name	Definition
C.Total.Margin.Category.Number	Numeric value of the control total category
C.Total.Margin.Category.Label	Label of the control total category
Category.Total.Target	The control total to be calibrated to (the specific entry in the <code>ctotal()</code> matrix)
Category.Total.Prop	Control total proportion (the ratio of the specific entry in the <code>ctotal()</code> matrix to the matrix total)
Unweighted.Count	Number of sample observations in the category
Unweighted.Prop	Unweighted proportion
Unweighted.Prop.Discrep	Difference <code>Unweighted.Prop - Category.Total.Prop</code>
Category.Total.SRCWGT	Weighted category total, with source weight
Category.Prop.SRCWGT	Weighted category proportion, with source weight
Category.Total.Discrep.SRCWGT	Difference <code>Category.Total.SRCWGT -</code> <code>- Category.Total.Target</code>
Category.Prop.Discrep.SRCWGT	Difference <code>Category.Prop.SRCWGT -</code> <code>- Category.Total.Prop</code>
Category.RelDiff.SRCWGT	<code>reldif(Category.Total.SRCWGT,</code> <code>Category.Total.Target)</code>
Overall.Total.SRCWGT	Sum of source weights
Source	The name of the matrix from which the totals were obtained
Comment	Placeholder for comments, to be entered during manual review

For each of the input weights (SRCWGT suffix), raked weights (RKDWGT suffix) and raking ratio (the ratio of raked and input weights, RKDRATIO suffix), the following summaries are provided.

Variable name	Definition
Min.WEIGHT	Min of source weights
P25.WEIGHT	25th percentile of source weights
P50.WEIGHT	Median of source weights
P75.WEIGHT	75th percentile of source weights
Max.WEIGHT	Max of source weights
Mean.WEIGHT	Mean of source weights
SD.WEIGHT	Standard deviation of source weights
DEFF.WEIGHT	Apparent UWE DEFF of source weights

### 3.3 Example

```
. use rakedwgt3-report, clear
(Weighting report on rakedwgt3)

. list C_Total_Margin_Variable_Name C_Total_Margin_Category_Label ///
>      Category_Total_Target Category_Total_RKDWGT DEFF_SRCWGT DEFF_RKDWGT , ///
>      sepy( C_Total_Margin_Variable_Name )
```

	C_Tota..	~y_Label	Categor~t	Categor..	DEFF_SR~T	DEFF_RK~T
1.	sex_age	11	41995394	41995394	1.2148059	1.6259899
2.	sex_age	12	42148662	42148662	1.2462168	1.5716613
3.	sex_age	13	26515340	26515340	1.2241095	1.5460785
4.	sex_age	21	41164255	41164255	1.2325105	1.5639529
5.	sex_age	22	43697440	43697440	1.1937826	1.5175312
6.	sex_age	23	32773080	32773080	1.233902	1.664307
7.	region	NE	40679030	40679030	1.3056639	1.3657837
8.	region	MW	49205289	49205289	1.3475551	1.4909581
9.	region	S	85024007	85024006	1.4950056	1.4912995
10.	region	W	53385843	53385844	1.459859	2.3772667
11.	race	White	1.784e+08	1.784e+08	1.4059259	1.4337901
12.	race	Black	29856865	29856865	1.5173846	1.5092533
13.	race	Other	20053682	20053682	1.3179136	1.2264706
14.	_one	1	.	2.283e+08	1.4164382	1.7349278

Functionality of `ipfraking_report` is aimed at manual quality control review, which typically involves (i) categories with raking factors that differ the most (in the output), and (ii) the resulting report file in Excel, although for some aspects of automated quality control, it can be useful, as well.

## 4 Collapsing weighting cells: `wgtcellcollapse`

An additional new component of `ipfraking` package is a tool to semi-automatically collapse weighting cells, in order to achieve a required minimal size of the weighting cell. (A typical recommendation is to have cells of size 30 to 50.)

```
wgtcellcollapse task [if] [in] , [task.options]
```

where *task* is one of:

**define** to define collapsing rules explicitly

**sequence** to create collapsing rules for a sequence of categories

**report** to list the currently defined collapsing rules

**candidate** to find rules applicable to a given category

**collapse** to perform cell collapsing

**label** to label collapsed cells using the original labels after `wgtcellcollapse collapse`

### 4.1 Syntax of `wgtcellcollapse report`

```
wgtcellcollapse report , variables(varlist) [ break ]
```

`variables(varlist)` is the list of variables for which the collapsing rules are to be reported

`break` requires `wgtcellcollapse report` to exit with error when technical inconsistencies are encountered

## 4.2 Syntax of `wgtcellcollapse define`

```
wgtcellcollapse define , variables(varlist) [ from(numlist) to(#)
    label(string) max(#) clear ]
```

`variables(varlist)` is the list of variables for which the collapsing rule can be used

`from(numlist)` is the list of categories that can be collapsed according to this rule

`to(#)` is the numeric value of the new, collapsed category

`label(string)` is the value label to be attached to the new, collapsed category

`max(#)` overrides the automatically determined max value of the collapsed variable

`clear` clears all the rules currently defined

Individual collapsing rules can be defined as follows.

```
.
. clear
.
. set obs 4
number of observations (_N) was 0, now 4
.
. gen byte x = _n
.
. label define x_lbl 1 "One" 2 "Two" 3 "Three" 4 "Four"
.
. label values x x_lbl
.
. wgtcellcollapse define, var(x) from(1 2 3) to(123)
.
. wgtcellcollapse report, var(x)
Rule (1): collapse together
  x == 1 (One)
  x == 2 (Two)
  x == 3 (Three)
into x == 123 (123)
WARNING: unlabeled value x == 123
.
```

Note how `break` option of `wgtcellcollapse report` can be used to abort the execution when technical deficiencies in the rules or in the data are encountered. In this case, the label of the new category 123 was not defined, and this is considered a serious

enough deficiency to stop.

```
.
. wgtcellcollapse report, var(x) break
Rule (1): collapse together
  x == 1 (One)
  x == 2 (Two)
  x == 3 (Three)
  into x == 123 (123)
  ERROR: unlabeled value x == 123
  assertion is false
r(9);

.
. wgtcellcollapse define, var(x) clear

.
. wgtcellcollapse define, var(x) from(1 2 3) to(123) label("One through three")
.
. wgtcellcollapse report, var(x) break
Rule (1): collapse together
  x == 1 (One)
  x == 2 (Two)
  x == 3 (Three)
  into x == 123 (One through three)

.
```

### 4.3 Syntax of wgtcellcollapse sequence

`wgtcellcollapse sequence , variables(varlist) from(numlist) depth(#)`

`variables(varlist)` is the list of variables for which the collapsing rule can be used

`from(numlist)` is the sequence of values from which the plausible subsequences can be constructed

`depth(#)` is the maximum number of the original categories that can be collapsed

Moderate length sequences of collapsing categories can be defined as follows.

```
. clear
. set obs 4
number of observations (_N) was 0, now 4
. gen byte x = _n
. label define x_lbl 1 "One" 2 "Two" 3 "Three" 4 "Four"
. label values x x_lbl
. wgtcellcollapse sequence, var(x) from(1 2 3 4) depth(3)
. wgtcellcollapse report, var(x)
Rule (1): collapse together
  x == 1 (One)
  x == 2 (Two)
  into x == 212 (One to Two)
```

*(Continued on next page)*



```

Rule (2): collapse together
  x == 2 (Two)
  x == 3 (Three)
  into x == 223 (Two to Three)

Rule (3): collapse together
  x == 3 (Three)
  x == 4 (Four)
  into x == 234 (Three to Four)

Rule (4): collapse together
  x == 1 (One)
  x == 2 (Two)
  x == 3 (Three)
  into x == 313 (One to Three)

Rule (5): collapse together
  x == 1 (One)
  x == 223 (Two to Three)
  into x == 313 (One to Three)

Rule (6): collapse together
  x == 3 (Three)
  x == 212 (One to Two)
  into x == 313 (One to Three)

Rule (7): collapse together
  x == 2 (Two)
  x == 3 (Three)
  x == 4 (Four)
  into x == 324 (Two to Four)

Rule (8): collapse together
  x == 2 (Two)
  x == 234 (Three to Four)
  into x == 324 (Two to Four)

Rule (9): collapse together
  x == 4 (Four)
  x == 223 (Two to Three)
  into x == 324 (Two to Four)

```

Note how `wgtcellcollapse` sequence automatically created labels for the collapsed cells.

When creating sequential collapses, `wgtcellcollapse` sequence uses the following mnemonics in creating the new categories:

- First comes the length of the collapsed subsequence (up to `depth( # )`).
- Then comes the starting value of the category in the subsequence (padded by zeroes as needed).
- Then comes the ending value of the category in the subsequence (padded by zeroes as needed).

In the example above, rules 7 through 9 lead to collapsing into the new category 324. This should be interpreted as “the subsequence of length 3 that starts with category 2 and ends with category 4”. A numeric value of the collapsed category that reads like



50412 means “the subsequence of length 5 that starts with category 4 and ends with category 12”. In that second example, `wgtcellcollapse sequence` padded the value of 4 with an additional zero, so that the length of resulting collapsed category value is always (of digits of the sequence length) + twice (of digits of the greatest source category).

Note that `wgtcellcollapse sequence` respects the order in which the categories are supplied in the `from()` option, and does not sort them. If the categories are supplied in the order 2, 4, 1 and 3, then `wgtcellcollapse sequence` would collapse 2 with 4, 4 with 1, and 1 with 3:

```
. wgtcellcollapse define, var(x) clear
. wgtcellcollapse sequence, var(x) from(2 4 1 3) depth(2)
. wgtcellcollapse report, var(x)
Rule (1): collapse together
  x == 2 (Two)
  x == 4 (Four)
  into x == 224 (Two to Four)
Rule (2): collapse together
  x == 4 (Four)
  x == 1 (One)
  into x == 241 (Four to One)
Rule (3): collapse together
  x == 1 (One)
  x == 3 (Three)
  into x == 213 (One to Three)
```

#### 4.4 Syntax of `wgtcellcollapse` candidate

`wgtcellcollapse candidate , variable(varname) category(#) [ max# ]`

`variable(varname)` is the variable whose collapsing rules are to be searched

`category(#)` is the category for which the candidate rules are to be identified

`max(#)` is the maximum value of the categories in the candidate rules to be returned

The rules found are quietly returned through the mechanism of `sreturn`, see [P] **return**, as they are intended to stay in memory sufficiently long for `wgtcellcollapse collapse` to evaluate each rule. Going back to the example with sequential collapses of depth 3, we can identify the following candidates for categories 2, 212 (collapsed values of 1 and 2), and a non-existent category of 55:

(Continued on next page)

```

. wgtcellcollapse candidate, var(x) cat(2)
. sreturn list
macros:
      s(goodrule) : "1 2 4 7 8"
      s(rule8)    : "2:234=324"
      s(rule7)    : "2:3:4=324"
      s(rule4)    : "1:2:3=313"
      s(rule2)    : "2:3=223"
      s(rule1)    : "1:2=212"
      s(cat)      : "2"
      s(x)        : "x"

. wgtcellcollapse candidate, var(x) cat(2) max(9)
. sreturn list
macros:
      s(goodrule) : "1 2 4 7"
      s(rule7)    : "2:3:4=324"
      s(rule4)    : "1:2:3=313"
      s(rule2)    : "2:3=223"
      s(rule1)    : "1:2=212"
      s(cat)      : "2"
      s(x)        : "x"

. wgtcellcollapse candidate, var(x) cat(212)
. sreturn list
macros:
      s(goodrule) : "6"
      s(rule6)    : "3:212=313"
      s(cat)      : "212"
      s(x)        : "x"

. wgtcellcollapse candidate, var(x) cat(55)
. sreturn list
macros:
      s(cat)      : "55"
      s(x)        : "x"

```

In the second call to the option `max(9)` was used to restrict the returned rules to the rules that deal with the original categories only (so rule 8 that involved a collapsed category 234 was omitted). In the third call, a list of rules that involve a collapsed category `cat(212)` was requested. Requests for nonexistent categories are not considered errors, but simply produce empty lists of “good rules”

## 4.5 Syntax of `wgtcellcollapse label`

`wgtcellcollapse label` , variable(*varname*) [ `verbose force` ]

variable(*varname*) is the collapsed variable to be labeled.

