

Iterative Proportional Fit (IPF) Exercise

CTPP 2000 provides a large number of tables, but there are times when a table of interest for a particular analysis does not exist. In these situations it is often possible to synthesize the information using a combination of tables provided by CTPP 2000 and an Iterative Proportional Fit (IPF) process. For example, you would like to know the relationship between Vehicles Available and Number of Workers in the Household for workers that used bus or trolley bus as their Means of Transportation to Work. A single table that relates all of these attributes is not included in CTPP 2000. Table 1.35 relates vehicles to modes and Table 1.37 relates number of workers to modes, but there isn't a table that relates vehicles to number of workers by mode. Table 1.65: Number of Workers in Household (6) by Vehicles Available (6) is provided, but this is a Place of Residence table with All Households as the universe. Because the universes are different, the tables cannot be combined directly. They can, however, be combined indirectly as either rates or distribution patterns.

Table 1.35: Vehicles Available (6) by Means of Transportation to Work (11)

Workers in Households	Total, all means of transportation	Drove alone	In 2-person carpool	In 3-person carpool	In 4-or-more person carpool	Bus or trolley bus	Streetcar, trolley car, subway, or elevated	Railroad or ferryboat	Bicycle or walked	Taxicab, motorcycle, or other means	Worked at home
Total, vehicles available	4625	3260	400	35	10	660	0	0	65	10	185
No Vehicles	330	35	45	0	0	230	0	0	20	0	0
1 Vehicle	2390	1785	200	20	10	290	0	0	25	10	50
2 vehicles available	1470	1090	115	10	0	105	0	0	15	0	135
3 vehicles available	370	295	35	5	0	30	0	0	5	0	0
4 or more vehicles available	65	55	5	0	0	5	0	0	0	0	0

Table 1.37: Number of Workers in Household (6) by Means of Transportation to Work (11)

Workers in Households	Total, all means of transportation	Drove alone	In 2-person carpool	In 3-person carpool	In 4-or-more person carpool	Bus or trolley bus	Streetcar, trolley car, subway, or elevated	Railroad or ferryboat	Bicycle or walked	Taxicab, motorcycle, or other means	Worked at home
Total, number of workers in household	4625	3260	400	35	10	660	0	0	65	10	185
No workers in household	0	0	0	0	0	0	0	0	0	0	0
1 worker in household	1695	1255	145	10	0	215	0	0	20	10	40
2 workers in household	2280	1530	190	15	10	360	0	0	30	0	145
3 workers in household	570	425	55	10	0	70	0	0	10	0	0
4 or more workers in household	80	50	10	0	0	15	0	0	5	0	0

Table 1.65: Number of Workers in Households (6) by Vehicles Available (6)

All Households	Total, vehicles available	No vehicles	1 vehicle	2 vehicles	3 vehicles	4 or more vehicles
Total, number of workers in household	3605	415	2125	885	160	20
No workers in household	560	185	295	80	0	0
1 worker in household	1695	130	1325	210	30	0
2 workers in household	1140	100	450	535	55	0
3 workers in household	190	0	55	50	70	15
4 or more workers in household	20	0	0	10	5	5

Using the data shown above, what is the percentage of zero car households that have two workers?

- 1) 18%
- 2) 24%
- 3) 29%
- 4) 36%

If anything other than 2: This answer is incorrect. Using the data from Table 1.65, the percentage of zero car households that have two workers is $100 / 415 = 24\%$.

If 2: Correct! Using the data from Table 1.65, the percentage of zero car households that have two workers is $100 / 415 = 24\%$.

If you calculate the percentages for each vehicle availability and number of worker category, you would end up with a table like the one shown below.

