



Research paper

Factors influencing the patronage of flexible transport in urban and rural areas. A case study in NSW, Australia

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ABSTRACT

Since 1990, gradual changes have been observed in the implementation of flexible transport service (FTS) schemes. A growing body of evidence suggests FTS are highly supportive for specific groups, like people with disabilities and the socially disadvantaged. Although this is more evident in rural and regional areas where there may be no fixed public transport routes, some urban FTS schemes have proven effective. However, little empirical research has focused on exploring the factors influencing patronage of FTS in urban and rural areas. This study aims to understand the relationships between patronage and the user's characteristics in New South Wales, Australia, by associating spatial datasets and employing statistical modelling to compare the experience in urban and rural contexts. Results show that users' characteristics of flexible transport are contrastingly different in urban and rural areas; and that this method represents an effective tool to capture the economic and social benefits for FTS users. This study posits that tangible evidence is not enough to evaluate and assess FTS schemes and points out that a careful understanding of the FTS user's benefits is needed to assess the effectiveness of FTS. These findings contribute to a better understanding of flexible transport implementation and provide evidence for FTS scheme proponents and transport funders.

1. Introduction

Flexible transport services (FTS) are progressively being implemented and are attractive because they provide a service customized to users. This is especially relevant because FTS provides a solution for users with mobility disadvantages (Nelson et al., 2017); represents an alternative to conventional public transport in locations where a fixed route service is expensive (Mageean & Nelson, 2003); and is an effective complement for other transport modes, e.g. for first/last mile connections to mainstream public transport (Ryley et al., 2014). Despite its many benefits there are issues with the evaluation of FTS schemes which are discussed below.

Although there is a growing body of literature that recognizes the importance of conducting a comprehensive evaluation of flexible transport (see, for example, Alonso-González et al. (2018); Grunicke et al. (2021)), most previous studies have focused on the evaluation of the operation of flexible transport. These studies use performance measures of FTS (see for example TCRP (2008)) but the post evaluation of an implemented flexible transport scheme in terms of wider benefits have received less attention. This might be due to limitations of individual

case studies where contextual factors are difficult to replicate. Nevertheless, the impact of flexible transport schemes and the contributing variables to the patronage of FTS have remained largely unstudied.

This study asks how we can understand the relationships between patronage and the users' characteristics in FTS schemes in urban and rural areas. To answer this question this study associates spatial datasets, namely the operational data from the transport provider, with the Australian Census data (ABS, 2016) using QGIS software. This association allow us to describe the relationships between patronage with economic and social variables collected in the Census. In addition, we developed a statistical model to explore how the service characteristics influence patronage in urban and rural FTS schemes.

This paper is organized as it follows; we begin by describing the method and the statistical model together with the selected FTS schemes characteristics and location. This is followed by the results of the datasets association describing the inferred economic and social benefits for FTS users. We conclude with a discussion of the study, limitations and areas for future research.

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2. Material and methods

This section describes the data sources and statistical methods used to evaluate the potential benefits of flexible transport in rural and urban areas. New South Wales (NSW), the largest state in southeast Australia is used as an empirical setting.

2.1. Data sources

Transport for New South Wales has launched several flexible transport trials since 2018 (in this context a trial is a temporary scheme that will be made permanent if the scheme is deemed viable). In this paper, a total of seven schemes were analysed, three from urban areas and four from rural or regional areas. Fig. 1 shows the location of the FTS schemes investigated in this study. Sub-section 2.2 shows the service characteristics of the flexible transport schemes. This study utilised a method similar to the one used by Loyola & Nelson, 2022. A brief description is offered below.

The method consists of combining multiple datasets and associated statistics that represent the population served by each flexible transport scheme. There are two key datasets, namely operational pick-up and drop-off data provided by TfNSW and the 2016 Australian Census data available publicly (ABS, 2016). To combine datasets, we used specialized spatial software (QGIS) that allows us to capture the characteristics of the most disaggregated statistical area from the Census (these statistical areas are called SA1 and correspond to 200–800 people).

