Task 10.2 Time Period Factors

Inputs
Area matrices from Task 10.1

Processing
Our aim is to allocate the forecast daily 24hr demands by purpose to the 3 time periods (am, interpeak and pm). We will do this after trip distribution before assignment. The process takes the 24 hour P/A matrices for each purpose and mode and apportions them between the 3 time periods, recognising the directionality of the travel in each time period (mainly leaving home on the am peak and mainly returning home in the evening peak). The resulting matrices will be in O/D form, as required for assignment (so that the traffic flows are correct in each direction).

Simple Example
The development of matrix factors simply involves computing the proportion of the total matrix for each mode and purpose in each time period, making due allowance for P/A and O/D structures which determine travel direction (as in the illustrative figure below).

TIME PERIOD FACTORS

24 Hours

	P/A		From Home OD		To Home OD		O/D	
	Res	CBD	Res	CBD	Res	CBD	Res	CBD
Res	20	100	10	50	10	0	20	50
CBD	0	10	0	5	50	5	50	10
	=130 trips		=65 trips		=65 trips		=from home + to home =130	

AM Peak

			From Home OD		To Home OD		O/D	
			Res	CBD	Res	CBD	Res	CBD
Res			8	40	1	0	9	40
CBD			0	4	5	0.5	5	4.5
			=80% from home = 52		=10% to home = 6.5		=from home + to home =58.5	

Interpeak

			From Home OD		To Home OD		O/D	
			Res	CBD	Res	CBD	Res	CBD
Res			1	5	1	0	2	5
CBD			0	0.5	5	0.5	5	1
			=10% from home = 6.5		=10% to home = 6.5		=from home + to home = 13	

PM Peak

			From Home OD		To Home OD		O/D	
			Res	CBD	Res	CBD	Res	CBD
Res			1	5	8	0	9	5
CBD			0	0.5	40	4	40	4.5
			=10% from home = 6.5		=80% to home = 52		=from home + to home =58.5	

A further refinement would be to vary the factors by location, but the sample statistics will not permit much of this. It may be worthwhile testing some such segmentations (in this example, distinguishing longer distance work trips to the CBD).

Mathematical Detail
The process is designed to do the following. Take for example the HBW matrix:

- this is in P/A form, which means that the matrix cell ij contains the total number of HBW trips made in the day which are produced in zone i, the home zone, and attracted to zone j where the workplace is located;
- in the am peak, about half of these trips will appear on the road network travelling from home to work, from i to j;
- in the pm peak the other half of the trips will occur in the opposite direction from j to i, as people return home from work;
- the time period factoring process takes the 24 hour matrix and converts it into an O/D matrix for each time period which reflects these characteristics of the different time periods.

We also need to check to any geographical variations. Given the small data set, I propose that we split the study area into 2 parts, Wellington city and the rest of the region ("other") and analyse the 2*2 matrix of trips to and from these areas (a-j below). In most cases we expect that there will not be any justification for a geographic segmentation.

	Wellington	Other	Total
Wellington	a	b	e
Other	c	d	f
Total	g	h	j

Process the observed data to create the following 2*2 O/D matrices - for each home-based trip purpose, and for car and public transport separately, using IJ to denote the above area classification:

From home (fh) trips:	To home (th) trips
$T_{mp}(fh)^{24}{}_{IJ}$	$T_{mp}(th)^{24}{}_{IJ}$
$T_{mp}(fh)^{7\text{-}9}{}_{IJ}$	$T_{mp}(th)^{7\text{-}9}{}_{IJ}$
$T_{mp}(fh)^{9\text{-}16}{}_{IJ}$	$T_{mp}(th)^{9\text{-}16}{}_{IJ}$
$T_{mp}(fh)^{16\text{-}18}{}_{IJ}$	$T_{mp}(th)^{16\text{-}18}{}_{IJ}$

Note that:

- $T_{mp}(fh)^{24}{}_{IJ}$ & $T_{mp}(th)^{24}{}_{IJ}$ are computed from the 24 hour PA matrix $T_{mp}{}^{24}{}_{IJ}$ as, respectively, $0.5{*}T_{mp}(fh)^{24}{}_{IJ}$ and the transpose of this (or, alternatively, they can be built up from the household trip data, and should amount to the same thing); they are OD matrices;
- the other matrices are built from the household data and are also OD matrices.

The time period factors are then the ratios of these matrices. Eg for the am peak, we will have:

$$T_{mp}(fh)^{7\text{-}9}{}_{IJ}/T_{mp}(fh)^{24}{}_{IJ} \;\; \& \;\; T_{mp}(th)^{7\text{-}9}{}_{IJ}/T_{mp}(th)^{24}{}_{IJ}$$

and we will have 9 values for each (in the 2*2 matrix, including also the row, column and overall totals). Allowing for sampling error we must decide whether any of the 4 cell (a-d) or 4 row/column total (e-h) values are significantly different from the average (j) to justify a geographic segmentation.

For NHB trips, there is no th/fh distinction, and they are on an O-D basis.

In all there are 2 modes* 4 time periods * (5 home based purposes * 2 directions + 1 NHB matrix) = 88 matrices (2*2). These must be converted into ratio matrices of which there are (2 modes * 3 time periods *(5 home based purposes * 2 directions + 1 NHB matrix) = 66 matrices of ratios.

Note that this differs from the approach used for generalised costs in that the 2 peak periods are separated, and the factors are directional and also mode specific[1]. A further difference will arise if we decide to use geographically varying factors.

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[1] To clarify the difference: the demand models operate essentially on a P/A basis, that is they describe the trips produced ‘from’ the home zone ‘to’ the zone of attraction. We also assume in the demand models that there is no significant difference between the generalised costs for the from and to home journeys, and therefore we use an estimate of the from home journey cost obtained from the am peak matrix for those trips occurring in the peak periods; as we expect broadly symmetry in the interpeak matrix and in interpeak journey times, P/A and O/D are indistinguishable.

This process will lead to a set of matrix factors which can be applied to the 24 hour directional matrices to develop time period matrices – which we may describe as $MF_{mp}(d)^{t}_{IJ}$ where d is direction and t time period.

Once we have created the matrix factors we can estimate the from home and two home matrices for each time period and then the 3 time period OD matrices are computed as :

am: $T_{mp}(fh)^{7\text{-}9}_{IJ} + T_{mp}(th)^{7\text{-}9}_{IJ}$
inter: $T_{mp}(fh)^{9\text{-}16}_{IJ} + T_{mp}(th)^{9\text{-}16}_{IJ}$
pm: $T_{mp}(fh)^{16\text{-}18}_{IJ} + T_{mp}(th)^{16\text{-}18}_{IJ}$

Outputs

Time period factors