`verbose` outputs the labeling results. There may be a lot of output.

`force` instructs `wgtcellcollapse label` to only use categories present in the data.

Example is given in section 4.7 below.

## 4.6 Syntax of `wgtcellcollapse collapse`

```
wgtcellcollapse collapse [if][in], variables(varlist) mincellsize(#)
    saving(dofile_name) [ generate(newvarname) replace append
    feed(varname) strict sort(varlist) run maxpass(#) maxcategory(#)
    zeroes(numlist) greedy ]
```

variables(*varlist*) provides the list of variables whose cells are to be collapsed. When more than one variable is specified, `wgtcellcollapse collapse` proceeds from right to left, i.e., first attempts to collapse the rightmost variable.

mincellsize(#) specifies the minimum cell size for the collapsed cells. For most weighting purposes, values of 30 to 50 can be recommended.

generate(*newvarname*) specifies the name of the collapsed variable to be created.

feed(*varname*) provides the name of an already existing collapsed variable.

strict modifies the behavior of `wgtcellcollapse collapse` so that only collapsing rules for which all participating categories have nonzero counts are utilized.

sort(*varlist*) sorts the data set before proceeding to collapse the cell. The default sort order is in terms of the values of the collapsed variable. A different sort order may produce a different set of collapsed cell when cells are tied on size.

maxpass(#) specifies the maximum number of passes through the data set. The default value is 10000.

maxcategory(#) is the maximum category value of the variable being collapsed. It is passed to the internal calls to `wgtcellcollapse candidate`, see above.

zeroes(*numlist*) provides a list of the categories of the collapsed variable that may have zero counts in the data.

greedy modifies the behavior `wgtcellcollapse collapse` to prefer the rules that collapse the maximum number of categories.

Options to deal with the do-file to write the collapsing code to:

saving(*dofile\_name*) specifies the name of the do-file that will contain the cell collapsing code.

replace overwrites the do-file if one exists.

append appends the code to the existing do-file.

run specifies that the do-file created is run upon completion. This option is typically specified with most runs.

The primary intent of `wgtcellcollapse collapse` is to create the code that can be utilized for both the survey data file and the population targets data file that are

assumed to have identically named variables. Thus it does not only manipulate the data in the memory and collapses the cells, but also produces the do-file code that can be recycled. To that effect, when a do-file is created with the `replace` and `saving()` options, the user needs to specify `generate()` option to provide the name of the collapsed variable; and when the said do-file is appended with the `append` and `saving()` options, the name of that variable is provided with the `feed()` option.

The algorithm `wgtcellcollapse collapse` uses to identify the cells to be collapsed is a variation of greedy search. It first identifies the cells with the lowest (positive) counts; finds the candidate rules for the variable(s) to be collapsed; evaluates the counts of the collapsed cells across all these candidate rules; and uses the rule that produces the smallest size of the collapsed cell across all applicable rules. So when it finds several rules that are applicable to the cell being currently processed that has a size of 5, and the candidate rules produce cells of sizes 7, 10 and 15, `wgtcellcollapse collapse` will use the rule that produces the cell of size 7. The algorithm runs until all cells have sizes of at least `mincellsize(#)` or until `maxpass(#)` passes through the data are executed. It is a pretty dumb algorithm, actually, and it fails quite often. For that reason, a number of hooks are provided to modify its behavior. Section 4.7 will demonstrate the typical failures, and the ways to overcome them.

*Hint 1.* Since `wgtcellcollapse collapse` works with the sample data, it will not be able to identify categories that are not observed in the sample (e.g., rare categories), but may be present in the population. This will lead to errors at the raking stage, when the control total matrices have more categories than the data, forcing `ipfraking` to stop. To help with that, the option `zeroes()` allows the user to pass the categories of the variables that are known to exist in the population but not in the sample.

*Hint 2.* The behavior of `wgtcellcollapse collapse`, `zeroes()` may still not be satisfactory. As it evaluates the sample sizes of the collapsed cells across a number of candidate rules that involve zero cells, it will probably pick up the rule with lowest number, and that rule may as well leave some other candidate rules with zero cells untouched. This may create problems when `wgtcellcollapse collapse` returns to those untouched cells, and looks for the existing cells to collapse them with, creating collapsing rules with breaks in the sequences. To improve upon that behavior, option `greedy` makes `wgtcellcollapse collapse` look for a rule that has as many categories as possible, thus collapsing as many categories with zero counts in one swipe as it can.

*Hint 3.* Other than for dealing with zero cells, the option `strict` should be specified most of the times. It effectively makes sure that the candidate rules correspond to the actual data.

*Hint 4.* Sometimes, you see some combinations in the data that seem like a no-brainer to collapse. Well, they are no-brainers to you, but `wgtcellcollapse collapse` is not that smart. If you want to guarantee some specific combination of cells to be collapsed by `wgtcellcollapse collapse`, your best bet may be to explicitly identify them with the `if` condition, and specify some ridiculously large cell size like `mincellsize(10000)` so that `wgtcellcollapse collapse` makes every possible effort to collapse those cells. It will exit with a complaint that this size could not be achieved, but hopefully the cells

will be collapsed as needed.

## 4.7 Motivating example

Development of `wgtcellcollapse` was to address the need to collapse cells of the margin variables so that each cell has a minimum sample size; and to do so in a way that can be easily made consistent between the sample data and the population targets data. The problem arises when some of the target variables have dozens of categories, most of which have small counts. While the primary motivation comes from transportation surveys, the ideas are also applicable to other domains, e.g., continuous age variables or highly detailed race/ethnicity or region of origin categories in health or economic surveys.

The workflow of `wgtcellcollapse` is demonstrated with the following simulated data set of trips along a metro line composed of 21 stations:

```
. use stations, clear
. list station_id, sep(0)
```

	station_id
1.	1. Alewife
2.	2. Brookline
3.	8. Carmenton
4.	11. Dogville
5.	18. East End
6.	24. Framington
7.	26. Grand Junction
8.	30. High Point
9.	36. Irvingtown
10.	39. Johnsville
11.	40. King Street
12.	44. Limerick
13.	47. Moscow City
14.	49. Ninth Street
15.	50. Ontario Lake
16.	53. Picadilly Square
17.	55. Queens Zoo
18.	60. Redline Circle
19.	62. Silver Spring
20.	68. Toledo Town
21.	69. Union Station

(Continued on next page)

Turnstile counts were collected at entrances and exits of the stations, producing the following population figures.

```
. use trip_population, clear
. table board_id daypart , c(sum num_pass) cellwidth(10) mi
```

board_id	daypart				
	AM Peak	Midday	PM Reverse	Night	Weekend
1. Alewife	1423	34	219	113	44
2. Brookline	7198	298	773	169	144
8. Carmenton	19254	181	3739	872	422
11. Dogville	12626	872	3476	769	1270
18. East End	2470	143	1263	145	114
24. Framington	634	50	1296	133	60
26. Grand Junction	2208	233	439	88	166
30. High Point	4319	424	3740	482	115
36. Irvingtown	1221	34	444	30	167
39. Johnsville	93	4	64	2	6
40. King Street	398	46	76	11	13
44. Limerick	1021	19	129	53	34
47. Moscow City	3300	776	984	140	301
49. Ninth Street	38	22	191	5	5
50. Ontario Lake	606	22	80	18	23
53. Picadilly Square	642	71	622	153	69
55. Queens Zoo	331	23	174	15	19
60. Redline Circle	270	4	63	13	3
62. Silver Spring	3402	240	950	206	445
68. Toledo Town	5085	61	744	272	112

```
. table alight_id daypart , c(sum num_pass) cellwidth(10) mi
```

alight_id	daypart				
	AM Peak	Midday	PM Reverse	Night	Weekend
2. Brookline	19	.	3	2	.
8. Carmenton	492	18	56	23	15
11. Dogville	2475	42	423	153	80
18. East End	929	31	193	67	68
24. Framington	404	13	91	28	27
26. Grand Junction	576	20	147	42	41
30. High Point	2189	89	560	165	167
36. Irvingtown	288	10	91	21	18
39. Johnsville	41	.	11	2	1
40. King Street	131	3	38	8	6
44. Limerick	277	9	87	20	18
47. Moscow City	1746	78	556	142	128
49. Ninth Street	88	2	25	3	4
50. Ontario Lake	232	11	70	14	14
53. Picadilly Square	633	33	198	47	47
55. Queens Zoo	230	10	71	13	14
60. Redline Circle	90	2	26	3	4
62. Silver Spring	1134	67	369	91	85
68. Toledo Town	1372	81	444	112	118
69. Union Station	53193	3038	16007	2733	2677

A survey was administered to a sample of the metro line users, with the following counts of cases collected.

As only 3654 surveys were collected from a total of 96783 riders, we would reasonably expect that things do not align quite well. We expect weighting to correct for at least a portion of that nonresponse. The data available for calibration includes the population turnstile counts listed above, and we will produce interactions of daypart and station that will serve as two weighting margins (one for the stations where the metro users boarded, and one for the stations where they got off).

First, we need to define the weighting rules. In this case, the stations are numbered sequentially, with the northernmost, say, station Alewife being number 3, and the southernmost station, Union Station, where everybody gets off to rush to their city jobs or attractions, being number 69. Below, we create a list of stations and provide it to `wgtcellcollapse` sequence. We would be collapsing stations along the line, with the expectation that travelers boarding or leaving at adjacent stations within the same day part are more similar to one another than the travelers boarding or leaving a particular station at different times of the day. Collapsing rules need to be defined for the `daypart` variable as well — mostly because `wgtcellcollapse collapse` expects all variables to have collapsing rules defined.

```
. use trip_sample, clear
. wgtcellcollapse sequence , var(daypart) from(2 3 4) depth(3)
. levelsof board_id, local(stations_on)
1 2 8 11 18 24 26 30 36 39 40 44 47 49 50 53 55 60 62 68
. levelsof alight_id, local(stations_off)
2 8 11 18 24 26 30 36 39 40 44 47 49 50 53 55 60 62 68 69
. local all_stations : list stations_on | stations_off
. * relies on stations being in sequential order!!!
. wgtcellcollapse sequence , var(board_id alight_id) from(`all_stations`) depth(20)
. save trip_sample_rules, replace
file trip_sample_rules.dta saved
```

The number of collapsing rules for variables `board_id` and `alight_id` created by `wgtcellcollapse sequence` is 2961 each.