Once the datasets are combined, we proceed to firstly, show the results of the dataset association per scheme and type (types: rural and urban). This is relevant because having a detailed description of the characteristics of the user base allows for a broader understanding of the FTS impact on the users and a comparison between urban and rural areas for the same region (NSW). Secondly, to capture how the socio-demographic characteristics affect patronage, we developed a count model controlling the socio-demographic characteristics, fleet size, and operating hours. Controlling for socio-demographic differences across regions where FTS was trialled is important because this allows us to identify the impact of fleet size and operation hours on patronage and how the impact may vary between urban and rural settings.

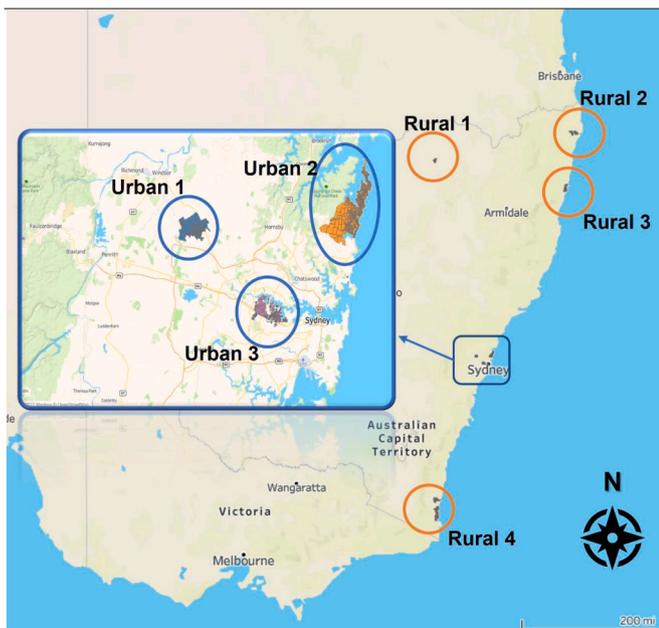


Fig. 1. Image of southeast Australia with the location of flexible transport services (FTS) schemes explored in this study.

2.2. Service characteristics

Several FTS schemes (called “On-Demand Transport” or ODT in New South Wales) were implemented by the NSW Government as part of its “Future Transport Strategy 2056” (Transport for NSW, 2018). Some of these schemes started as pilots and did not continue, other schemes were made permanent and are currently operating. For this study we have chosen seven established FTS schemes. Table 1 shows selected service characteristics of the seven schemes investigated in this study.

2.3. Modelling method

A Negative Binomial is specified for the count of on-demand transport daily trips for each stop. Briefly, for a discrete random variable, Y , that represents the daily trips and their observed frequencies, y_i for each stop point $i = 1, \dots, n$, where y_i is a non-negative integer count, and regressors x_i (including fleet size and operating hours). The model is specified as:

$$Prob(Y = y_i | x_i, \epsilon_i) = \frac{\theta^\lambda \lambda_i^{y_i}}{\Gamma(\theta) y_i!} \frac{\Gamma(y_i + \theta)}{(\lambda_i + \theta)^{y_i + \theta}}, y_i = 0, 1, \dots; \log \lambda_i = \beta' x_i;$$

$$\log \mu_i = \log \lambda_i + \epsilon_i$$

where λ_i is the variance of y_i per unit of time T_i ; μ_i is the conditional mean, ϵ_i is the heterogeneity, $\theta = 1/\alpha$ is the over-dispersion parameter, $\Gamma(\cdot)$ is the gamma function, and q_i is the ancillary probability, described by a binary logit $q_i = \Lambda(\gamma' z_i) = \frac{\exp(\gamma' z_i)}{1 + \exp(\gamma' z_i)}$, or binary probit model $q_i = \Phi(\gamma' z_i) = \int_{-\infty}^{\gamma' z_i} \frac{\exp(-\frac{t^2}{2})}{\sqrt{2\pi}} dt$ with γ being a vector of parameters to be estimated for a set of variables z_i which may or may not share with x_i .

