TN35 - WELLINGTON TRANSPORT ANALYTICAL TOOLS 2019-23 UPDATE – INCOME SEGMENTATION MODULE

PREPARED FOR GREATER WELLINGTON REGIONAL COUNCIL

[November 2023]

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REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
1	15/11/2023	First external draft	GC	SW	JEB	JEB
2	22/11/2023	Final	GC	SW	JEB	JEB

Greater Wellington Regional Council

TN35 - Wellington Transport Analytical Tools 2019-23 update – Income Segmentation Module

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1. Introduction

This technical note is part of a series documenting the 2019-2023 update of the Wellington Regional Transportation Planning Analytical Tools. The higher-level Analytical Tools are maintained and operated by Greater Wellington Regional Council (GWRC), who is the client for this project. This project is being delivered by Stantec and Jacobs, supported by GWRC transport modellers.

This note details the income segmentation module added to the Wellington Transport Strategy Model (WTSM), and includes the following sections:

- Summary of the income segmentation module
- Segmentation of households and travel demand by income
- Calculation of values of time for each income segment and trip purpose
- Implementation of the income segmentation module in WTSM
- Effect of running the income segmentation module on a base scenario and impact on validation
- Testing for the income segmentation module for two different options: a toll on Transmission Gully and a Wellington CBD cordon charge
- Conclusion and comments on limitations of the module

2. Summary

In a standard WTSM run, road pricing (e.g. for toll or cordon charges) is represented through the use of average values of time (VoT) applied to trip purposes in the demand model, and the overall average in the assignments. As a result, there is no differentiation in demand response for different households' income, and in the case of route choice also no differentiation by trip purpose. In reality both these aspects impact the willingness to pay for the additional cost.

The income segmentation module provides this added level of detail, leading to different responses to road pricing for each demand segment by trip purpose and household income.

This process was implemented as a post-model run module, turned off by default but can be activated for scenarios that include such road pricing schemes. This approach was developed after review of several other such models in New Zealand and Australia. The process is run as follows:

- Carry out a standard run of the model, including the road pricing which is applied with WTSM standard values of time. This allows capturing the overall effect of the additional charges.
- Final daily demand matrices by purpose (all modes aggregated) are then segmented to account for income levels by zone (split into low, medium and high income), for each trip purpose.
- Generalised costs for each demand segment are recalculated, using their respective values of time.
- The mode choice model is then re-run using these sets of generalised costs, and for each demand segment.
- The matrices by mode are then converted to time period origin-destination trip matrices (and converted to vehicle for private light vehicles) using the same process as the overall model. Subsequent WTSM processes are applied as per a normal model run.
- A final assignment of the new public transport and private vehicle demands is carried out. For the road assignment, this is a multi-class assignment with each segment assigned separately with their respective value of time (some trip purposes being grouped together if they have the same value of time, for example all non-work home-based trips). This accounts for the impact of road pricing on route choice for each demand segment.

The road pricing module therefore allows estimating the more detailed impact of road pricing on mode and route choice.

3. Segmentation of Demand

The first step of the income segmentation module splits travel demand into low, medium and high income brackets. This is carried out using the proportion of households in each segment, for each model zone.

Data relating to the distribution of households per income bracket was obtained from Statistics New Zealand at a Statistical Area 2 (SA2) level, which shows the number of households in each SA2 per household income band:

- <$20k
- $20k-30k
- $30k-$50k
- $50k-$70k
- $70-$100k
- $100k-$150k
- >$150k

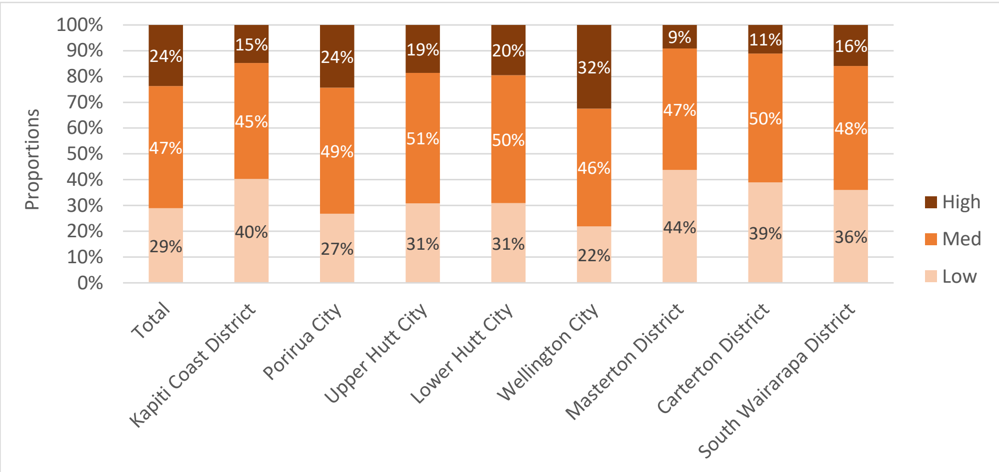
The data also includes the median household income for each SA2.

These categories were grouped into low, medium and high income categories. The objective was initially to create three segments each including about one third of households but this was not feasible. In the end, the following thresholds were used:

- Low: <$50k
- Medium: $50k-$150k
- High: >$150k

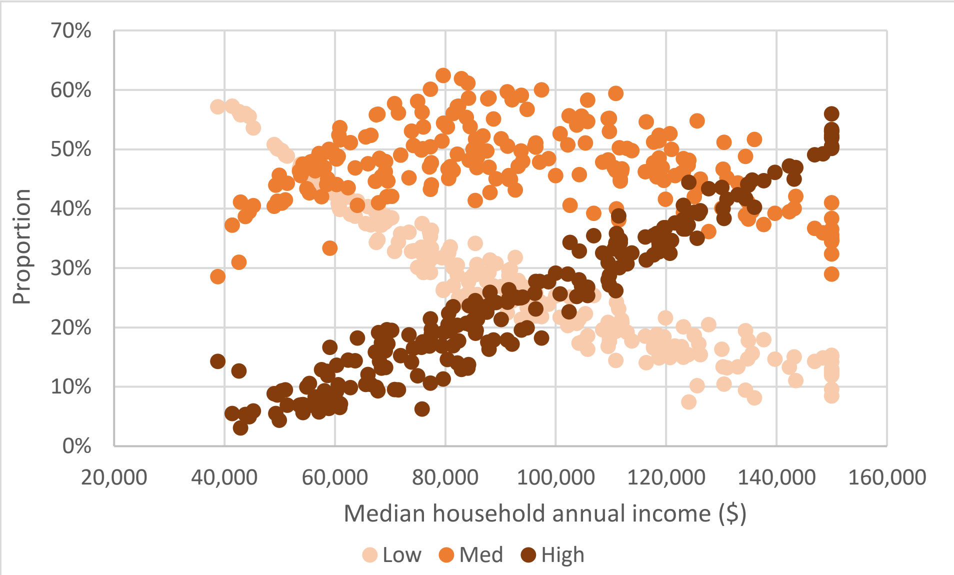
The following figures show the resulting proportion of households in each income segment by Territorial Authority (TA) and in total.

Figure 3.1: Household proportions per income segment



The following figure shows the relationship between median household income and the proportion of households per income band for all SA2s. As can be observed, there is a clear relationship with the number of low income households decreasing and high income households increasing as the median income rises.

Figure 3.2: SA2 household proportions per income segment



The proportions of households per income band per SA2 was then allocated to WTSM zones within each SA2 and this information was added to the land use input files to the model.

As a result, it must be noted that for forecasting, future zonal proportions of households per income band will need to be specified, accounting for projected variations in income distribution per sectors.

4. Values of time

The value of time is used in the model to convert monetary costs into units of time to be added to the generalised costs of travel (noting they are not necessarily the values used in economic analysis). In WTSM values of time are used during the demand model stage where they differ by purpose and during the assignment stage where a global average is applied. More information on how these values were derived can be found in 'TN22 – Model input parameters'. It must be noted that the WTSM values of time were derived using values from the 2020 Monetised Benefits and Cost Manual (MBCM), before its 2023 update.