### The first pass of cell collapse and raking

Let us say that we want to define weighting cells with at least 20 cases in each. We will thus start with weighting cells defined as station-by-daypart interaction, and collapsing stations within daypart to achieve the cell sizes of at least 20 cases. Here is what a simple run of `wgtcellcollapse collapse` might look like.

```
. use trip_sample_rules, clear
. wgtcellcollapse collapse, variables(daypart board_id) mincellsize(20) ///
> generate(dpston1) saving(dpston1.do) replace run
Pass 0 through the data...
smallest count = 1 in the cell      2000039
Invoking rule 39:40=23940
```

Table 1: Sample frequencies of the trips boardings and alightings.

```
. use trip_sample, clear
. table board_id daypart , c(freq) cellwidth(10) mi
```

board_id	daypart				
	AM Peak	Midday	PM Reverse	Night	Weekend
1. Alewife	46	4	11	7	3
2. Brookline	236	4	35	6	7
8. Carmenton	653	4	184	47	24
11. Dogville	410	41	166	35	56
18. East End	85	5	64	4	4
24. Framington	30	3	74	3	1
26. Grand Junction	72	13	23	5	6
30. High Point	158	20	187	25	12
36. Irvingtown	34	2	25	1	15
39. Johnsville	5	1	1	.	.
40. King Street	17	1	2	.	1
44. Limerick	28	.	9	1	3
47. Moscow City	94	31	49	7	13
49. Ninth Street	.	.	9	.	.
50. Ontario Lake	13	1	4	1	1
53. Picadilly Square	23	4	35	7	5
55. Queens Zoo	10	1	14	.	2
60. Redline Circle	13	.	5	.	.
62. Silver Spring	106	18	38	12	17
68. Toledo Town	149	6	33	11	3

```
. table alight_id daypart , c(freq) cellwidth(10) mi
```

alight_id	daypart				
	AM Peak	Midday	PM Reverse	Night	Weekend
2. Brookline	1	.	.	.	.
8. Carmenton	11	1	1	.	1
11. Dogville	85	1	14	6	5
18. East End	36	1	18	1	4
24. Framington	15	1	2	2	2
26. Grand Junction	15	2	8	1	1
30. High Point	73	4	22	11	8
36. Irvingtown	9	.	4	2	2
39. Johnsville	3	.	1	.	.
40. King Street	.	.	3	.	.
44. Limerick	13	.	2	.	2
47. Moscow City	81	6	22	6	6
49. Ninth Street	3	1	1	.	.
50. Ontario Lake	2	.	1	2	1
53. Picadilly Square	23	1	8	3	2
55. Queens Zoo	6	.	5	1	.
60. Redline Circle	5	.	.	.	.
62. Silver Spring	49	.	19	3	9
68. Toledo Town	43	3	24	6	7
69. Union Station	1,709	138	813	128	123



```

    replace dpston1 = 2023940 if inlist(dpston1, 2000039, 2000040)
Pass 1 through the data...
    smallest count = 1 in the cell      2000050
    Invoking rule 50:53=25053
    replace dpston1 = 2025053 if inlist(dpston1, 2000050, 2000053)
Pass 2 through the data...
    smallest count = 1 in the cell      2000055
    Invoking rule 55:25053=35055
    replace dpston1 = 2035055 if inlist(dpston1, 2000055, 2025053)
Pass 3 through the data...
    smallest count = 1 in the cell      3000039
    Invoking rule 39:40=23940
    replace dpston1 = 3023940 if inlist(dpston1, 3000039, 3000040)
    (output omitted)
Pass 35 through the data...
    smallest count = 11 in the cell      5031826
    Invoking rule 30:31826=41830
    replace dpston1 = 5041830 if inlist(dpston1, 5000030, 5031826)
Pass 36 through the data...
    smallest count = 12 in the cell      2065068
    WARNING: could not find any rules to collapse dpston1 == 2065068
Pass 37 through the data...
    smallest count = 12 in the cell      3033944
    Invoking rule 26:23036:33944=62644
    replace dpston1 = 3062644 if inlist(dpston1, 3000026, 3023036, 3033944)
    (output omitted)
Pass 38 through the data...
    smallest count = 13 in the cell      1000050
    Invoking rule 50:53=25053
    replace dpston1 = 1025053 if inlist(dpston1, 1000050, 1000053)
    (output omitted)
Pass 43 through the data...
    smallest count = 14 in the cell      3000055
    Invoking rule 53:55=25355
    replace dpston1 = 3025355 if inlist(dpston1, 3000053, 3000055)
Pass 44 through the data...
    smallest count = 15 in the cell      5104068
    WARNING: could not find any rules to collapse dpston1 == 5104068
Pass 45 through the data...
    smallest count = 17 in the cell      5000062
    Invoking rule 11:18:24:26:30:36:39:40:44:47:49:50:53:55:60:62=161162
    replace dpston1 = 5161162 if inlist(dpston1, 5000011, 5000018, 5000024, 5000026, 5
> 000030, 5000036, 5000039, 5000040, 5000044, 5000047, 5000049, 5000050, 5000053, 50
> 00055, 5000060, 5000062)
Pass 46 through the data...
    smallest count = 18 in the cell      2000062
    Invoking rule 30:36:39:40:44:47:49:50:53:55:60:62=123062
    replace dpston1 = 2123062 if inlist(dpston1, 2000030, 2000036, 2000039, 2000040, 2
> 000044, 2000047, 2000049, 2000050, 2000053, 2000055, 2000060, 2000062)
Pass 47 through the data...
    smallest count = 18 in the cell      3054960
    Invoking rule 62:54960=64962
    replace dpston1 = 3064962 if inlist(dpston1, 3000062, 3054960)
Pass 48 through the data...
    smallest count = 22 in the cell      1023940
    Done collapsing! Exiting...

. return list
scalars:

```

```

r(arg_min_id) = 1023940
r(min) = 22

macros:
  r(cfailed) : "2065068,5104068"
  r(failed) : "2065068 5104068"

. wgtcellcollapse collapse, variables(daypart alight_id) mincellsize(20) ///
> generate(dpstoffs1) saving(dpstoffs1.do) replace run
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
  Invoking rule 2:8=20208
  replace dpstoffs1 = 1020208 if inlist(dpstoffs1, 1000002, 1000008)
Pass 1 through the data...
  smallest count = 1 in the cell      2000008
  Invoking rule 8:11=20811
  replace dpstoffs1 = 2020811 if inlist(dpstoffs1, 2000008, 2000011)
Pass 2 through the data...
  smallest count = 1 in the cell      2000018
  Invoking rule 18:24=21824
  replace dpstoffs1 = 2021824 if inlist(dpstoffs1, 2000018, 2000024)
  (output omitted)
Pass 37 through the data...
  smallest count = 7 in the cell      5000068
  Invoking rule 62:68=26268
  replace dpstoffs1 = 5026268 if inlist(dpstoffs1, 5000062, 5000068)
Pass 38 through the data...
  smallest count = 8 in the cell      2044753
  WARNING: could not find any rules to collapse dpstoffs1 == 2044753
Pass 39 through the data...
  smallest count = 8 in the cell      4053647
  Invoking rule 30:53647=63047
  replace dpstoffs1 = 4063047 if inlist(dpstoffs1, 4000030, 4053647)
  (output omitted)
Pass 44 through the data...
  smallest count = 10 in the cell     4041126
  Invoking rule 41126:63047=101147
  replace dpstoffs1 = 4101147 if inlist(dpstoffs1, 4041126, 4063047)
Pass 45 through the data...
  smallest count = 10 in the cell     4055368
  WARNING: could not find any rules to collapse dpstoffs1 == 4055368
Pass 46 through the data...
  smallest count = 12 in the cell     1020208
  Invoking rule 20208:21118:24=50224
  replace dpstoffs1 = 1050224 if inlist(dpstoffs1, 1020208, 1021118, 1000024)
  (output omitted)
Pass 52 through the data...
  smallest count = 15 in the cell     3044955
  Invoking rule 44955:60:62=64962
  replace dpstoffs1 = 3064962 if inlist(dpstoffs1, 3044955, 3000060, 3000062)
Pass 53 through the data...
  smallest count = 16 in the cell     5026268
  Invoking rule 69:26268=36269
  replace dpstoffs1 = 5036269 if inlist(dpstoffs1, 5000069, 5026268)
Pass 54 through the data...
  smallest count = 22 in the cell     3000047
  Done collapsing! Exiting...

. return list

scalars:

```

```

r(arg_min_id) = 3000047
r(min) = 22

macros:
r(cfailed) : "2044753,4055368"
r(failed) : "2044753 4055368"

```

The collapsed values of the variables `dpston` (DayPart-Station-ON) and `dpstoffs` (DayPart-Station-OFF) combine the values of the parent variables. The value of `dpston==1000001` indicates `daypart==1` and station ID 1. The value of `dpston==2023940`, the very first collapsed cell, indicates `daypart==2` and sequence of two stations from 39 to 40. The value of `dpston==3064960` indicates `daypart==3` and sequence of six stations from 49 to 60.

Note that `wgtcellcollapse` returns a list of the cells that it could not collapse in `r(failed)` macro (and a comma delimited list, in `f(cfailed)`). These returned values should be used in production code by making an `assert` (Gould 2003) that these macros are empty. While we know that some cell counts are less than 20, we will ignore the issue for the moment, as there are bigger concerns with the collapsed cells at the moment, as will become clear once we follow through with the workflow and attempt raking.

From the above run, `wgtcellcollapse` produced two files, one for each weighting margin, called `dpston.do` and `dpstoffs.do`. An interested reader is welcome to `list` them; they contain long sequences of `replace` commands to perform the cell collapsing. The point of creating these is that they can be run on the population data to create identical categories:

```

. use trip_population, clear
. run dpston1.do
. total num_pass , over(dpston1)
Total estimation      Number of obs   =      719
      1000001: dpston1 = 1000001
      1000002: dpston1 = 1000002
(output omitted)
      5104068: dpston1 = 5104068
      5161162: dpston1 = 5161162

```

	Over	Total	Std. Err.	[95% Conf. Interval]	
num_pass					
1000001		1423	967.7508	-476.9595	3322.959
1000002		7198	4895.91	-2414.011	16810.01
(output omitted)					
5104068		270	116.7702	40.74822	499.2518
5161162		1723	909.6551	-62.90172	3508.902

```

. matrix dpston1 = e(b)
. matrix coleq dpston1 = _one
. matrix rownames dpston1 = dpston1
. run dpstoffs1.do

```

(Continued on next page)



```
. total num_pass , over(dpstoffs1)
Total estimation      Number of obs   =      719
      1000011: dpstoffs1 = 1000011
      1000018: dpstoffs1 = 1000018
(output omitted)
      5000060: dpstoffs1 = 5000060
      5036269: dpstoffs1 = 5036269
      5140853: dpstoffs1 = 5140853
```

	Over	Total	Std. Err.	[95% Conf. Interval]	
num_pass					
	1000011	2475	1468.807	-408.6691	5358.669
	1000018	929	360.7303	220.7878	1637.212
(output omitted)					
	5000060	4	2	.0734531	7.926547
	5036269	2880	980.8909	954.2428	4805.757
	5140853	634	139.2172	360.6787	907.3213

```
. matrix dpstoffs1 = e(b)
. matrix coleq dpstoffs1 = _one
. matrix rownames dpstoffs1 = dpstoffs1
```

