



Infrastructure Victoria Bike Use Propensity Index Forecast

Methodology

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Institute for
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Glossary of terms

ABS – Australian Bureau of Statistics

DZN – Destination Zone an ABS Census geography developed to analyse work commuting patterns

SA2 – Statistical Area Level 2 an ABS Census geography which represents a community

SALUP – Small Area Land Use Projections

VITM – Victorian Integrated Transport Model

1. Methodology



This report outlines the methodology used to create the *Bike Use Propensity Index*. The Bike Use Propensity Index was developed by the Institute for Sensible Transport based on variables associated with latent demand for cycling and published by Fishman et al.¹ The Bike Use Propensity Index provides a score, from 0 to 5+ of the latent demand for cycling in a particular area.

The Index is spatially presented, allowing identification of areas of higher and lower latent demand for cycling. The Propensity Index can help guide areas for future investment in cycling infrastructure by identifying the areas where the most significant uptake in cycling is likely to occur.

For the purposes of this project, the Index has also used projected demographic and travel data to forecast Bike Use Propensity Index scores into the future.

The development of a Victoria-wide Bike Use Propensity Index can assist Infrastructure Victoria as it develops it's 30 Year Infrastructure Strategy.

1.1 Methodology

The Bike Use Propensity Index combines seven variables collected as part of the ABS Census. This Index uses ABS Census data along side SALUP and VITM data provided to the Institute for Sensible Transport by Infrastructure Victoria. This allows the forecasting of latent demand.

The statistical basis for the Index was developed through the collection of data on riding behaviour and demographic factors. Binary logistic regression was used to analyse this data in SPSS and STATA.

The results, published in the journal *Transportation Research: Part A*, revealed some statistically significant factors for the propensity to cycle.

The data that forms the basis of the Index is collected from the following variables shown in Figure 1. Data sources for each variable are also shown.

Residential population density - origin

- People per hectare (SA2)
- Data from SALUP
- Projected into future

Density of young people - origin

- Number of people aged 12 to 25 per hectare (SA2)
- Data from SALUP
- Projected into future

Low motor vehicle ownership - origin

- Number of households with zero or one car per hectare (SA2)
- ABS Census
- Not projected into future

Bicycle use - origin

- Number of people riding to work per hectare (SA2)
- ABS Census
- Not projected into future

Employment density - destination

- Number of people working per hectare (DZN)
- SALUP
- Projected into future

Bicycle use - destination

- Number of people riding to work per hectare (DZN)
- ABS Census
- Not projected into future

Short Car trips - destination

- Number of short car trips (5km and under) per hectare (SA2)
- VITM
- Projected into future

Figure 1 Variables underpinning Bike Use Propensity Index

Variables in the Index are calculated as *origin variables*, for the more residential-oriented

¹ Fishman et al 2015, 'Factors influencing bike share membership: An analysis of Melbourne and Brisbane', *Transportation Research Part A: Policy and Practice*, vol. 71, pp. 17-30, <https://www.sciencedirect.com/science/article/abs/pii/S0965856414002638>

variables, and *destination variables*. Both sets of variables are grouped together, to develop an origin score and a destination score. This helps to reveal areas with high latent demand as origins or destinations, but not as both. Both scores are then combined as a composite to generate the *Bike Use Propensity Index*. This process avoids undervaluing employment-rich areas with low residential populations. As a result, essential bike destinations, such as employment hubs, are adequately considered.

Geographic areas are given an absolute score of between 0 and approximately 5 for each variable. Scores can go over 5, as they are based on observed real world data. There are outliers which far exceed the average, and allowing these areas to exceed 5 makes a smoother distribution of areas across the scale (as described below). Further, the data used is not limited to what is observed today. For example, the density of an area in the future may exceed the density of the densest area today.

These scores are then averaged to reveal an overall bike use propensity score between 0 and 5. A score close to 0 indicates a low propensity to cycle, while a score of 5+ indicates a high propensity to cycle. The mapped values are aggregates of the attributes' scores.

Areas that receive very high Index scores will have scored highly across all the variables included in the Index. In almost all cases, an area scoring above 4.5 will have been the highest score in most variables. The maps used in this report have been colour-scaled to be comparable within the study area. However, the score is relative to all other regions in Australia (for example, the Melbourne and Sydney CBDs have areas with scores above 4.5).

Analysis of the Bike Use Propensity Index, and the results of this report, have been completed using STATA, Excel, and ArcGIS Pro.