The values of times used in a standard run of WTSM are as follows:

Table 4.1: WTSM values of time (2018 $)

Trip Purpose	VoT ($/hr)
Home-based work	$12.0
Employer business	$35.0
Other purposes	$10.0
All (for assignment)	$11.6

While the value of time is not exactly the same as the willingness to pay, these were considered to be sufficiently similar given the intended use of the income segmentation module. This is considered appropriate and is consistent with similar models reviewed such as the Auckland Macro Strategic Model (MSM). This simplification must however be borne in mind when using the model and its output. This is discussed in more detail in section 7.

The calculation of values of time per income band was based on a review of models in New Zealand and Australia, updated with assumptions specific to New Zealand. The calculations are as follows:

- The median annual income per household for each income band are calculated from the Statistics NZ data, and are then converted to income per person.
- The results are converted to weekly, and then to average hourly wages (Full-Time Equivalent, assuming a 38.8 hour average working week, based on data from Statistics NZ for the Wellington region).

- For each band, this income is converted into a value of time by using the ratio of WTSM average value of time to average hourly wage ($31 in 2018[1]). This leads to a ratio of 39% (similar to a value of 40% in Austroads standard adopted in Australian models used as a base for this approach).

This approach therefore returns values of time for each income segment, for all trip purposes combined.

However the review of other models showed that income is not necessarily a perfect measure of values of time and indeed applying the initial values calculated with this approach led to a response from the pricing module deemed overly strong. To alleviate this issue, an elasticity of 0.5 to variation in values of time respective to variations in income was applied. This value is consistent with the elasticity used in the Auckland MSM model.

Finally, the value of time for income and trip purpose segments was calculated by applying the pro-rata of standard WTSM trip purpose VoT versus overall VoT to each income segment.

The resulting values of time used in the income segmentation model are shown in the following table.

Table 4.2: Values of time for income segmentation (2018 $)

Trip Purposes	VoT ($/hr)		
	Low	Medium	High
Home-based work	$8.7	$11.5	$15.7
Employer business	$25.5	$33.4	$45.9
Other purposes	$7.3	$9.5	$13.1
All (for assignment)	$8.4	$11.1	$15.2

5. Implementation in WTSM

5.1 Demand model

The income segmentation is a post-run module which is undertaken after a standard WTSM scenario has been carried out and reached convergence.

The alternative would have required income segmentation to be weaved throughout the model, which was not considered appropriate for the envisaged use of this module given the trade-off in complexity and run time, and the fact it will likely be run infrequently for specific options that include forms of road pricing.

Daily, all-modes travel demand matrices (in 24hr Production-Attraction format) are first split into low, medium and high income bands for each trip purpose. For home-based purposes (home-based work / education / shopping /other), this is based on proportions from the zone where the household is located. For non-home based purposes (non-home based and employer's business), overall averages are applied.

Generalised costs per mode are then recalculated separately for each segment, based on their respective values of time.

For modal share calculations, the initial approach to calculate changes with income accounted for was to use an incremental mode choice model. This was investigated but it was clear that because of the structure of WTSM, implementing this approach would lead to either too much complexity or too many limitations. Instead, a different methodology was adopted where the WTSM mode choice is run another time, with the same parameters as during the standard model run but again separately for each income band. This approach also provides a better consistency with results from the main model run.

The mode choice model is run separately for each trip purpose and income band, and with daily demand matrices. The resulting matrices per mode are then carried through the rest of the demand model calculations as per during the standard model run, including:

- Factoring to Origin-Destination matrices by time period
- Occupancy factoring for private vehicles
- Work-from-home adjustments

[1] https://www.mbie.govt.nz/assets/630c3ec66c/minimum-wage-review-2018.pdf

- Factoring for light commercial vehicles growth

This results in separate demand matrices by mode, time period, trip purpose and income segments.

It must be noted that this process does not apply to demand generated by the Airport, Cook Straight ferry terminals ,and Externals models, which are not segmented by income in the absence of data relating to these specific segments, and the fact that they are likely to have significantly different time imperatives.