We can then go back to the sample data and try creating raked weights:

```
. use trip_sample, clear
. run dpston1
. run dpstoffs1
. gen byte _one = 1
. ipfraking [pw=_one], ctotal(dpston1 dpstoffs1) gen(raked_weight1)
categories of dpston1 do not match in the control dpston1 and in the data (nolab opt
> ion)
This is what dpston1 gives:
  _one:1000001 _one:1000002 _one:1000008 _one:1000011 _one:1000018 _one:1000024 _one
> :1000026 _one:1000030 _one:1000036 _one:1000044 _one:1000047 _one:1000049 _one:100
> 0062 _one:1000068 _one:1023940 _one:1025053 _one:1025560 _one:2000011 _one:2065068
> _one:2070126 _one:2110847 _one:2123062 _one:3000008 _one:3000011 _one:3000018 _on
> e:3000024 _one:3000030 _one:3000036 _one:3000047 _one:3000068 _one:3020102 _one:30
> 25355 _one:3062644 _one:3064962 _one:4030108 _one:4041830 _one:4084768 _one:413115
> 3 _one:5030108 _one:5041830 _one:5053647 _one:5104068 _one:5161162
This is what I found in data:
  _one:1000001 _one:1000002 _one:1000008 _one:1000011 _one:1000018 _one:1000024 _one
> :1000026 _one:1000030 _one:1000036 _one:1000044 _one:1000047 _one:1000062 _one:100
> 0068 _one:1023940 _one:1025053 _one:1025560 _one:2000011 _one:2065068 _one:2070126
> _one:2110847 _one:2123062 _one:3000008 _one:3000011 _one:3000018 _one:3000024 _on
> e:3000030 _one:3000036 _one:3000047 _one:3000068 _one:3020102 _one:3025355 _one:30
> 62644 _one:3064962 _one:4030108 _one:4041830 _one:4084768 _one:4131153 _one:503010
> 8 _one:5041830 _one:5053647 _one:5104068 _one:5161162
This is what dpston1 has that data don't:
  _one:1000049
This is what data have that dpston1 doesn't:
  <none>
r(111);
```

```
. ipfraking [pw=_one], ctotal(dpstoffs1 dpston1) gen(raked_weight1)
categories of dpstoffs1 do not match in the control dpstoffs1 and in the data (nolab o
> ption)
This is what dpstoffs1 gives:
  _one:1000011 _one:1000018 _one:1000030 _one:1000047 _one:1000068 _one:1000069 _one
> :1025355 _one:1043644 _one:1060226 _one:1064962 _one:2044753 _one:2190869 _one:300
> 0002 _one:3000047 _one:3000068 _one:3000069 _one:3050826 _one:3053044 _one:3064962
> _one:4000002 _one:4000008 _one:4000049 _one:4055368 _one:4075069 _one:4101147 _on
> e:5000055 _one:5000060 _one:5036269 _one:5140853
This is what I found in data:
  _one:1000011 _one:1000018 _one:1000030 _one:1000047 _one:1000068 _one:1000069 _one
> :1025355 _one:1043644 _one:1060226 _one:1064962 _one:2044753 _one:2190869 _one:300
> 0047 _one:3000068 _one:3000069 _one:3050826 _one:3053044 _one:3064962 _one:4055368
> _one:4075069 _one:4101147 _one:5036269 _one:5140853
This is what dpstoffs1 has that data don't:
  _one:3000002 _one:4000002 _one:4000008 _one:4000049 _one:5000055 _one:5000060
This is what data have that dpstoffs1 doesn't:
  <none>
r(111);
.
```

We see that raking failed, because survey nonresponse wiped out some of the smaller stations from the sample. (Note also the informative error message with diagnostics of missing categories produced by `ipfraking`. This is a functionality added since the first 2010 publication in *The Stata Journal*. The message lists the categories found in the data, in the control totals, and in the mismatch.) We should have suspected as much from the full output of the population control totals, where e.g. the line for `dpstoffs==5000060` showed only 4 alightings at station Redline Circle (60) on the weekends.

### The second pass of cell collapse and raking: `zeroes()` option

Having identified the issue, we can overcome it with `zeroes()` option of `wgtcellcollapse collapse` whose purpose is specifically to add missing categories. This option provides the list of stations that may have zero sample counts in a given daypart. For instance, notice that the sample registers only one alighting at Brookline (2) in AM Peak daypart, even though there are passengers exiting in other dayparts. All in all, `wgtcellcollapse` needs to be made aware of the zero sample boardings at Johnsville (39), King Street (40), Limerick (44), Ninth Street (49), Queens Zoo (55) and Redline Circle (60); as well as zero alightings at Brookline (2), Carmenton (8), Irvingtown (36), Johnsville (39), King Street (40), Limerick (44), Moscow City (47), Ninth Street (49), Ontario Lake (50), Queens Zoo (55), Redline Circle (60), and Silver Spring (62).

(Continued on next page)

```

. use trip_sample_rules, clear
. wgtcellcollapse collapse, variables(daypart board_id) mincellsize(20) ///
>     zeroes(39 40 44 49 55 60) ///
>     generate(dpston2) saving(dpston2.do) replace run
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
Processing zero cells...
    Invoking rule 49:50=24950 to collapse zero cells
    replace dpston2 = 1024950 if inlist(dpston2, 1000049, 1000050)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 40:44=24044 to collapse zero cells
    replace dpston2 = 2024044 if inlist(dpston2, 2000040, 2000044)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 49:50=24950 to collapse zero cells
    replace dpston2 = 2024950 if inlist(dpston2, 2000049, 2000050)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 55:60=25560 to collapse zero cells
    replace dpston2 = 2025560 if inlist(dpston2, 2000055, 2000060)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 36:39=23639 to collapse zero cells
    replace dpston2 = 4023639 if inlist(dpston2, 4000036, 4000039)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 40:44=24044 to collapse zero cells
    replace dpston2 = 4024044 if inlist(dpston2, 4000040, 4000044)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 49:50=24950 to collapse zero cells
    replace dpston2 = 4024950 if inlist(dpston2, 4000049, 4000050)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 53:55=25355 to collapse zero cells
    replace dpston2 = 4025355 if inlist(dpston2, 4000053, 4000055)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 24950:53:55:60=54960 to collapse zero cells
    replace dpston2 = 4054960 if inlist(dpston2, 4024950, 4000053, 4000055, 4000060)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 39:40=23940 to collapse zero cells
    replace dpston2 = 5023940 if inlist(dpston2, 5000039, 5000040)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 49:50=24950 to collapse zero cells
    replace dpston2 = 5024950 if inlist(dpston2, 5000049, 5000050)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 24950:25355:60=54960 to collapse zero cells
    replace dpston2 = 5054960 if inlist(dpston2, 5024950, 5025355, 5000060)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
Pass 12 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 39:24044=33944
    replace dpston2 = 2033944 if inlist(dpston2, 2000039, 2024044)

```

```

(output omitted)
Pass 44 through the data...
  smallest count = 10 in the cell      5020102
  Invoking rule 8:20102=30108
  replace dpston2 = 5030108 if inlist(dpston2, 5000008, 5020102)
Pass 45 through the data...
  smallest count = 10 in the cell      5055368
  WARNING: could not find any rules to collapse dpston2 == 5055368
Pass 46 through the data...
  smallest count = 11 in the cell      2100844
  Invoking rule 47:100844=110847
  replace dpston2 = 2110847 if inlist(dpston2, 2000047, 2100844)
(output omitted)
Pass 57 through the data...
  smallest count = 18 in the cell      3054960
  Invoking rule 62:54960=64962
  replace dpston2 = 3064962 if inlist(dpston2, 3000062, 3054960)
Pass 58 through the data...
  smallest count = 18 in the cell      4055368
  WARNING: could not find any rules to collapse dpston2 == 4055368
Pass 59 through the data...
  smallest count = 20 in the cell      2000030
  Done collapsing! Exiting...
. return list
scalars:
  r(arg_min_id) = 2000030
  r(min) = 20
macros:
  r(cfailed) : "5055368,4055368"
  r(failed) : "5055368 4055368"
. wgtcellcollapse collapse, variables(daypart alight_id) mincellsize(20) ///
>   zeroes(2 8 36 39 40 44 47 49 50 55 60 62) ///
>   generate(dpstoffs2) saving(dpstoffs2.do) replace run
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
Processing zero cells...
  Invoking rule 39:40=23940 to collapse zero cells
  replace dpstoffs2 = 1023940 if inlist(dpstoffs2, 1000039, 1000040)
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
  Invoking rule 2:8=20208 to collapse zero cells
  replace dpstoffs2 = 2020208 if inlist(dpstoffs2, 2000002, 2000008)
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
  Invoking rule 30:36=23036 to collapse zero cells
  replace dpstoffs2 = 2023036 if inlist(dpstoffs2, 2000030, 2000036)
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
  Invoking rule 26:30:36:39=42639 to collapse zero cells
  replace dpstoffs2 = 2042639 if inlist(dpstoffs2, 2000026, 2000030, 2000036, 2000039)
(output omitted)
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
  Invoking rule 24950:53:55:60=54960 to collapse zero cells
  replace dpstoffs2 = 5054960 if inlist(dpstoffs2, 5024950, 5000053, 5000055, 5000060)
Pass 0 through the data...

```



```

    smallest count = 1 in the cell      1000002
Pass 24 through the data...
    smallest count = 1 in the cell      1000002
    Invoking rule 2:8=20208
    replace dpstoffs2 = 1020208 if inlist(dpstoffs2, 1000002, 1000008)
    (output omitted)
Pass 50 through the data...
    smallest count = 3 in the cell      5022426
    Invoking rule 18:22426=31826
    replace dpstoffs2 = 5031826 if inlist(dpstoffs2, 5000018, 5022426)
Pass 51 through the data...
    smallest count = 4 in the cell      2023036
    WARNING: could not find any rules to collapse dpstoffs2 == 2023036
Pass 52 through the data...
    smallest count = 4 in the cell      2110244
    WARNING: could not find any rules to collapse dpstoffs2 == 2110244
Pass 53 through the data...
    smallest count = 4 in the cell      4031826
    Invoking rule 30211:31826=60226
    replace dpstoffs2 = 4060226 if inlist(dpstoffs2, 4030211, 4031826)
Pass 54 through the data...
    smallest count = 4 in the cell      5043644
    Invoking rule 43644:64760=103660
    replace dpstoffs2 = 5103660 if inlist(dpstoffs2, 5043644, 5064760)
Pass 55 through the data...
    smallest count = 5 in the cell      1000060
    Invoking rule 24950:25355:60=54960
    replace dpstoffs2 = 1054960 if inlist(dpstoffs2, 1024950, 1025355, 1000060)
Pass 56 through the data...
    smallest count = 5 in the cell      2074968
    Invoking rule 72647:74968=142668
    replace dpstoffs2 = 2142668 if inlist(dpstoffs2, 2072647, 2074968)
Pass 57 through the data...
    smallest count = 5 in the cell      3025560
    Invoking rule 34953:25560=54960
    replace dpstoffs2 = 3054960 if inlist(dpstoffs2, 3034953, 3025560)
Pass 58 through the data...
    smallest count = 6 in the cell      1000055
    Invoking rule 53:55=25355
    replace dpstoffs2 = 1025355 if inlist(dpstoffs2, 1000053, 1000055)
    (output omitted)
Pass 67 through the data...
    smallest count = 10 in the cell     4060226
    Invoking rule 30:60226=70230
    replace dpstoffs2 = 4070230 if inlist(dpstoffs2, 4000030, 4060226)
Pass 68 through the data...
    smallest count = 11 in the cell     5103660
    WARNING: could not find any rules to collapse dpstoffs2 == 5103660
Pass 69 through the data...
    smallest count = 12 in the cell     1020208
    Invoking rule 20208:21118:24=50224
    replace dpstoffs2 = 1050224 if inlist(dpstoffs2, 1020208, 1021118, 1000024)
    (output omitted)