3. Results

This study associates pick-up locations with disaggregated information from the Census, and statistical methods to explore the relationship between patronage and socio-demographic variables in different FTS schemes within the same region (NSW). The following sub-sections show the results from the dataset association in terms of urban and rural FTS schemes (sub-section 3.1) and a Negative Binomial model to show how the socio-demographic characteristics affect patronage (sub-section 3.2).

3.1. Users' characteristics - urban vs rural

A useful way to calculate the social benefits is given by the number of people who need assistance. The Census captures this number and defines it as “the number of people with a profound or severe core activity limitation. People with a profound or severe core activity limitation are those needing assistance in their day-to-day lives in one or more of the three core activity areas of self-care, mobility and communication because of 1) a long-term health condition (lasting six months or more), 2) a disability (lasting six months or more), or 3) old age” (ABS, 2021). To be able to visualize the people needing assistance we have divided the number of people who need assistance by the total population at each statistical area - SA1-to create a variable called Assistance Index. Fig. 2 compares the patronage (percent per scheme per SA1), population (per SA1), median weekly household income per SA1, and the Assistance Index to capture where FTS schemes are more likely to help people who need help based on income and social benefits. Further contextual information is given in the Appendix.

In terms of income, Fig. 2 compares the patronage and the income from users in urban and rural schemes. On average, the weekly household income for rural schemes is AUD 965 while the average for the urban schemes is AUD 1835. These results are important because they illustrate the type of relationships that can be captured using this study

Table 1
Characteristics of the FTS schemes.

Type	Scheme (code)	Operated by	Location	Number of vehicles (details of vehicles, if available)	Operating hours
Urban	Urban 1 (M01)	Cooee	The Ponds	6	Monday-Friday: 5:00am–9:00pm
	Urban 2 (P03)	Keolis Downer	Northern Beaches	10 (8 Kia Carnivals, 2 Mercedes Sprinters)	Monday–Wednesday: 6:00am–10:00pm Thursday–Friday: 6:00am–11:30pm Saturday: 7:00am–11:30pm Sunday: 7:00am–9:00pm Service operates on some but not all public holidays (decided by operator, approved by TfNSW)
	Urban 3 (SBSC)	BRIDJ/Transit Systems	Inner West	8 (10 at peak times)	Weekdays: 6:00am–11:30pm Weekends: 8:00am–8:30pm
Rural	Rural 1 (R06)	Reynolds and Fogarty	Moree	3 (Category 2 vehicles)	Monday to Sunday 7:00am–7:00pm including public holidays
	Rural 2 (R07)	Buslines	Northern Rivers	2 (11 seater Toyota Commuter minibuses fitted with wheelchair hoists)	Monday–Friday: 6:45am–6:00pm Saturday: 7:45am–2:15pm
	Rural 3 (R08)	Forest CDC	Coffs Harbour	2 (Kia Carnivals with capacity for 6 passengers)	Monday–Friday: 7:00am–7:00pm Saturday: 8:00am–2:00pm
	Rural 4 (R09)	Sapphire Coast Buslines	Bega Tura Beach/Merimbula/ Pambula service Eden service	3 (2 × 17 seater, low floor, mini bus with one wheelchair position (Bega & Tura Beach) 1 x existing school bus with low floor (Eden))	Bega & Tura Beach/ ...: Mon to Sun 9:30am–2:45pm, Sat 9:30am–3:35pm Eden: Monday to Friday 8:45am – 1pm (school days only)