5.2 Assignments

The road assignment within the income segmentation module is generally based on the same processes and parameters as the assignment carried out during a standard model run, with the exception that demand is separated by trip purposes (some grouped if using the same values of time) and income segments, each with their respective values of time. As a result the road assignment is a multi-class assignment with the following classes:

- Home-based work, low income
- Home-based work, medium income
- Home-based work, high income
- Employer business, low income
- Employer business, medium income
- Employer business, high income
- Other purposes (home-based education / shopping / other), low income
- Other purposes, medium income
- Other purposes, high income
- Other light vehicles (Airport model, ferry terminals model, externals)
- Heavy vehicles

For public transport, the same assignment is run as during a standard model run, with demand for all purposes and income segments aggregated before the assignment. This is for two reasons:

- The PT assignment is already a multiclass with 5 different public transport classes and further segmentation would have led to many classes to assign and significant additional complexity.
- Values of time have a very negligible impact on route or service choice in the public transport assignment, given that the same fares apply to all services on both the bus and rail networks. While this could have an impact on boarding / alighting patterns (for example a bus passenger alighting earlier to avoid a fare zone crossing) or for the limited amount of ferry passengers who pay a higher fare, analysis of results showed no notable effect.

6. Income segmentation module results

This section presents the effect of the income segmentation module, first looking at a base year scenario with no road pricing applied, and then for two tests:

- A scenario with a toll applied to the new Transmission Gully Motorway
- A scenario with a cordon charge applied to the Wellington CBD

6.1 Impact on base year validation

In order to demonstrate that turning on the income segmentation functionality without road pricing applied does not lead to significantly different results from a standard run, a base year 2018 scenario was run in WTSM with the new module then applied.

Validation metrics were then compared, with results presented in the following tables. Results that do not meet the guidelines are highlighted in grey. More details on the validation criteria used are given in 'TN31 – WTSM Validation'.

Note: validation results for the base are slightly different to the ones presented in TN31 – WTSM validation due to an updated version of EMME being used with a newer version of the Junction Capacity Analysis Tool (JCAT). The difference is however negligible.

Table 6.1: Screenlines validation - light vehicles

Criteria		Base					With Income Segmentation				
		AM	IP	PM	ON	Daily	AM	IP	PM	ON	Daily
GEH	>60% with GEH<5	70%	70%	73%	69%	73%	63%	69%	72%	70%	77%
	>75% with GEH<7.5	83%	81%	83%	88%	86%	83%	81%	84%	88%	86%
	>90% with GEH<10	91%	91%	91%	95%	92%	91%	89%	92%	95%	94%
% Difference	70% with difference <10%	50%	56%	59%	39%	64%	50%	50%	59%	36%	62%
	80% with difference <20%	79%	77%	82%	67%	82%	79%	79%	82%	67%	80%

Table 6.2: Traffic counts validation - light vehicles

Criteria		Base					With Income Segmentation				
		AM	IP	PM	ON	Daily	AM	IP	PM	ON	Daily
GEH	>65% with GEH<5	58%	59%	56%	67%	66%	56%	59%	56%	67%	68%
	>75% with GEH<7.5	77%	79%	80%	84%	81%	78%	80%	78%	83%	82%
	>85% with GEH<10	88%	87%	88%	90%	90%	88%	86%	89%	91%	91%
	>95% with GEH<12	93%	90%	94%	94%	94%	92%	90%	93%	94%	94%
Difference	70% of links with flow<700vph within 100	67%	68%	58%	89%	85%	64%	69%	58%	90%	86%
	70% of links with 700<flow<2700vph within 15%	65%	65%	66%	33%	77%	63%	67%	66%	67%	84%
	70% of links with flow>200vph within 400	100%	0%	83%	0%	0%	100%	0%	67%	0%	0%
Other	r2 > 0.85	0.97	0.96	0.97	0.95	0.97	0.97	0.96	0.97	0.95	0.97
	Slope of trendline between 0.9 and 1.1	0.97	1.02	0.98	1.02	1.01	0.95	1.01	0.97	1.01	1.00
	RMSE <30%	26%	28%	24%	32%	24%	26%	28%	24%	31%	23%