```

(Continued on next page)

```

Pass 76 through the data...
  smallest count = 15 in the cell      3054960
  Invoking rule 62:54960=64962
  replace dpstoffs2 = 3064962 if inlist(dpstoffs2, 3000062, 3054960)
Pass 77 through the data...
  smallest count = 21 in the cell      4070230
  Done collapsing! Exiting...
. return list
scalars:
      r(arg_min_id) = 4070230
      r(min) = 21
macros:
      r(cfailed) : "2023036,2110244,5103660"
      r(failed) : "2023036 2110244 5103660"

```

We will continue to disregard the cell counts of insufficient size for the time being. Running the resulting do-files `dpston.do` and `dpstoffs.do` on the population data to create control totals, and providing these control totals to `ipfraking` program produces an apparently successful raking result:

```

. use trip_sample, clear
. run dpston2
. run dpstoffs2
. gen byte _one = 1
. ipfraking [pw=_one], ctotals(dpston2 dpstoffs2) gen(raked_weight2)
Iteration 1, max rel difference of raked weights = 36.208881
Iteration 2, max rel difference of raked weights = .05484732
Iteration 3, max rel difference of raked weights = .0055794
Iteration 4, max rel difference of raked weights = .00053851
Iteration 5, max rel difference of raked weights = .00005171
Iteration 6, max rel difference of raked weights = 4.962e-06
Iteration 7, max rel difference of raked weights = 4.762e-07
The worst relative discrepancy of 3.9e-08 is observed for dpstoffs2 == 5180262
Target value = 483; achieved value = 483
Summary of the weight changes

```

	Mean	Std. dev.	Min	Max	CV
Orig weights	1	0	1	1	0
Raked weights	26.487	5.9013	8.1096	37.001	.2228
Adjust factor	26.4869		8.1096	37.0014	

```

. whatsdeff raked_weight2

```

Group	Min	Mean	Max	CV	DEFF	N	N eff
Overall	8.11	26.49	37.00	0.2228	1.0496	3654	3481.24

Note the use of utility program `whatsdeff` to compute the design effect due to unequal weighting; see section 2.3. The problem of zero cells appeared to have been solved: each and every population combination of daypart and station is properly reflected in control total categories, and there are

The weighting cells, however, are still not without problems. Consider this cross-

tab of original and collapsed stations (the first part of the *if* expression identifies the daypart, AM Peak; the second part identifies collapsed stations, given the nomenclature of `dpstoffs` variable described on page 4.7 as the concatenation of the first variable of the interaction, `daypart`; the length of the collapsed sequence, and its starting and end points; station numbers take up to two characters, and hence the collapsed values would use categories of `alight_id` like 20102, and mod by  $100 \times 100$  would be greater than the maximum two-digit number, 99).

```
. tab alight_id dpstoffs2 if daypart == 1 & mod(dpstoffs2,100*100)>99
```

alight_id	Long ID of the interaction				Total
	1025355	1043644	1060226	1064962	
2. Brookline	0	0	1	0	1
8. Carmenton	0	0	11	0	11
24. Framington	0	0	15	0	15
26. Grand Junction	0	0	15	0	15
36. Irvingtown	0	9	0	0	9
39. Johnsville	0	3	0	0	3
44. Limerick	0	13	0	0	13
49. Ninth Street	0	0	0	3	3
50. Ontario Lake	0	0	0	2	2
53. Picadilly Square	23	0	0	0	23
55. Queens Zoo	6	0	0	0	6
60. Redline Circle	0	0	0	5	5
62. Silver Spring	0	0	0	49	49
Total	29	25	42	59	155

To human eye, it is obvious that Picadilly Square (53) and Queens Zoo (55) should have been a part of the six-station sequence 1064962 spanning from Ninth Street (49) to Silver Spring (62). Instead, `wgtcellcollapse` decided to separate these two stations out into their own cell. How did that happen? The logic of `wgtcellcollapse` is to collapse categories in such a way as to produce the result with the smallest possible count. Thus, within AM Peak daypart, the sequence of collapsing steps was as follows.

**Pass 0** The zero cells were collapsed first: Johnsville (39) and King Street (40) resulting in an intermediate cell of size 3.

**Pass 24** The smallest cell of size 1 (Brookline (2)) was collapsed with its neighbor (Carmenton (8)) resulting in an intermediate cell of size 12.

**Pass 38** The smallest cell of size 2 (Ontario Lake (50)) was collapsed with its neighbor (Ninth Street (49)) resulting in an intermediate cell of size 5.

**Pass 47** The smallest cell of size 3, collapsed Johnsville (39) and King Street (40), was further collapsed with its neighbor Irvingtown (36) resulting in an intermediate cell of size .

**Pass 55** The smallest cell of size 5, Redline Circle (60), was collapsed by a three-way rule with a duo Picadilly Square (53) + Queens Zoo (55), which actually was empty, and a small cell Ontario Lake (50) + Ninth Street (49), resulting in an intermediate cell of size 10.

Let us look at that last step in more detail. At this stage, Redline Circle (60) with 5 exiting passengers in the sample could be collapsed with:

1. Silver Spring (62), to form a cell of size 54;
2. Queens Zoo (55), to form a cell of size 11;
3. a sequence of Picadilly Square (53) and Queens Zoo (55), to form a cell of size 34;
4. ...and a number of other options

However, at pass 55, `wgtcellcollapse` picked the rule 24950:25355:60=54960 which, at the time it was processed, had a count of 5 in the cell 24950, a count of zero in the cell 25355, and a count of 5 in the original station Redline Circle (60). (Note that the cell 25355 would actually form later at pass 58.) The problem lies with the zero count of the ghost of the cell 25355.

To overcome this problem, `wgtcellcollapse` have a `strict` option that only allows the rules that have a non-zero count in every component of the rule (so the problematic rule 24950:25355:60=54960 would not be a legal one under that restriction). As is easily seen, this option directly contradicts the `zeroes()` option, and that necessitates separate runs.

### **The third pass of cell collapse and raking: `strict` and `feed` options**

We will separate the two runs of `wgtcellcollapse` into a run that only deals with zeroes, and another run that deals with everything else. To prevent `wgtcellcollapse` from any further merges, `mincellsize(1)` can be specified in the first run. As the relevant variables will have already been created by the first run, the option to pass the variable name to be further modified is `feed()`. To make sure that the relevant variable exists in the data set, the option `run` instructs `wgtcellcollapse` to run the do-file it just created, thus creating or modifying the collapsed cell variable. Finally, instead of specifying `replace` to overwrite the do-files that `wgtcellcollapse` creates, we need to specify `append` to keep adding to these files.

```
. use trip_sample_rules, clear
. wgtcellcollapse collapse, variables(daypart board_id) mincellsize(1) ///
>     zeroes(39 40 44 49 55 60) ///
>     generate(dpston3) saving(dpston3.do) replace run
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
Processing zero cells...
    Invoking rule 49:50=24950 to collapse zero cells
    replace dpston3 = 1024950 if inlist(dpston3, 1000049, 1000050)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 40:44=24044 to collapse zero cells
    replace dpston3 = 2024044 if inlist(dpston3, 2000040, 2000044)
(output omitted)
```

```

Pass 0 through the data...
  smallest count = 1 in the cell      2000039
  Invoking rule 24950:25355:60=54960 to collapse zero cells
  replace dpston3 = 5054960 if inlist(dpston3, 5024950, 5025355, 5000060)
Pass 0 through the data...
  smallest count = 1 in the cell      2000039
Pass 12 through the data...
  smallest count = 1 in the cell      2000039
  Done collapsing! Exiting...
. wgtcellcollapse collapse, variables(daypart board_id) mincellsize(20) ///
>      strict feed(dpston3) saving(dpston3.do) append run
Pass 12 through the data...
  smallest count = 1 in the cell      2000039
  Invoking rule 39:24044=33944
  replace dpston3 = 2033944 if inlist(dpston3, 2000039, 2024044)
(output omitted)
Pass 40 through the data...
  smallest count = 6 in the cell      4000002
  Invoking rule 1:2=20102
  replace dpston3 = 4020102 if inlist(dpston3, 4000001, 4000002)
Pass 41 through the data...
  smallest count = 7 in the cell      4025355
  WARNING: could not find any rules to collapse dpston3 == 4025355
Pass 42 through the data...
  smallest count = 7 in the cell      5025355
  WARNING: could not find any rules to collapse dpston3 == 5025355
Pass 43 through the data...
  smallest count = 8 in the cell      2021824
  Invoking rule 26:21824=31826
  replace dpston3 = 2031826 if inlist(dpston3, 2000026, 2021824)
(output omitted)
Pass 57 through the data...
  smallest count = 19 in the cell     3025560
  Invoking rule 62:25560=35562
  replace dpston3 = 3035562 if inlist(dpston3, 3000062, 3025560)
Pass 58 through the data...
  smallest count = 20 in the cell     5026268
  Done collapsing! Exiting...
. wgtcellcollapse collapse, variables(daypart alight_id) mincellsize(1) ///
>      zeroes(2 8 36 39 40 44 47 49 50 55 60 62) ///
>      generate(dpstoffs3) saving(dpstoffs3.do) replace run
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
Processing zero cells...
  Invoking rule 39:40=23940 to collapse zero cells
  replace dpstoffs3 = 1023940 if inlist(dpstoffs3, 1000039, 1000040)
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
  Invoking rule 2:8=20208 to collapse zero cells
  replace dpstoffs3 = 2020208 if inlist(dpstoffs3, 2000002, 2000008)
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
  Invoking rule 30:36=23036 to collapse zero cells
  replace dpstoffs3 = 2023036 if inlist(dpstoffs3, 2000030, 2000036)
Pass 0 through the data...
  smallest count = 1 in the cell      1000002

```

```

    Invoking rule 26:30:36:39=42639 to collapse zero cells
    replace dpstoffs3 = 2042639 if inlist(dpstoffs3, 2000026, 2000030, 2000036, 2000039)
Pass 0 through the data...
    smallest count = 1 in the cell      1000002
    Invoking rule 24:26:30:36:39:40=62440 to collapse zero cells
    replace dpstoffs3 = 2062440 if inlist(dpstoffs3, 2000024, 2000026, 2000030, 2000036,
> 2000039, 2000040)
Pass 0 through the data...
    smallest count = 1 in the cell      1000002
    Invoking rule 44:62440=72444 to collapse zero cells
    replace dpstoffs3 = 2072444 if inlist(dpstoffs3, 2000044, 2062440)
(output omitted)
Pass 0 through the data...
    smallest count = 1 in the cell      1000002
    Invoking rule 24950:53:55:60=54960 to collapse zero cells
    replace dpstoffs3 = 5054960 if inlist(dpstoffs3, 5024950, 5000053, 5000055, 5000060)
Pass 0 through the data...
    smallest count = 1 in the cell      1000002
Pass 24 through the data...
    smallest count = 1 in the cell      1000002
    Done collapsing! Exiting...

. wgtcellcollapse collapse, variables(daypart alight_id) mincellsize(20) ///
>      strict feed(dpstoffs3) saving(dpstoffs3.do) append run
Pass 24 through the data...
    smallest count = 1 in the cell      1000002
    Invoking rule 2:8=20208
    replace dpstoffs3 = 1020208 if inlist(dpstoffs3, 1000002, 1000008)
Pass 25 through the data...
    smallest count = 1 in the cell      2000011
    Invoking rule 11:18=21118
    replace dpstoffs3 = 2021118 if inlist(dpstoffs3, 2000011, 2000018)
(output omitted)
Pass 46 through the data...
    smallest count = 2 in the cell      5023639
    Invoking rule 23639:24044=43644
    replace dpstoffs3 = 5043644 if inlist(dpstoffs3, 5023639, 5024044)
Pass 47 through the data...
    smallest count = 2 in the cell      5025355
    WARNING: could not find any rules to collapse dpstoffs3 == 5025355
(output omitted)
Pass 51 through the data...
    smallest count = 4 in the cell      2023036
    WARNING: could not find any rules to collapse dpstoffs3 == 2023036
Pass 52 through the data...
    smallest count = 4 in the cell      2110244
    Invoking rule 47:110244=120247
    replace dpstoffs3 = 2120247 if inlist(dpstoffs3, 2000047, 2110244)
(output omitted)
Pass 76 through the data...
    smallest count = 16 in the cell     5026268
    Invoking rule 170260:26268=190268
    replace dpstoffs3 = 5190268 if inlist(dpstoffs3, 5170260, 5026268)
Pass 77 through the data...
    smallest count = 21 in the cell     4070230
    Done collapsing! Exiting...