1.2 Variables

The sections below detail how scores for each individual variable are assessed and calculated. For

each variable, a powered regression is undertaken. This means the score rises in a non-linear way, rising quicker at low numbers and slower with high numbers. This allows the score to reflect the diminishing effect of a certain threshold of density.

Origin variables are calculated at ABS 2021 Statistical Area Level 2 (SA2). SA2s are defined by the ABS as '*medium-sized general purpose areas [whose] purpose is to represent a community that interacts together socially and economically.*'² Each SA2 covers a population of between 3,000 and 25,000 people, with more people being in denser urban SA2s and fewer being in sparser regional SA2s. The SA2 provides a grain fine enough to identify corridors, but still coarse enough to remove distortive pockets of high density. There are 522 SA2s in Victoria.

Destination variables are calculated at the ABS 2021 Destination Zone (DZN) level. The ABS develops DZNs '*with state and territory transport authorities for the analysis of Place of Work Census of Population and Housing data, commuting patterns and the development of transport policy.*'³ DZNs are smaller than SA2s, but align with SA2 boundaries. This means they can be joined to form an SA2. DZNs are used as they highlight key destination hotspots which would be destinations in their own right, and should have maximum proximity to cycling infrastructure. However, the short trip variable is not calculated at a DZN level, but at a SA2 level. This is because all short trips, not just employment or goods/services trips are included, meaning the coverage of area is likely to be greater (e.g., visiting other residents, parks, leisure, etc). There are 3,011 DZNs in Victoria.

It should be noted that while the curves for each variable are not perfect fits for the data, they have high R² value, indicating they are a good fit. There is a skew away from the higher bands (as noted below), however, this means that they represent the few highest scoring areas in Victoria. As areas are scored on a scale, there is potential to differentiate down to several decimal places. Lastly, these skews are uniform across all values, and do

² ABS 2021, *Statistical Area Level 2*, <https://www.abs.gov.au/statistics/standards/australian-statistical-geography-standard-asgs-edition-3/jul2021-jun2026/main-structure-and-greater-capital-city-statistical-areas/statistical-area-level-2>

³ ABS 2021, *Destination Zones*, <https://www.abs.gov.au/statistics/standards/australian-statistical-geography-standard-asgs-edition-3/jul2021-jun2026/non-abs-structures/destination-zones>

not meaningfully impact the overall composite index.

1.2.1 Residential population density - origin

Residential density is measured as people per hectare at a SA2 level. There is a known relationship between residential density and active travel, which is also influenced by the built form.⁴ The area is taken from the ABS, coded into the SA2 geography shapefile. Population data is sourced from SALUP data provided to the Institute for Sensible Transport by Infrastructure Victoria. This data was analysed, with the top threshold of each quintile used to generate a powered curve to match density with a score. This is shown in Figure 2.

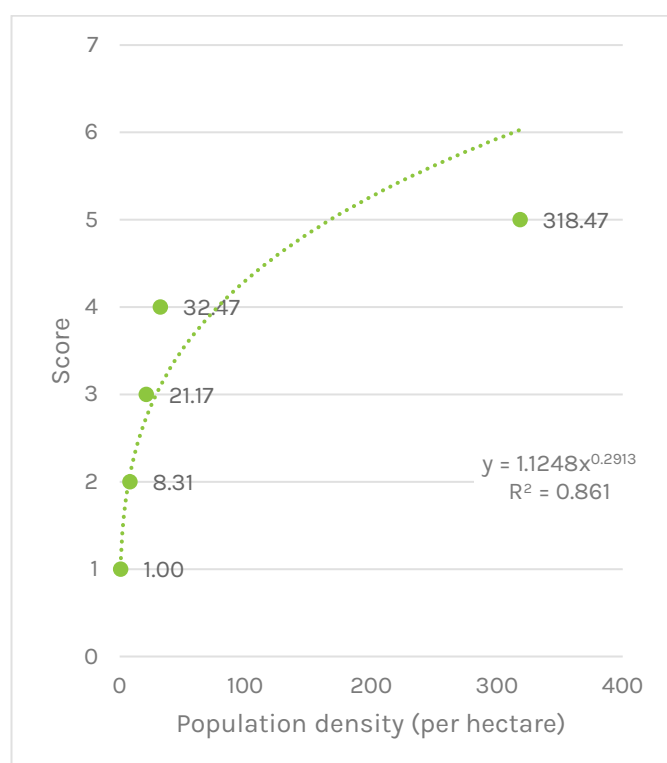


Figure 2 Population density

Note: The dots above show the break point from one score band to the next. The break values are shown to the right.