Table 6.3: Wellington CBD bus cordon validation

Links of CBD Cordon	Base					With Income Segmentation				
	Obs	Mod	Diff	% Diff	GEH	Obs	Mod	Diff	% Diff	GEH
AM Peak - Inbound										
Oriental Parade	515	612	97	19%	2.3	515	609	94	18%	2.3
Cambridge Terrace	1,919	1,832	-87	-5%	1.2	1,919	1,855	-64	-3%	0.9
Elizabeth Street	2,607	2,598	-9	0%	0.1	2,607	2,631	24	1%	0.3
Willis Street	1,072	1,289	217	20%	3.6	1,072	1,297	225	21%	3.8
Taranaki Street	1,348	983	-365	-27%	6.2	1,348	999	-349	-26%	5.9
Hawker Street	26	5	-21	-81%	3.1	26	5	-21	-81%	3.1
Tinakori Road	1,451	1,539	88	6%	1.3	1,451	1,537	86	6%	1.3
Kelburn Parade	1,100	1,097	-3	0%	0.0	1,100	1,165	65	6%	1.1

Links of CBD Cordon	Base					With Income Segmentation				
	Obs	Mod	Diff	% Diff	GEH	Obs	Mod	Diff	% Diff	GEH
Murphy Street	520	507	-13	-2%	0.3	520	514	-6	-1%	0.1
Thorndon Quay	3,196	2,763	-433	-14%	4.6	3,196	2,837	-359	-11%	3.8
Total	**13,756**	**13,225**	**-531**	**-4%**	**2.6**	**13,756**	**13,449**	**-307**	**-2%**	**1.5**
PM Peak - Outbound										
Oriental Parade	397	522	125	32%	3.4	397	521	124	31%	3.3
Kent Terrace	1,945	1,558	-387	-20%	5.3	1,945	1,571	-374	-19%	5.1
Elizabeth Street	1,572	1,947	375	24%	5.2	1,572	1,976	404	26%	5.5
Victoria Street	1,148	1,107	-41	-4%	0.7	1,148	1,124	-24	-2%	0.4
Taranaki Street	1,084	799	-285	-26%	5.4	1,084	816	-268	-25%	5.0
Hawker Street	98	14	-84	-86%	6.5	98	14	-84	-86%	6.5
Tinakori Road	1,421	1,130	-291	-20%	4.7	1,421	1,133	-288	-20%	4.6
Kelburn Parade	756	908	152	20%	3.0	756	911	155	20%	3.1
Molesworth Street	832	660	-172	-21%	3.6	832	669	-163	-20%	3.4
Thorndon Quay	2,718	2,476	-242	-9%	2.7	2,718	2,540	-178	-7%	2.0
Total	**11,970**	**11,121**	**-849**	**-7%**	**4.6**	**11,970**	**11,275**	**-695**	**-6%**	**3.7**

Table 6.4: Rail guard counts

Line	Base					With Income Segmentation				
	Obs	Mod	Diff	% Diff	GEH	Obs	Mod	Diff	% Diff	GEH
AM Peak - Inbound										
Johnsonville	1,632	1,379	-253	-16%	3.8	1,632	1,382	-250	-15%	3.7
Hutt / Melling / Wairarapa	8,205	8,402	197	2%	1.2	8,205	8,773	568	7%	3.6
Kapiti	6,349	7,123	774	12%	5.4	6,349	7,403	1,054	17%	7.3
Total	**16,186**	**16,904**	**718**	**4%**	**3.2**	**16,186**	**17,558**	**1,372**	**8%**	**6.1**
PM Peak - Outbound										
Johnsonville	1,319	1,373	54	4%	0.8	1,319	1,383	64	5%	1.0
Hutt / Melling / Wairarapa	6,873	6,743	-130	-2%	0.9	6,873	7,032	159	2%	1.1
Kapiti	5,409	5,842	433	8%	3.3	5,409	6,051	642	12%	4.9
Total	**13,601**	**13,958**	**357**	**3%**	**1.8**	**13,601**	**14,466**	**865**	**6%**	**4.2**