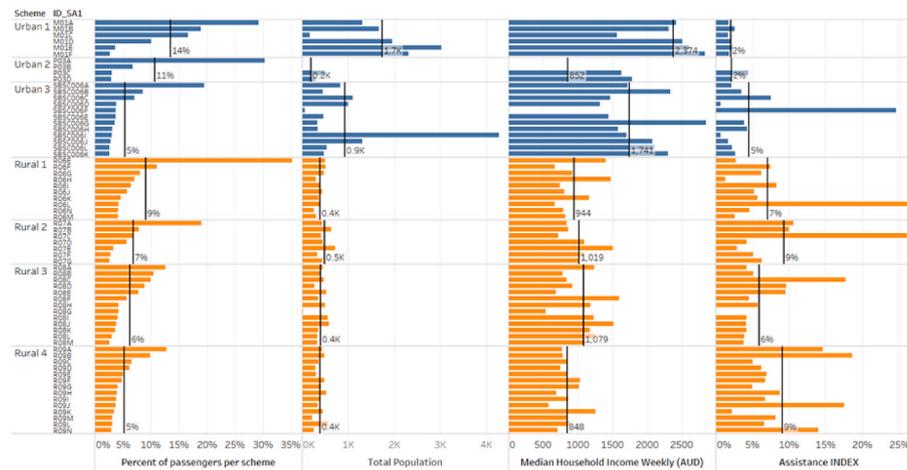


Fig. 2. Patronage, population, household weekly income, and Assistance Index for statistical areas (SA1) with patronage above 2.5%.

methodology. In essence, since we now know the average income and the patronage in a statistical area (SA1), we can estimate the economic gains for FTS users with an inverse relationship - the lower the income indicates that the FTS scheme represents a higher value for its users.

In terms of social benefits, we can also use Fig. 2 to compare the patronage and the Assistance Index to capture where FTS schemes are more likely to help people who need help. Fig. 2 shows that the Assistance Index is much higher in rural areas (average 7.7%) than in urban areas (average 3.5%). Interestingly, the relationships in the data may not align with initial expectations. When comparing indicators within urban or rural schemes, it is essential to consider the percentage of passengers per scheme. For instance, comparing the Assistance Index between Urban 3 and Urban 1: In Urban 3, the highest Assistance Index of 24.6% (SA1: SBSC006F) is linked to 4% of passengers in the scheme, which equals 1,986 FTS users. In contrast, in Urban 1, the highest Assistance Index (SA1: M01B) of 2.6% corresponds to 19% of passengers in the scheme, totalling 18,577 FTS users. Thus, it should be noted that when evaluating indicators captured through this method, it is crucial to take into account the population served. Additionally, various other indicators can help determine which groups receive more social benefits, such as the Aboriginal population, the number of cars per household, age, household structure, and other socio-demographic information found in Census data (see section 6, limitations).

3.2. Model specification and estimation

Table 2 shows the estimation results of the negative binomial model for daily trips at each stop point (pick-up location) served by on-demand transport. Overall, all variables have the expected sign. Interpretation of the model parameters is straightforward, with a positive parameter indicating the positive relationship between that explanatory variable and the dependent variables. For example, compared to Mondays (i.e., the base) demand for FTS on the weekends is much lower (see the significant and negative parameter estimates associated with Saturday and Sunday dummies) while the variation in daily trips across the weekdays is not statistically significant (all other day-of-the-week dummies are not significant at 95% level of confidence). The following highlights the important modelling results.

- All else being equal, demand for FTS is expected to be lower in areas with higher median personal income; however, the effect of income varies by setting with income having less negative effect on the demand for FTS in regional areas, except for Northern Rivers (Rural 2) where the impact of income is even more negative. This can be seen by the statistically significant interaction in terms of median income and regional dummies.

Table 2
Estimation of daily trips for each stop served by flexible transport.