The distribution of scores applied to SA2s in Victoria is shown in Table 1. Note that while the distribution is skewed towards the middle score band, the score goes to several decimal places, allowing for further graduation, if required.

Table 1 Distribution of population density scores

Score	Count (SA2)	Percentage
0 to 1	111	22%
1 to 2	107	21%
2 to 3	188	37%
3 to 4	95	18%
4 to 5+	13	3%

Population projections from SALUP were used to forecast density, and recalculate scores for future years. These forecasts are based on the same powered equation, revealing increases in propensity.

1.2.2 Density of young people - origin

Density of young people is measured per hectare at a SA2 level. Young people are defined as people between the ages of 12 and 25. This data is taken at the available age ranges included in SALUP, and includes high school students, and younger adults; two cohorts which are known to disproportionately engage in cycling. The area is taken from the ABS, coded into the SA2 geography shapefile. Data is sourced from SALUP data provided to the Institute for Sensible Transport by Infrastructure Victoria. This data was analysed, with the top threshold of each quintile used to generate a powered curve to match density with a score. This is shown in Figure 3.

⁴ Cervero and Kochelman 1997, 'Travel demand and the 3Ds: Density, diversity, and design', *Transportation Research Part D: Transport and Environment*, vol. 2, iss. 3, pp. 199-219
<https://www.sciencedirect.com/science/article/abs/pii/S1361920997000096>

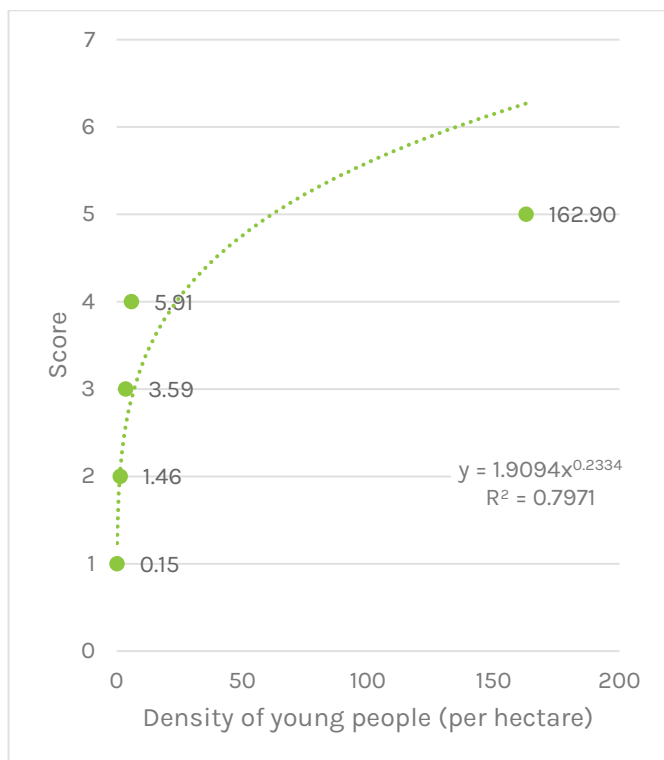


Figure 3 Young person density

Note: The dots above show the break point from one score band to the next. The break values are shown to the right.

The distribution of scores applied to SA2s in Victoria is shown in Table 2. Note that while the distribution is skewed towards the middle score band, the score goes to several decimal places, allowing for further graduation, if required.

Table 2 Distribution of young person density scores

Score	Count (SA2)	Percentage
0 to 1	95	19%
1 to 2	121	24%
2 to 3	246	48%
3 to 4	45	9%
4 to 5+	6	1%

Young people population projections from SALUP were used to forecast density, and recalculate scores for future years. These forecasts are based on the same powered equation, revealing increases in propensity.

1.2.3 Low motor vehicle ownership - origin

Density of low car ownership is measured per hectare at a SA2 level. Low car ownership households are defined as those with zero or one car. This is the data sourced from the 2021 ABS

Census. The area is taken from the ABS, coded into the SA2 geography shapefile. This data was analysed, with the top threshold of each quintile used to generate a powered curve to match density with a score. This is shown in Figure 4.