Table 6.5: Bus screenlines

Criteria		Base				With Income Segmentation			
		AM	IP	PM	ON	AM	IP	PM	ON
GEH	>60% with GEH<5	78%	72%	61%	87%	80%	70%	63%	85%
	>70% with GEH<7.5	85%	87%	72%	98%	85%	83%	70%	93%
	>80% with GEH<10	93%	93%	89%	100%	93%	91%	80%	100%
	>90% with GEH<12	98%	98%	91%	100%	100%	98%	89%	100%
Other	Slope of trendline between 0.9 and 1.1	0.91	0.93	0.89	0.92	0.92	0.97	0.91	0.94
	r2 > 0.85	97%	93%	97%	92%	97%	92%	96%	92%

Table 6.6: Rail screenlines

Criteria		Base			With Income Segmentation		
		AM	IP	PM	AM	IP	PM
GEH	>50% with GEH<5	56%	89%	61%	56%	61%	50%
	>60% with GEH<7.5	83%	100%	78%	72%	100%	78%
	>70% with GEH<10	100%	100%	83%	94%	100%	78%
	>85% with GEH<12	100%	100%	100%	100%	100%	100%
Other	Slope of trendline between 0.9 and 1.1	0.96	1.24	1.01	1.00	1.29	1.05
	r2 > 0.85	99%	97%	99%	99%	97%	99%

Results show that the income segmentation module does not lead to significant impact on model validation. The main effect is for rail demand which increases by 3-4%. In addition analysis of volume changes for both car and public transport indicated that the impact on volumes overall is low.

Therefore with income segmentation activated, the model still passes the vast majority of validation checks.

6.2 Test 1 – Transmission Gully tolling

The income segmentation module was first tested using a $3.5 toll (all day, both directions) applied to the new Transmission Gully motorway, as show in the figure below.

Figure 6.1: Toll on Transmission Gully

Because Transmission Gully was opened after the 2018 base year, a WTSM run with the new motorway added but no toll was first run for comparison, both with and without income segmentation. The model was then run with the toll applied both with and without the income segmentation module.

The following tables presents the resulting volumes and traffic reduction caused by the toll, showing results without income segmentation, with income segmentation, and for the latter broken down by income band in Table 6.7 and trip purposes in Table 6.8. Results are also shown for traffic generated by the State highway 1 external, Airport and ferry terminal models which are not included in the income segmentation process.

Results are given for southbound traffic, both in the AM peak and for the whole day.

Table 6.7: Transmission Gully tolling test - light vehicle southbound volumes, by income

Scenario	Total - No Income Segmentation	Total With Income Segmentation	Low Income	Medium Income	High Income	Externals, Airport, Ferry
AM peak period (3hr)						
Base	2,955	2,920	617	862	352	1,089
Toll	2,157	2,047	160	546	272	1,069
% Difference	-27%	-30%	-74%	-37%	-23%	-2%
Daily						
Base	9,882	9,833	1,428	2,119	933	5,353
Toll	5,903	5,512	295	874	523	3,820
% Difference	-40%	-44%	-79%	-59%	-44%	-29%

Table 6.8: Transmission Gully tolling test - light vehicle southbound volumes, by purpose

Scenario	Total - No Income Segmentation	Total With Income Segmentation	HBW	BSN	Other	Externals, Airport, Ferry
AM peak period (3hr)						
Base	2,955	2,920	1,542	95	194	1,089
Toll	2,157	2,047	854	68	56	1,069
% Difference	-27%	-30%	-45%	-28%	-71%	-2%
Daily						
Base	9,882	9,833	2,554	575	1,351	5,353
Toll	5,903	5,512	1,070	381	241	3,820
% Difference	-40%	-44%	-58%	-34%	-82%	-29%

In these tables, it is confirmed that without a toll, with or without the income segmentation module produces similar traffic flows.

The results also show that the overall traffic reduction with income segmentation is circa 10% higher than without for both the AM peak period and daily. There is however a clear difference in terms of impact by income band and trip purposes, with the toll having a stronger impact on low income demand and lesser for high income, and also stronger impact on ‘Other’ purposes than work-related ones (HBW and BSN).