Percent of Households by Number of Workers by Vehicles Available					
Percent of Households	No vehicles	1 vehicle	2 vehicles	3 vehicles	4 or more vehicles
Total	100%	100%	100%	100%	100%
No workers in household	45%	14%	9%	0%	0%
1 worker in household	31%	62%	24%	19%	0%
2 workers in household	24%	21%	60%	34%	0%
3 workers in household	0%	3%	6%	44%	75%
4 or more workers in household	0%	0%	1%	3%	25%

You could then apply this distribution to the data from Table 1.35 to estimate the mode shares by vehicles available and number of workers in the household. The table below shows what this might look like for the bus/trolley bus mode category.

Number of Workers using Bus or Trolley Bus Modes						
Workers in Households	Total, vehicles available	No vehicles	1 vehicle	2 vehicles	3 vehicles	4 or more vehicles
Total	660	230	290	105	30	5
No workers in household	152	103	40	9	0	0
1 worker in household	283	72	181	25	6	0
2 workers in household	191	55	61	63	10	0
3 workers in household	30	0	8	6	13	4
4 or more workers in household	3	0	0	1	1	1

If you compare the totals by number of workers to the values found in Table 1.37, you will see that the values do not match. This should be expected when using a simple proportional distribution.

Number of Workers using Bus or Trolley Bus Modes			
Workers in Households	CTPP Totals	Estimated Totals	Factor
Total	660	660	1.00
No workers in household	0	152	0.00
1 worker in household	215	283	0.76
2 workers in household	360	191	1.89
3 workers in household	70	30	2.31
4 or more workers in household	15	3	4.45

To correct this problem, you could apply an Iterative Proportional Fit (IPF) or FRATAR procedure to adjust the cell values based on the joint distribution. The IPF process calculates a correction factor based on the number of workers in the household totals and applies it to each row value. It then sums up the column totals and compares the values to the target totals. A correction factor is calculated and applied to the values in each column. This process is performed several times until the differences between the estimated totals and the target totals are approximately zero.

If you were to apply an IPF process, the results for the bus/trolley bus mode are shown in the following table. Notice that this table is similar but not exactly the same as the one shown previously. The workers from no-worker households were eliminated and the number of 2 worker households with no vehicles or 1 vehicle increased significantly. This implies that households with more workers than vehicles are more likely to use transit to worker than the average household in this neighborhood.

Number of Workers using Bus or Trolley Bus Modes						
Workers in Households	Total, vehicles available	No vehicles	1 vehicle	2 vehicles	3 vehicles	4 or more vehicles
Total	660	230	290	105	30	5
No workers in household	0	0	0	0	0	0
1 worker in household	215	73	131	10	1	0
2 workers in household	360	157	125	71	6	0
3 workers in household	70	0	34	15	18	3
4 or more workers in household	15	0	0	9	4	2

If you would like to try this for yourself, an Excel spreadsheet with the above information is provided. To operate this spreadsheet you can use the following steps.

- 1) Copy the values from D5:H9 on the worksheet labeled Table 1.65 to the corresponding location on the IPF worksheet. This will initialize the IPF process with the CTPP table values.
- 2) Then you can decide which travel mode you would like to estimate from the options in Tables 1.35 and 1.37. The default IPF application uses the Bus and Trolley Bus mode information. If you wish to apply the process to a different mode, copy the column values

from Table 1.35 to the row values D11:H11 in the IPF worksheet. Then copy the column values from Table 1.37 to the column values J5:J9 in the IPF worksheet.

- 3) At this point the IPF worksheet automatically calculates the first round of IPF adjustments to the data. The table labeled STEP 1 in the IPF worksheet shows the results after the column adjustments are applied. The table labeled STEP 2 shows the results of applying row adjustments to the results of the column adjustments.
- 4) The percent errors shown in J17:J21 and E33:H33 represent the overall status of the IPF process. If these values are near zero, the process is complete.
- 5) Since all of the percent errors are not likely to be zero, you will need to iterate through the process several more times until the percent errors are zero. To do this you copy the data from D27:H32 in the last table to D5:H9 in the first table of the IPF worksheet. You need to use the PASTE SPECIAL command and select the “Values” option to copy the data without the formulas. Repeat this process several times until the errors are zero.