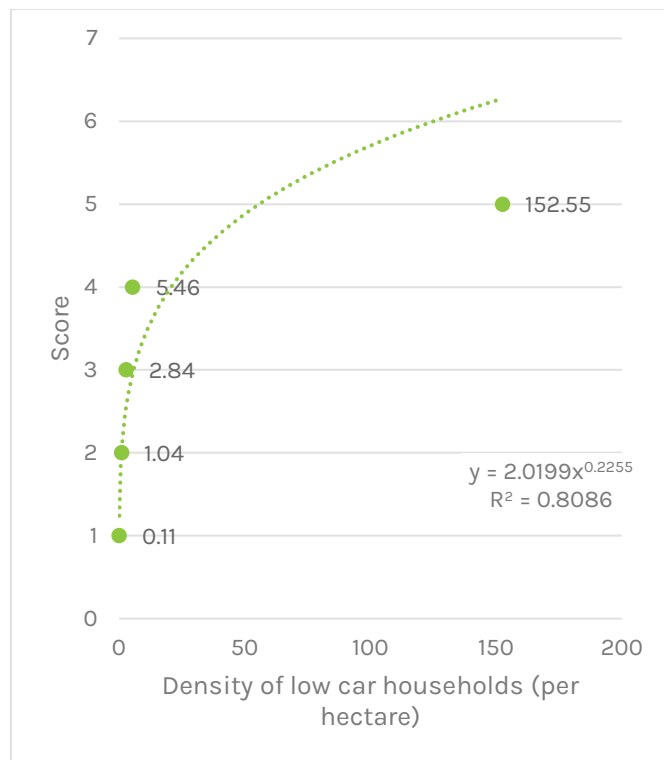


Figure 4 Low car ownership density

Note: The dots above show the break point from one score band to the next. The break values are shown to the right.

The distribution of scores applied to SA2s in Victoria is shown in Table 3. Note that while the distribution is skewed towards the middle score band, the score goes to several decimal places, allowing for further graduation, if required.

Table 3 Distribution of low car ownership density scores

Score	Count (SA2)	Percentage
0 to 1	97	19%
1 to 2	126	24%
2 to 3	221	43%
3 to 4	52	10%
4 to 5+	19	4%

Car projections into the future are not currently known. As such, the 2021 data is used in all forecast periods.

1.2.4 Bicycle use - origin

Density of bicycle use as an origin is measured per hectare at a SA2 level. Bicycle use is based on ABS 2021 Census data. Bicycle use as an origin is included as it provides an indication of where people are currently cycling from. This is important for two reasons. Firstly, it shows where infrastructure is likely to be used by existing users. Secondly, existing bicycle use is a predictor of latent demand, as it shows areas where cycling is most likely to be prevalent, and there is an effect where more people cycling encourages others to cycle.

The data is sourced from the 2021 ABS Census. The area is taken from the ABS, coded into the SA2 geography shapefile. This data was analysed, with the top threshold of each quintile used to generate a powered curve to match density with a score. This is shown in Figure 4.

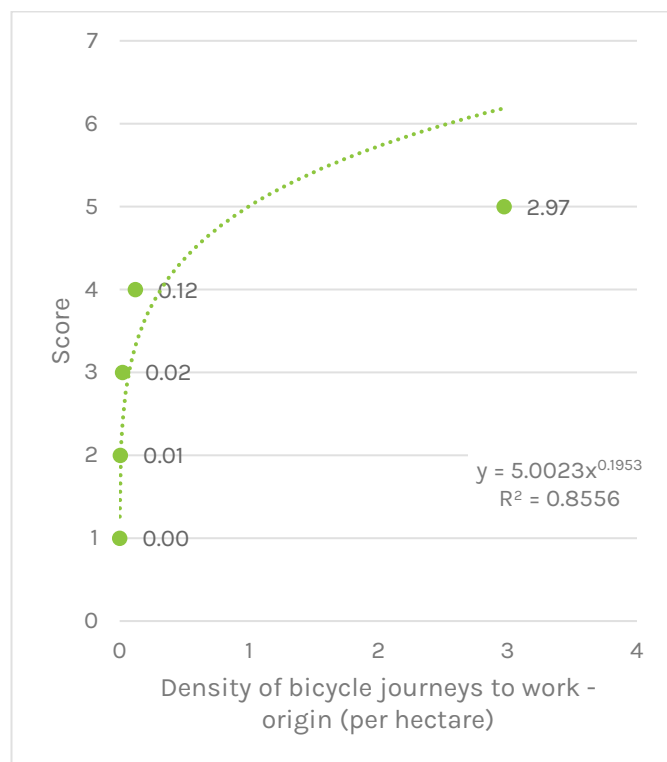


Figure 5 Bicycle use as an origin density

Note: The dots above show the break point from one score band to the next. The break values are shown to the right.