It can be observed that the effect of the toll is limited for Airport, ferry and external related volumes in the AM peak (while they are not included in the income segmentation process the toll still applies to these segment albeit with standard WTSM VoTs). This is likely due to the nature of this demand that is more long distance (from/to the SH1 external, or from/to the Airport and Ferry Terminals) and therefore more likely to travel the whole length of Transmission Gully, compared with some of the more local traffic that might only use a portion of it between the Kapiti Coast and Porirua or SH58 to the Hutt Valley. As a result these trips would benefit more from the travel time reduction, especially in the AM peak period southbound.

It is difficult to assess the response from the model and compare to existing tolls, as every toll scheme is different depending on the travel time savings and availability of alternative. These results were however deemed realistic and suitable for the intended model use.

Another analysis was carried out looking at the response for each demand segment, including income band and trip purpose, for increasing toll prices. The results are shown in the following figure.

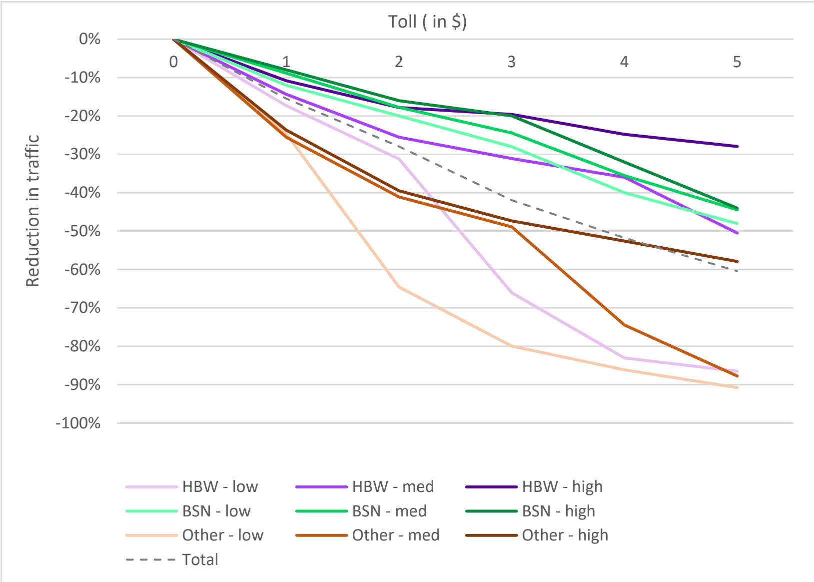


Figure 6.2: Demand response to tolling per segment

From this analysis it can be observed that levels of income have a clear impact on response to price, with for example home-based work trips for low income reducing strongly with a $3 toll, whereas middle income shows a more marked drop with $5. High income demand reduces more gradually.

There are also notable differences per purpose. Some of it can be explained by their respective values of time, for instance 'Other' purposes having a lower value of time show a stronger decrease. But similarly to the earlier comment on Airport, ferry and external demand, some of the difference is likely due to the nature of trips for each purpose. For example, home-based work trips are more likely to be longer distance with many trips heading to the Wellington CBD. Those are therefore more likely to travel the whole length of the motorway and experience more travel time benefits than shorter trips for other purposes.

6.3 Test 2 – Wellington CBD cordon

A second test was carried out with a cordon charge applied to the Wellington CBD as follows:

- $3.5 in the peak direction during the AM (inbound) and PM (outbound) peak periods
- Half price ($1.75) in both directions during the rest of the day

The cordon is shown in the following figure and mostly impacts on trips from/to the CBD, with less impact on through traffic which is more likely to use the SH1 corridor, excluded from the cordon.

Figure 6.3: CBD cordon

The following table presents the reduction in daily light vehicle demand attracted to the Wellington CBD delimited by the cordon.