```

The result still isn't satisfactory, as some collapsed cells still overlap:

```
. tab alight_id dpstoffs3 if daypart == 2 & mod(dpstoffs3,100*100)>99
```

alight_id	Long ID of the interaction			Total
	2023036	2042639	2200269	
8. Carmenton	0	0	1	1
11. Dogville	0	0	1	1
18. East End	0	0	1	1
24. Framington	0	0	1	1
26. Grand Junction	0	2	0	2
30. High Point	4	0	0	4
47. Moscow City	0	0	6	6
49. Ninth Street	0	0	1	1
53. Picadilly Square	0	0	1	1
68. Toledo Town	0	0	3	3
69. Union Station	0	0	138	138
Total	4	2	153	159

This overlap can be traced back to the collapsing of zero cells: first, the cell 2023036 came to being by a reasonable, at its face, collapsing of the zero cell Irvingtown (36) with non-zero cell High Point (30); and then the cell 2042639 came to being by a long overreach for the zero cell Johnsville (39) to be collapsed with a non-zero cell Grand Junction (26).

#### The fourth pass of cell collapse and raking: `greedy` and `maxcat()` options

The next improvement I am going to demonstrate is to fix the problem of weak performance in collapsing the zero cells with an additional option `greedy`. It modifies behavior of `wgtcellcollapse` to require that, among the possible candidate rules with the lowest count, the rule with the *greatest* number of components is preferred. That way, the long streaks of zeroes from Irvingtown (36) to Limerick (44) in midday part could be collapsed simultaneously into one cell. To support this option, and avoid complex collapses of zero cells with the already defined cells, option `maxcategory()` specifies the greatest value of a component of a rule. By specifying `maxcategory(99)`, we can instruct `wgtcellcollapse` to only use rules that deal with individual stations (that have category numbers from 1 to 69, and thus are below 99), and do not use the rules that involve collapsed cells (which would have numbers of at least 20102 for the collapsed cell Alewife (1) and Brookline (2)). In the first run, those collapsed cells will always be empty ghosts, and they should not be used in defining how the cells be collapsed.

Note also that with the `greedy` option, one would want to specify the zeroes somewhere in the middle of the streak, and possibly across multiple categories of the interacting variable. In our example, specifying `(zeroes(36))` would collapse the midday streak of zero counts, but the need to collapse the zeroes in the night and the weekend dayparts would still remain, necessitating something like `zeroes(40)` — which, in turn, will likely create overlapping artifacts in the midday section. However, specifying `zeroes(40)` without `(zeroes(36))` would take care of all the streaks observed in Table 1.

```

. use trip_sample_rules, clear
. wgtcellcollapse collapse, variables(daypart board_id) mincellsize(1) ///
>     zeroes(39 44 49 60) greedy maxcategory(99) ///
>     generate(dpston4) saving(dpston4.do) replace run
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
Processing zero cells...
    Invoking rule 49:50=24950 to collapse zero cells
    replace dpston4 = 1024950 if inlist(dpston4, 1000049, 1000050)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 40:44=24044 to collapse zero cells
    replace dpston4 = 2024044 if inlist(dpston4, 2000040, 2000044)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 49:50=24950 to collapse zero cells
    replace dpston4 = 2024950 if inlist(dpston4, 2000049, 2000050)
    (output omitted)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 55:60=25560 to collapse zero cells
    replace dpston4 = 5025560 if inlist(dpston4, 5000055, 5000060)
Pass 0 through the data...
    smallest count = 1 in the cell      2000039
Pass 10 through the data...
    smallest count = 1 in the cell      2000039
    Done collapsing! Exiting...

. wgtcellcollapse collapse, variables(daypart board_id) mincellsize(20) ///
>     strict feed(dpston4) saving(dpston4.do) append run
Pass 10 through the data...
    smallest count = 1 in the cell      2000039
    Invoking rule 39:24044=33944
    replace dpston4 = 2033944 if inlist(dpston4, 2000039, 2024044)
Pass 11 through the data...
    smallest count = 1 in the cell      2024950
    Invoking rule 53:24950=34953
    replace dpston4 = 2034953 if inlist(dpston4, 2000053, 2024950)
Pass 12 through the data...
    smallest count = 1 in the cell      2025560
    Invoking rule 34953:25560=54960
    replace dpston4 = 2054960 if inlist(dpston4, 2034953, 2025560)
Pass 13 through the data...
    smallest count = 1 in the cell      3000039
    Invoking rule 39:40=23940
    replace dpston4 = 3023940 if inlist(dpston4, 3000039, 3000040)
    (output omitted)
Pass 55 through the data...
    smallest count = 19 in the cell      3025560
    Invoking rule 62:25560=35562
    replace dpston4 = 3035562 if inlist(dpston4, 3000062, 3025560)
Pass 56 through the data...
    smallest count = 20 in the cell      5026268
    Done collapsing! Exiting...

. assert "`r(failed)'" == ""

```

(Continued on next page)



```

. wgtcellcollapse collapse, variables(daypart alight_id) mincellsize(1) ///
>     zeroes(2 40 49 50 60) greedy maxcategory(99) ///
>     generate(dpstoffs4) saving(dpstoffs4.do) replace run
Pass 0 through the data...
    smallest count = 1 in the cell      1000002
Processing zero cells...
    Invoking rule 39:40=23940 to collapse zero cells
    replace dpstoffs4 = 1023940 if inlist(dpstoffs4, 1000039, 1000040)
Pass 0 through the data...
    smallest count = 1 in the cell      1000002
    Invoking rule 1:2:8=30108 to collapse zero cells
    replace dpstoffs4 = 2030108 if inlist(dpstoffs4, 2000001, 2000002, 2000008)
    (output omitted)
Pass 0 through the data...
    smallest count = 1 in the cell      1000002
    Invoking rule 49:50=24950 to collapse zero cells
    replace dpstoffs4 = 5024950 if inlist(dpstoffs4, 5000049, 5000050)
Pass 0 through the data...
    smallest count = 1 in the cell      1000002
    Invoking rule 49:50:53:55:60=54960 to collapse zero cells
    replace dpstoffs4 = 5054960 if inlist(dpstoffs4, 5000049, 5000050, 5000053, 5000055,
> 5000060)
Pass 0 through the data...
    smallest count = 1 in the cell      1000002
Pass 14 through the data...
    smallest count = 1 in the cell      1000002
    Done collapsing! Exiting...
. wgtcellcollapse collapse, variables(daypart alight_id) mincellsize(20) ///
>     strict feed(dpstoffs4) saving(dpstoffs4.do) append run
Pass 14 through the data...
    smallest count = 1 in the cell      1000002
    Invoking rule 2:8=20208
    replace dpstoffs4 = 1020208 if inlist(dpstoffs4, 1000002, 1000008)
Pass 15 through the data...
    smallest count = 1 in the cell      2000011
    Invoking rule 11:18=21118
    replace dpstoffs4 = 2021118 if inlist(dpstoffs4, 2000011, 2000018)
Pass 16 through the data...
    smallest count = 1 in the cell      2000024
    Invoking rule 24:26=22426
    replace dpstoffs4 = 2022426 if inlist(dpstoffs4, 2000024, 2000026)
    (output omitted)
Pass 65 through the data...
    smallest count = 18 in the cell      5074968
    Invoking rule 69:74968=84969
    replace dpstoffs4 = 5084969 if inlist(dpstoffs4, 5000069, 5074968)
Pass 66 through the data...
    smallest count = 21 in the cell      2200168
    Done collapsing! Exiting...
. assert "`r(failed)'" == ""

```

We have finally been able to produce a clean collapse of everything! Note the use of `assert "`r(failed)'" == ""` in the above code snippet to make sure that all cells have the minimal required size of 20.

As a very minor point, we can see some room for improvement in collapsing the cells on the weekend:

```
. tab alight_id dpstoffs4 if daypart == 5 & mod(dpstoffs4,100*100)>99
```

alight_id	Long ID of the interaction		Total
	5084969	5150150	
8. Carmenton	0	1	1
11. Dogville	0	5	5
18. East End	0	4	4
24. Framington	0	2	2
26. Grand Junction	0	1	1
30. High Point	0	8	8
36. Irvingtown	0	2	2
44. Limerick	0	2	2
47. Moscow City	0	6	6
50. Ontario Lake	0	1	1
53. Picadilly Square	2	0	2
62. Silver Spring	9	0	9
68. Toledo Town	7	0	7
69. Union Station	123	0	123
Total	141	32	173

Instead of two cells with sizes 141 and 32, it seems like we could produce three cells, with Union Station (69) being its own cell, and everything else split somewhere in the middle.