The distribution of scores applied to SA2s in Victoria is shown in Table 3. Note that while the distribution is skewed towards the middle score band, the score goes to several decimal places, allowing for further graduation, if required.

Table 4 Distribution of bicycle use as an origin density scores

Score	Count (SA2)	Percentage
0 to 1	66	14%
1 to 2	129	27%
2 to 3	175	37%
3 to 4	61	13%
4 to 5+	47	10%

Bicycle use projections into the future are not currently known. As such, the 2021 data is used in all forecast periods.

1.2.5 Employment density - destination

Employment density is measured as people per hectare at a DZN level. Like population density, employment density is known to correlate with bike use and latent demand. The area is taken from the ABS, coded into the DZN geography shapefile. Employment data is sourced from SALUP data provided to the Institute for Sensible Transport by Infrastructure Victoria. This data was analysed, with the top threshold of each quintile used to generate a powered curve to match density with a score. This is shown in Figure 6.

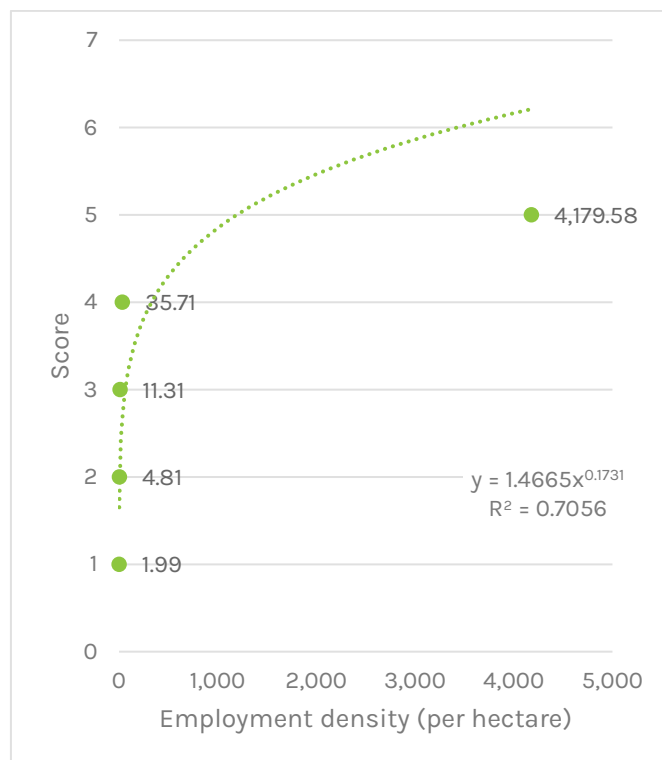


Figure 6 Employment density

Note: The dots above show the break point from one score band to the next. The break values are shown to the right.

The distribution of scores applied to DZNs in Victoria is shown in Table 5. Note that while the distribution is skewed towards the lower middle score bands, the score goes to several decimal places, allowing for further graduation, if required.

Table 5 Distribution of employment density scores

Score	Count (DZN)	Percentage
0 to 1	235	8%
1 to 2	1286	43%
2 to 3	1249	41%
3 to 4	170	6%
4 to 5+	70	2%

Employment projections from SALUP were used to forecast density, and recalculate scores for future years. These forecasts are based on the same powered equation, revealing increases in propensity.

1.2.6 Bicycle use - destination

Density of bicycle use as a destination is measured per hectare at a DZN level. Bicycle use is based on ABS 2021 Census data. Bicycle use as a destination is included as it provides an indication of where people are currently cycling to. This is important for two reasons. Firstly, it shows where infrastructure is likely to be used by existing users. Secondly, existing bicycle use is a predictor of latent demand, as it shows areas where cycling is most likely to be prevalent, and there is an effect where more people cycling encourages others to cycle.

This data is sourced from the 2021 ABS Census. The area is taken from the ABS, coded into the DZN geography shapefile. This data was analysed, with the top threshold of each quintile used to generate a powered curve to match density with a score. This is shown in Figure 7.