Table 6.9: Wellington CBD cordon test - daily light vehicle demand

Scenario	Total - No Income Segment	Total - With Income Segment	Low Income	Medium Income	High Income
Base	147,012	143,088	31,412	66,877	44,800
Cordon Pricing	127,222	122,749	25,360	57,339	40,051
% Diff	-13%	-14%	-19%	-14%	-11%

As per the previous test, results with income segmentation are similar to the test without it but show a slightly more pronounced impact. Again the difference is clearer when looking at results by income band.

No clear guidelines were found to compare with the response from the model. However results appear sensible and in line with previous modelling carried out for Wellington, and similar schemes in other cities including Auckland.

Reduction for a number of sectors was also analysed to investigate the difference in effect of the income segmentation process on sectors with different income makeups. Pairs of neighbouring sectors with similar travel times and costs to the CBD but different proportions of high and low income households were identified to assess the differences in response. Results are shown in the following table. For each pair of sectors, the first one is 'high income' with more high income households and less low income, whereas the second sector is the opposite.

Table 6.10: Daily light vehicle reduction between sectors and CBD

Production Sector	Light Vehicle Demand Reduction		% relative difference in reduction
	No Income Segmentation	With Income Segmentation	
Seatoun	-18%	-17%	-5%
Strathmore Park	-18%	-20%	9%
Island Bay	-21%	-21%	2%
Berhampore	-20%	-23%	12%
Karori East	-18%	-17%	-4%
Karori West	-18%	-19%	5%
Whitby	-15%	-12%	-18%
Ascot Park	-14%	-18%	35%
Lower Hutt West	-8%	-8%	1%
Lower Hutt East	-7%	-10%	42%
Paraparaumu West	-11%	-12%	10%
Paraparaumu East	-10%	-14%	36%

Results show that the income segmentation module leads to more differentiation by sector depending on their income levels, with lower income sectors experiencing a more pronounced decrease than without income segmentation, while higher income sectors are less impacted in comparison.

Finally, while the Transmission Gully test mostly leads to changes in routing (with some slight shift to rail), the cordon test mostly impacts mode share as the CBD is still by far the main attractor regionally and the toll applies to all routes to/from the CBD. The following table shows the resulting changes in demand for other modes, which all show an increase.

Table 6.11: Changes in daily demand per mode from Wellington CBD cordon

Mode	Total, With Income Segmentation	Low income	Medium income	High income
Active	+8%	+7%	+8%	+8%
Bus	+11%	+12%	+11%	+10%
Rail	+13%	+14%	+13%	+10%

7. Conclusion

This technical note has detailed the income segmentation module added to the Wellington Transport Strategy Model, which is to be run after scenarios including tolls, congestion charging or other types of road pricing in WTSM. Negligible change on the base year validation was shown (i.e. the base year validation with income segmentation remains robust), and the effect of the module for two road pricing tests was demonstrated.

Results show that income segmentation leads to a logical differentiation of results per income segment and trip purposes, relative to their respective values of times. It must be however noted that for the two tests carried out overall results were not significantly different from the previous model run without income segmentation. This can be explained by the fact that the medium income band which represents about 50% of the demand has similar values of times to the overall values applied in a standard model run, while response for low income and high income to some extent cancel each other out. This may however not be the case for all road pricing schemes and this should be reviewed when modelling such scenarios.

The benefits of using this module are therefore in looking at changes in demand and volumes at a more disaggregated level, where it can highlight how different income bands and areas are impacted by road pricing policies.

As for any model, this module has a number of limitations that must be considered if assessing road pricing mechanisms.

First, while it allows for taking into account how income impacts on mode and route choice, it does not allow for any potential changes in trip rates and destination, as trip generation and distribution are not included in the income segmentation module.

Furthermore, while it includes an improvement in distribution of the standard WTSM values of times, it still provides a limited representation of willingness to pay with no accounting for perception factor for the toll scheme being tested or perception of alternatives roads and modes, which can greatly differ between studies and pricing schemes. For more detailed modelling of road pricing mechanisms, it is suggested that toll perception or discount factors are investigated, and the values of time would also need to be calibrated from stated and revealed preference data collected specifically for the intended application. As a result the income segmentation module is not considered suitable for estimation of toll revenue or economic assessment, for which more detailed model parameter calibration would be needed.

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