### The fifth pass of cell collapse and raking: *if* conditions

We will now code the collapsing cells for that day part “by hand”, and we will put those custom coded cells upfront before the main run. (Some special treatment had to be given to the zero cells to avoid overlapping cells around Ninth Street (49) for the night and weekend day parts; without the separation, it is getting collapsed in a long overreach all the way up to Redline Circle (60).)

```
. use trip_sample_rules, clear
. wgtcellcollapse collapse, variables(daypart board_id) mincellsize(1) ///
>     zeroes(39 44 49 60) greedy maxcategory(99) ///
>     generate(dpston5) saving(dpston5.do) replace run
Pass 0 through the data...
  smallest count = 1 in the cell      2000039
Processing zero cells...
  Invoking rule 49:50=24950 to collapse zero cells
  replace dpston5 = 1024950 if inlist(dpston5, 1000049, 1000050)
Pass 0 through the data...
  smallest count = 1 in the cell      2000039
  Invoking rule 40:44=24044 to collapse zero cells
  replace dpston5 = 2024044 if inlist(dpston5, 2000040, 2000044)
Pass 0 through the data...
  smallest count = 1 in the cell      2000039
  Invoking rule 49:50=24950 to collapse zero cells
  replace dpston5 = 2024950 if inlist(dpston5, 2000049, 2000050)
```

```

(output omitted)
Pass 0 through the data...
  smallest count = 1 in the cell      2000039
  Invoking rule 55:60=25560 to collapse zero cells
  replace dpston5 = 5025560 if inlist(dpston5, 5000055, 5000060)
Pass 0 through the data...
  smallest count = 1 in the cell      2000039
Pass 10 through the data...
  smallest count = 1 in the cell      2000039
  Done collapsing! Exiting...

. wgtcellcollapse collapse, variables(daypart board_id) mincellsize(20) ///
>      strict feed(dpston5) saving(dpston5.do) append run
Pass 10 through the data...
  smallest count = 1 in the cell      2000039
  Invoking rule 39:24044=33944
  replace dpston5 = 2033944 if inlist(dpston5, 2000039, 2024044)
Pass 11 through the data...
  smallest count = 1 in the cell      2024950
  Invoking rule 53:24950=34953
  replace dpston5 = 2034953 if inlist(dpston5, 2000053, 2024950)
(output omitted)
Pass 55 through the data...
  smallest count = 19 in the cell      3025560
  Invoking rule 62:25560=35562
  replace dpston5 = 3035562 if inlist(dpston5, 3000062, 3025560)
Pass 56 through the data...
  smallest count = 20 in the cell      5026268
  Done collapsing! Exiting...

. assert "`r(failed)'" == ""

. wgtcellcollapse collapse, variables(daypart alight_id) mincellsize(1) ///
>      zeroes(2 40 60) greedy maxcategory(99) ///
>      generate(dpstoffs) saving(dpstoffs.do) replace run
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
Processing zero cells...
  Invoking rule 39:40=23940 to collapse zero cells
  replace dpstoffs = 1023940 if inlist(dpstoffs, 1000039, 1000040)
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
  Invoking rule 1:2:8=30108 to collapse zero cells
  replace dpstoffs = 2030108 if inlist(dpstoffs, 2000001, 2000002, 2000008)
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
  Invoking rule 30:36:39:40:44=53044 to collapse zero cells
  replace dpstoffs = 2053044 if inlist(dpstoffs, 2000030, 2000036, 2000039, 2000040,
> 2000044)
(output omitted)
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
  Invoking rule 53:55:60=35360 to collapse zero cells
  replace dpstoffs = 5035360 if inlist(dpstoffs, 5000053, 5000055, 5000060)
Pass 0 through the data...
  smallest count = 1 in the cell      1000002
Pass 12 through the data...
  smallest count = 1 in the cell      1000002
  Done collapsing! Exiting...

```

```

. wgtcellcollapse collapse if inlist(daypart,4,5) & inrange(alight_id,49,50), ///
>     variables(daypart alight_id) mincellsize(1) ///
>     feed(dpstoffs) zeroes(49) maxcategory(99) saving(dpstoffs.do) append run
Pass 12 through the data...
    smallest count = 1 in the cell      1000002
Processing zero cells...
    Invoking rule 49:50=24950 to collapse zero cells
    replace dpstoffs = 4024950 if inlist(dpstoffs, 4000049, 4000050)
Pass 12 through the data...
    smallest count = 1 in the cell      1000002
    Invoking rule 49:50=24950 to collapse zero cells
    replace dpstoffs = 5024950 if inlist(dpstoffs, 5000049, 5000050)
Pass 12 through the data...
    smallest count = 1 in the cell      1000002
Pass 14 through the data...
    smallest count = 1 in the cell      5024950
    Done collapsing! Exiting...

. * special cells for weekend
. wgtcellcollapse collapse if daypart==5 & inrange(alight_id,1,36), ///
>     variables(daypart alight_id) mincellsize(50) ///
>     strict feed(dpstoffs) saving(dpstoffs.do) append run
Pass 14 through the data...
    smallest count = 1 in the cell      5000026
    Invoking rule 24:26=22426
    replace dpstoffs = 5022426 if inlist(dpstoffs, 5000024, 5000026)
Pass 15 through the data...
    smallest count = 1 in the cell      5030108
    Invoking rule 11:30108=40111
    replace dpstoffs = 5040111 if inlist(dpstoffs, 5000011, 5030108)
Pass 16 through the data...
    smallest count = 2 in the cell      5033640
    Invoking rule 30:33640=43040
    replace dpstoffs = 5043040 if inlist(dpstoffs, 5000030, 5033640)
Pass 17 through the data...
    smallest count = 3 in the cell      5022426
    Invoking rule 18:22426=31826
    replace dpstoffs = 5031826 if inlist(dpstoffs, 5000018, 5022426)
Pass 18 through the data...
    smallest count = 6 in the cell      5040111
    Invoking rule 40111:31826=70126
    replace dpstoffs = 5070126 if inlist(dpstoffs, 5040111, 5031826)
Pass 19 through the data...
    smallest count = 10 in the cell     5043040
    Invoking rule 70126:43040=110140
    replace dpstoffs = 5110140 if inlist(dpstoffs, 5070126, 5043040)
Pass 20 through the data...
    smallest count = 23 in the cell     5110140
    WARNING: could not find any rules to collapse dpstoffs == 5110140
Pass 21 through the data...
    smallest count = .i in the cell     1000002
    Done collapsing! Exiting...

```

*(Continued on next page)*

```

. wgtcellcollapse collapse if daypart==5 & inrange(alight_id,44,68), ///
>     variables(daypart alight_id) mincellsize(50) ///
>     strict feed(dpstoffs5) saving(dpstoffs5.do) append run
Pass 20 through the data...
  smallest count = 1 in the cell      5024950
  Invoking rule 24950:35360=54960
  replace dpstoffs5 = 5054960 if inlist(dpstoffs5, 5024950, 5035360)
Pass 21 through the data...
  smallest count = 2 in the cell      5000044
  Invoking rule 44:47=24447
  replace dpstoffs5 = 5024447 if inlist(dpstoffs5, 5000044, 5000047)
Pass 22 through the data...
  smallest count = 3 in the cell      5054960
  Invoking rule 24447:54960=74460
  replace dpstoffs5 = 5074460 if inlist(dpstoffs5, 5024447, 5054960)
Pass 23 through the data...
  smallest count = 7 in the cell      5000068
  Invoking rule 62:68=26268
  replace dpstoffs5 = 5026268 if inlist(dpstoffs5, 5000062, 5000068)
Pass 24 through the data...
  smallest count = 11 in the cell     5074460
  Invoking rule 74460:26268=94468
  replace dpstoffs5 = 5094468 if inlist(dpstoffs5, 5074460, 5026268)
Pass 25 through the data...
  smallest count = 27 in the cell     5094468
  WARNING: could not find any rules to collapse dpstoffs5 == 5094468
Pass 26 through the data...
  smallest count = .i in the cell     1000002
  Done collapsing! Exiting...

. * all other cells
. wgtcellcollapse collapse, variables(daypart alight_id) mincellsize(20) ///
>     strict feed(dpstoffs5) saving(dpstoffs5.do) append run
Pass 25 through the data...
  smallest count = 1 in the cell     1000002
  Invoking rule 2:8=20208
  replace dpstoffs5 = 1020208 if inlist(dpstoffs5, 1000002, 1000008)
Pass 26 through the data...
  smallest count = 1 in the cell     2000011
  Invoking rule 11:18=21118
  replace dpstoffs5 = 2021118 if inlist(dpstoffs5, 2000011, 2000018)
  (output omitted)
Pass 64 through the data...
  smallest count = 15 in the cell     3054960
  Invoking rule 62:54960=64962
  replace dpstoffs5 = 3064962 if inlist(dpstoffs5, 3000062, 3054960)
Pass 65 through the data...
  smallest count = 21 in the cell     2200168
  Done collapsing! Exiting...

. assert "`r(failed)'" == ""

```

The special missing value `.i` that appears in the smallest count report is used internally to stop `wgtcellcollapse` after all of the relevant cases selected by the *if* conditions have been processed.

Checking on the last improvement, we see how the manual resolution succeeded:

```
. tab alight_id dpstoffs5 if daypart == 5
```

alight_id	Interactions of daypart			Total
	alight_id, with some collapsing			
	5000069	5094468	5110140	
8. Carmenton	0	0	1	1
11. Dogville	0	0	5	5
18. East End	0	0	4	4
24. Framington	0	0	2	2
26. Grand Junction	0	0	1	1
30. High Point	0	0	8	8
36. Irvingtown	0	0	2	2
44. Limerick	0	2	0	2
47. Moscow City	0	6	0	6
50. Ontario Lake	0	1	0	1
53. Picadilly Square	0	2	0	2
62. Silver Spring	0	9	0	9
68. Toledo Town	0	7	0	7
69. Union Station	123	0	0	123
Total	123	27	23	173

The resulting do-files can now be applied to producing control totals, and eventually to raking:

```
. use trip_population, clear
. run dpston5.do
. total num_pass , over(dpston5)
Total estimation      Number of obs   =      719
      1000001: dpston5 = 1000001
      1000002: dpston5 = 1000002
(output omitted)
      5000011: dpston5 = 5000011
      5026268: dpston5 = 5026268
      5030108: dpston5 = 5030108
      5051836: dpston5 = 5051836
      5093960: dpston5 = 5093960
```

Over	Total	Std. Err.	[95% Conf. Interval]	
num_pass				
1000001	1423	967.7508	-476.9595	3322.959
1000002	7198	4895.91	-2414.011	16810.01
(output omitted)				
5000011	1270	834.301	-367.961	2907.961
5026268	557	364.4324	-158.4805	1272.481
5030108	610	263.2061	93.25444	1126.746
5051836	622	215.5712	198.7749	1045.225
5093960	473	261.8954	-41.17225	987.1723

```
. matrix dpston5 = e(b)
. matrix coleq dpston5 = _one
. matrix rownames dpston5 = dpston5
. run dpstoffs5.do
```

```
. total num_pass , over(dpstoffs5)
Total estimation          Number of obs   =          719
      1000018: dpstoffs5 = 1000018
      1000030: dpstoffs5 = 1000030
(output omitted)
      5000069: dpstoffs5 = 5000069
      5094468: dpstoffs5 = 5094468
      5110140: dpstoffs5 = 5110140
```

	Over	Total	Std. Err.	[95% Conf. Interval]	
num_pass					
	1000018	929	360.7303	220.7878	1637.212
	1000030	2189	868.0319	484.8161	3893.184
(output omitted)					
	5000069	2677	895.7917	918.316	4435.684
	5094468	432	87.57763	260.0612	603.9388
	5110140	423	120.0254	187.3574	658.6426

```
. matrix dpstoffs5 = e(b)
. matrix coleq dpstoffs5 = _one
. matrix rownames dpstoffs5 = dpstoffs5
. use trip_sample_rules, clear
. run dpston5
. run dpstoffs5
. gen byte _one = 1
. ipfraking [pw=_one], ctotal(dpston5 dpstoffs5) gen(raked_weight5)
Iteration 1, max rel difference of raked weights = 37.856256
Iteration 2, max rel difference of raked weights = .06404821
Iteration 3, max rel difference of raked weights = .00891802
Iteration 4, max rel difference of raked weights = .00128619
Iteration 5, max rel difference of raked weights = .00018966
Iteration 6, max rel difference of raked weights = .00002818
Iteration 7, max rel difference of raked weights = 4.198e-06
Iteration 8, max rel difference of raked weights = 6.257e-07
The worst relative discrepancy of 7.8e-08 is observed for dpstoffs5 == 5110140
Target value =          423; achieved value =          423
```