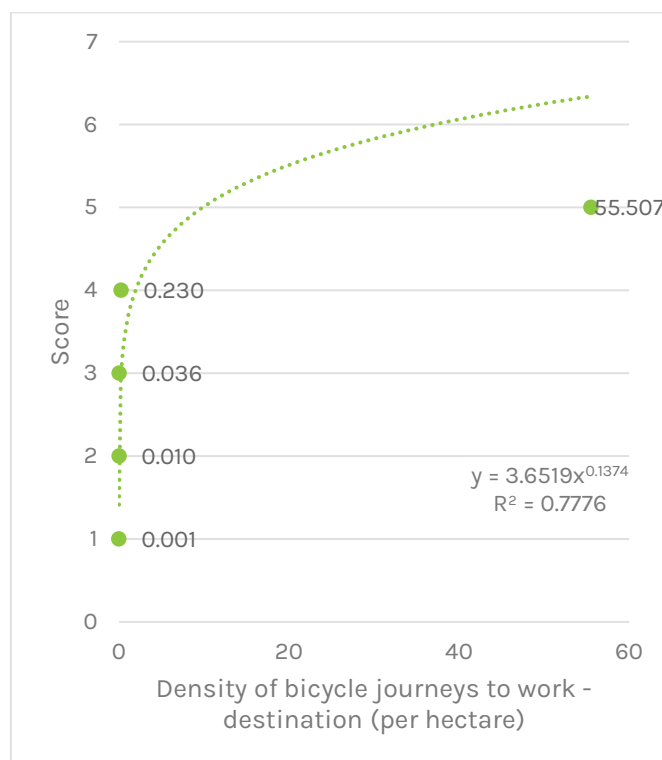


Figure 7 Bicycle use as a destination density

Note: The dots above show the break point from one score band to the next. The break values are shown to the right.

The distribution of scores applied to DZNs in Victoria is shown in Table 6. Note that while the distribution is skewed towards the middle score band, the score goes to several decimal places, allowing for further graduation, if required.

Table 6 Distribution of bicycle use as an origin density scores

Score	Count (DZN)	Percentage
0 to 1	30	2%
1 to 2	146	10%
2 to 3	866	58%
3 to 4	325	22%
4 to 5+	138	9%

Bicycle use projections into the future are not currently known. As such, the 2021 data is used in all forecast periods.

1.2.7 Short Car trips - destination

Density of short car trips is measured per hectare at a SA2 level. Short car trips are defined as those under 5km. Trips under 5km are most transferable to bicycle, noting that the majority of bicycle trips are 5km or under, with an average bike trip

distance in Victoria being around 4 to 4.5km. Short car trips include trips by all purposes and is sourced from VITM provided to the Institute for Sensible Transport by Infrastructure Victoria. The area is taken from the ABS, coded into the SA2 geography shapefile. This data was analysed, with the top threshold of each quintile used to generate a powered curve to match density with a score. This is shown in Figure 8.

Note that VITM data does not fully align with 2021 SA2 boundaries, and there were six SA2s (Brunswick East, Burnside, Lake King, Shepparton - South East, Traralgon - East, and Wodonga) which did not have data. For these six, the average of neighbouring SA2s with similar built form contexts was used.

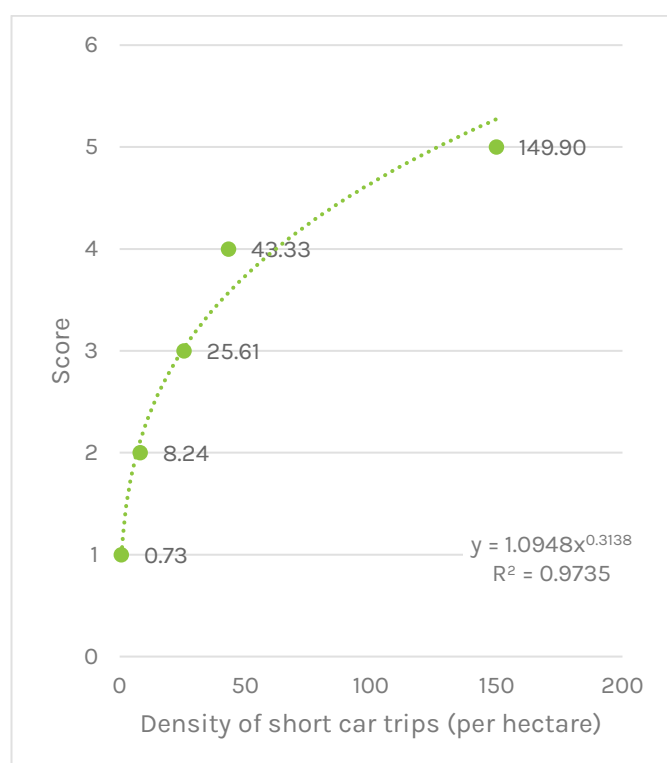


Figure 8 Short car trips density

Note: The dots above show the break point from one score band to the next. The break values are shown to the right.

To align this score with the other variables, each DZN is given the same score as the SA2 it sits within. The distribution of SA2 scores applied to DZNs in Victoria is shown in Table 7. Note that while the distribution is skewed towards the fourth score band, the score goes to several decimal places, allowing for further graduation, if required.

Table 7 Distribution of short car trips density scores

Score	Count (DZN)	Percentage
0 to 1	327	11%
1 to 2	444	15%
2 to 3	622	21%
3 to 4	1,260	42%
4 to 5+	358	12%

Short car trips projections from VITM were used to forecast density, and recalculate scores for future years. These forecasts are based on the same powered equation, revealing increases in propensity.

1.3 Notes

1.3.1 Use of 2021 Census data for bicycle use

The propensity index uses 2021 Census data for bicycle use. This may be seen to cause a distortion, as Melbourne was subject to health orders which restricted movement on the day the census was taken. However, the 2021 was used for the index as it is still deemed most appropriate for the following reasons:

- When looking at those who went to work, shown in Figure 9, results are broadly similar:
 - 2016 bicycle mode share: 1.5%
 - 2021 bicycle mode share: 1.1% (-0.3%)
 - Standard deviation across all LGAs 0.3%

As such, while the data does show a decrease in cycling participation across Victoria, this has been largely similar across all LGAs (notwithstanding the comments below in dot point four).
- ABS 2016 SA2 geographies do not align well to 2021 SA2 in areas of change. This means that the data would be coarser in SA2s which have been split, which is common for growth areas and areas of high change.
- Using 2016 would not account for population growth, and therefore bicycle use growth to 2021, and would therefore be highly unrepresentative of growth areas and areas of high change.

4. There are only four LGAs with a mode share decrease of over -0.5%, which are:

- Merri-Bek (-1.0%)
- Darebin (-0.7%)
- Yarra (-0.6%)
- Maribyrnong (-0.6%)

These areas have all larger numbers of professional workers, which are most likely to continue to be working in hybrid arrangements. As such, that the depressed journey to work cycling activity may be a better reflection of current work commuting practices, rather than a one-off anomaly of the Census.

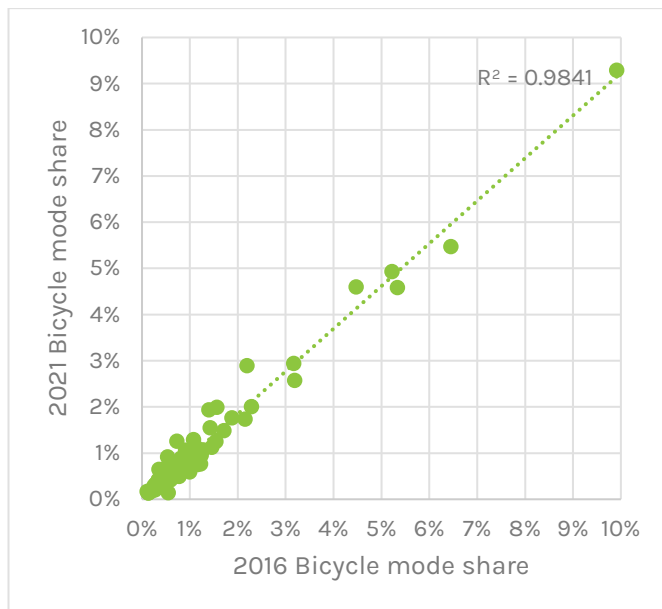


Figure 9 Comparison of 2016 and 2021 Census bicycle mode shares

Note: The dots above represent an LGA in Victoria.

1.3.2 Conversion of destination data to SA2

For the online mapping version of the Bicycle Use Propensity Index, the destination data is presented in SA2 format. The DZN scores were aggregated up to the SA2 level weighted by area.

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