Summary of the weight changes

	Mean	Std. dev.	Min	Max	CV
Orig weights	1	0	1	1	0
Raked weights	26.487	5.754	13.174	38.634	.2172
Adjust factor	26.4869		13.1743	38.6339	

```
. whatsdeff raked_weight5
```

Group	Min	Mean	Max	CV	DEFF	N	N eff
Overall	13.17	26.49	38.63	0.2172	1.0472	3654	3489.37

### Informative labels

As the final touch, let us consider the variety of labels that can be attached to the resulting collapsed cells.

```
. wgtcellcollapse label, var(dpston5)
(language default renamed unlabeled_ccells)
(language numbered_ccells now current language)
(language texted_ccells now current language)
To attach the numeric labels (of the kind "dpston5==1000001"), type:
  label language numbered_ccells
To attach the text labels (of the kind "dpston5==AM Peak; 1. Alewife"), type:
  label language texted_ccells
The original state, which is also the current state, is:
  label language unlabeled_ccells

. wgtcellcollapse label, var(dpstoffs5)
To attach the numeric labels (of the kind "dpstoffs5==1000018"), type:
  label language numbered_ccells
To attach the text labels (of the kind "dpstoffs5==AM Peak; 18. East End"), type:
  label language texted_ccells
The original state, which is also the current state, is:
  label language unlabeled_ccells

. label language numbered_ccells
. tab dpstoffs5 if daypart==5
```

Long ID of the interaction	Freq.	Percent	Cum.
daypart==5, alight_id==69	123	71.10	71.10
daypart==5, alight_id==94468	27	15.61	86.71
daypart==5, alight_id==110140	23	13.29	100.00
Total	173	100.00	

```
. label language texted_ccells
. tab dpstoffs5 if daypart==5
```

Long ID of the interaction	Freq.	Percent	Cum.
Weekend; 69. Union Station	123	71.10	71.10
Weekend; 44. Limerick to 68. Toledo Tow	27	15.61	86.71
Weekend; 1. Alewife to 40. King Street	23	13.29	100.00
Total	173	100.00	

```
. label language unlabeled_ccells
. tab dpstoffs5 if daypart==5
```

Interactions of daypart alight_id, with some collapsing	Freq.	Percent	Cum.
5000069	123	71.10	71.10
5094468	27	15.61	86.71
5110140	23	13.29	100.00
Total	173	100.00	



Using the mechanics of labels in multiple languages, `wgtcellcollapse` label defines three “languages” to describe the cells. The language `numbered_ccells` may be convenient for debugging purposes in fine-tuning the collapsing algorithms, while the language `texted_ccells` would prove useful for `ipfraking_report` in creating human-readable labels.

## 5 Linear calibrated weights

Using the existing example, let me demonstrate the linear calibration option of `ipfraking`.

```
. set rmsg on
r; t=0.00 14:59:22
. ipfraking [pw=_one], ctotal(dpston5 dpstoffs) nograph gen(raked_weight5)
Iteration 1, max rel difference of raked weights = 37.856256
Iteration 2, max rel difference of raked weights = .06404821
Iteration 3, max rel difference of raked weights = .00891802
Iteration 4, max rel difference of raked weights = .00128619
Iteration 5, max rel difference of raked weights = .00018966
Iteration 6, max rel difference of raked weights = .00002818
Iteration 7, max rel difference of raked weights = 4.198e-06
Iteration 8, max rel difference of raked weights = 6.257e-07
The worst relative discrepancy of 7.8e-08 is observed for dpstoffs == 5110140
Target value = 423; achieved value = 423
Summary of the weight changes
```

	Mean	Std. dev.	Min	Max	CV
Orig weights	1	0	1	1	0
Raked weights	26.487	5.754	13.174	38.634	.2172
Adjust factor	26.4869		13.1743	38.6339	

```
r; t=2.16 14:59:24
. ipfraking [pw=_one], ctotal(dpston5 dpstoffs) nograph gen(raked_weight5l) linear
Linear calibration
The worst relative discrepancy of 1.8e-14 is observed for dpstoffs == 5110140
Target value = 423; achieved value = 423
Summary of the weight changes
```

	Mean	Std. dev.	Min	Max	CV
Orig weights	1	0	1	1	0
Raked weights	26.487	5.7523	12.518	38.204	.2172
Adjust factor	26.4869		12.5178	38.2040	

```
r; t=0.63 14:59:25
. set rmsg off
. label variable raked_weight5l "Linear calibrated weights"
. compare raked_weight5 raked_weight5l
```

	count	minimum	difference average	maximum
raked_w-5<raked_-5l	1896	-1.813144	-.0476911	-3.11e-11
raked_w-5>raked_-5l	1758	2.18e-09	.0514348	2.405758
jointly defined	3654	-1.813144	3.21e-10	2.405758

total

3654

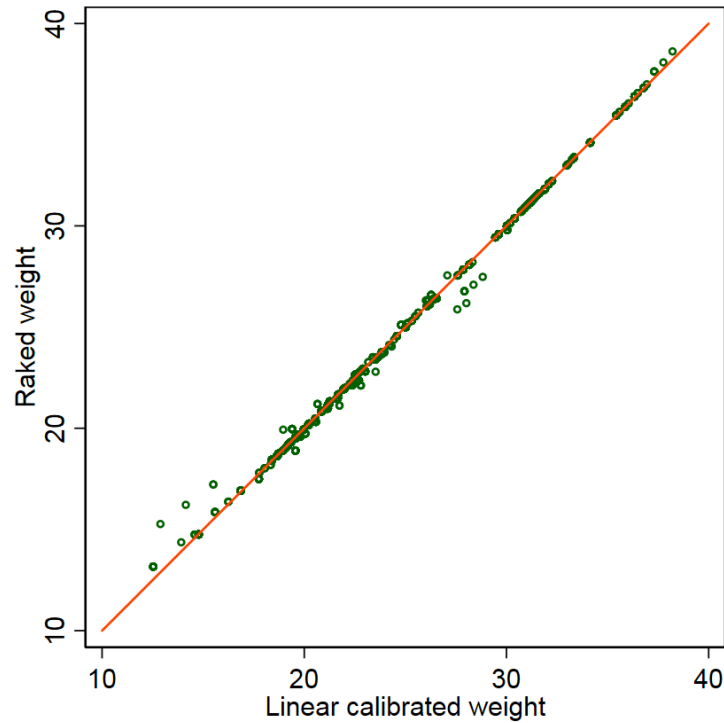


Figure 1: Linear and raked weights

The speed advantages of `linear` calibration are quite clear (0.63 seconds vs. 2.16 seconds), and raking convergence of raking in 8 iterations is lighting-fast, in author's experience; it is not unusual to see dozens and hundreds of iterations, especially when higher order interactions with many cells and subtle correlations between them are being used as raking margins. The weights are very similar to one another, with the lowest of the linearly calibrated weights being slightly smaller than comparable raked weights. As mentioned before, in the extreme situations, linearly calibrated weights may become negative.

## Acknowledgements

The author is grateful to Jason Brinkley and Tom Guterbock for bug reports and functionality suggestions. The opinions stated in this paper are of the author only, and do not represent the position of Abt Associates.

## 6 References

- AAPOR. 2014. *AAPOR Terms and Conditions for Transparency Certification*. The American Association for Public Opinion Research. Available at [http://www.aapor.org/AAPOR\\_Main/media/MainSiteFiles/TI-Terms-and-Conditions-10-4-17.pdf](http://www.aapor.org/AAPOR_Main/media/MainSiteFiles/TI-Terms-and-Conditions-10-4-17.pdf).
- Binder, D. A., and G. R. Roberts. 2003. Design-based and Model-based Methods for Estimating Model Parameters. In *Analysis of Survey Data*, ed. R. L. Chambers and C. J. Skinner, chap. 3. New York: John Wiley & Sons.
- Deville, J. C., and C. E. Särndal. 1992. Calibration Estimators in Survey Sampling. *Journal of the American Statistical Association* 87(418): 376–382.
- Deville, J. C., C. E. Särndal, and O. Sautory. 1993. Generalized Raking Procedures in Survey Sampling. *Journal of the American Statistical Association* 88(423): 1013–1020.
- Gould, W. 2003. Stata tip 3: How to be assertive. *Stata Journal* 3(4).
- Groves, R. M., D. A. Dillman, J. L. Eltinge, and R. J. A. Little. 2001. *Survey Nonresponse*. Wiley Series in Survey Methodology, Wiley-Interscience.
- Holt, D., and T. M. F. Smith. 1979. Post Stratification. *Journal of the Royal Statistical Society, Series A* 142(1): 33–46.
- Horvitz, D. G., and D. J. Thompson. 1952. A Generalization of Sampling Without Replacement From a Finite Universe. *Journal of the American Statistical Association* 47(260): 663–685.
- Kolenikov, S. 2014. Calibrating survey data using iterative proportional fitting. *The Stata Journal* 14(1): 22–59.
- . 2016. Post-stratification or non-response adjustment? *Survey Practice* 9(3). Available at <http://www.surveyppractice.org/index.php/SurveyPractice/article/view/315>.
- Korn, E. L., and B. I. Graubard. 1995. Analysis of Large Health Surveys: Accounting for the Sampling Design. *Journal of the Royal Statistical Society, Series A* 158(2): 263–295.
- . 1999. *Analysis of Health Surveys*. John Wiley and Sons.
- Kott, P. S. 2006. Using Calibration Weighting to Adjust for Nonresponse and Coverage Errors. *Survey Methodology* 32(2): 133–142.
- . 2009. Calibration Weighting: Combining Probability Samples and Linear Prediction Models. In *Sample Surveys: Inference and Analysis*, ed. D. Pfeffermann and C. R. Rao, vol. 29B of *Handbook of Statistics*, chap. 25. Oxford, UK: Elsevier.

- Pew Research Center. 2012. Assessing the Representativeness of Public Opinion Surveys. Technical report, Pew Research Center for People and Press. Available at [http://www.people-press.org/files/legacy-pdf/Assessing the Representativeness of Public Opinion Surveys.pdf](http://www.people-press.org/files/legacy-pdf/Assessing%20the%20Representativeness%20of%20Public%20Opinion%20Surveys.pdf).
- Pfeffermann, D. 1993. The role of sampling weights when modeling survey data. *International Statistical Review* 61: 317–337.
- Särndal, C.-E. 2007. The calibration approach in survey theory and practice. *Survey Methodology* 33(2): 99–119.
- Thompson, M. E. 1997. *Theory of Sample Surveys*, vol. 74 of *Monographs on Statistics and Applied Probability*. New York: Chapman & Hall/CRC.

**About the author**

Stanislav (Stas) Kolenikov is a Senior Scientist at Abt Associates. His work involves applications of statistical methods in data collection for public opinion research, public health, transportation, and other disciplines that utilize collection of survey data. Within survey methodology, his expertise includes advanced sampling techniques, survey weighting, calibration, missing data imputation, variance estimation, nonresponse analysis and adjustment, small area estimation, and mode effects. Besides survey statistics, Stas has extensive experience developing and applying statistical methods in social sciences, with focus on structural equation modeling and microeconometrics. He has been writing Stata programs since 1998 when Stata was version 5.