term	Description	Estimate	se	sign.	p-value
(Intercept)	constant	3.4158	0.072	***	0.000
dow_1	Sunday dummy (base = Monday)	-0.0443	0.015	***	0.002
dow_3	Tuesday dummy (base = Monday)	0.0061	0.008		0.465
dow_4	Wednesday dummy (base = Monday)	0.0053	0.008		0.523
dow_5	Thursday dummy (base = Monday)	0.0006	0.008		0.941
dow_6	Friday dummy (base = Monday)	-0.0151	0.008	*	0.076
dow_7	Saturday dummy (base = Monday)	-0.0435	0.010	***	0.000
flsize	fleet size (or number of vehicles)	0.1849	0.002	***	0.000
operatehr	operating hours	0.0255	0.004	***	0.000
totpop	SA1 population	0.0001	0.000	***	0.000
medpinc	SA1 median personal weekly income (\$)	-0.0012	0.000	***	0.000
medwrent	SA1 median weekly rent cost (\$)	-0.0005	0.000	***	0.000
medmort	SA1 median monthly mortgage repayment (\$)	-0.0001	0.000	***	0.000
assistedpop	SA1 population need assistance	-0.0041	0.000	***	0.000
percveh0	SA1 percent of zero vehicle household	3.1082	0.070	***	0.000
contract_R06	Contract R06 dummy (base metro area)	-4.4267	0.044	***	0.000
contract_R07	Contract R07 dummy (base metro area)	-1.9519	0.072	***	0.000
contract_R08	Contract R08 dummy (base metro area)	-2.3079	0.081	***	0.000
contract_R09	Contract R09 dummy (base metro area)	-3.4877	0.093	***	0.000
medpinc_contractR06	median personal weekly income * Contract R06	0.0041	0.000	***	0.000
medpinc_contractR07	median personal weekly income * Contract R07	-0.0003	0.000	***	0.006
medpinc_contractR08	median personal weekly income * Contract R08	0.0005	0.000	***	0.000
medpinc_contractR09	median personal weekly income * Contract R09	0.0026	0.000	***	0.000
theta	Dispersion parameter	3.085			
LogLik	Log Likelihood	-549,178			

Note: *** significance at 1% and * 10% level.

- Controlling for the difference in operating hours, fleet size, population, and other socio-demographics, FTS in regional areas have significantly lower expected trips than those in an urban setting (the base).
- As expected, longer operating hours and higher fleet size are associated with higher demand for FTS, as shown by the positive and significant parameters for these two variables.

4. Discussion

The main factor for the evaluation of an implemented public transport service is generally patronage. In the case of flexible transport services (FTS), this is usually the more important factor too. This makes sense because patronage is an accurate indicator of the usefulness of an FTS scheme. This study aims to explore the relationship between patronage and the socio-demographic characteristics of its users. To achieve that the method associated operational data with Census data to infer the economic and social benefits per statistical area (SA1). In addition, this study developed a statistical model to evaluate how the socio-demographic characteristics of its users affect patronage.

The results of this study show that by the association of relevant data we can establish an accurate estimation of the economic and social benefits for its users. Because we know the patronage at each SA1 (from the operational data) and the socio-demographic characteristics of each SA1 (from the Census data) we can illustrate the relationship between patronage and the different economic and social characteristics captured by the Census data. The economic gains can be established by the correspondence between patronage with the average weekly income of the users at each SA1 (see Fig. 2). Other variables found in the Census that are indicative of economic status, like the number of vehicles per household, the weekly rent, or the household size, were also investigated in the modelling with all variables but household being found to influence daily trips. The social benefits can be inferred in the same way but using patronage and social indicators to show how disadvantaged the users of FTS might be. These indicators range from ethnicity (especially important in rural areas), family composition, and people who need assistance (the Assistance Index in Fig. 2).

To show how this method can be used we explored the relationship between patronage with variables from the Census data from seven FTS schemes in the state of NSW Australia. Three of these schemes were from urban areas and four were from rural areas (see Table 1 for details). Results show that the correspondence between patronage and socio-demographic variables varies among schemes in urban and rural settings. We found that the expected economic benefits and social benefits are generally greater in rural areas than in urban areas. Interestingly, the results of the NegBin model shows that patronage is expected to be lower in areas with higher median personal income, and flexible transport in regional areas has significantly lower expected trips than those in an urban setting. The results from the data association and the model are very relevant because it shows that although we can expect higher patronage in urban areas, the economic and social needs are greater in rural areas (which means that where ridership is higher the benefit is not as great). In other words, having lower patronage should not impede implementing FTS schemes in a rural setting where its deployment could generate economic and social benefits that might be more representative than those in urban settings.

5. Limitations

In this study, the determination of economic and social benefits is primarily founded on the proportion of lower-income individuals and those requiring assistance (as defined in the Census) within a specific geographical area and we have used the Assistance Index as an indicator of the social benefits. It is acknowledged that the Census data can be used to collect social indicators that might be quite insightful like age and sex, marital status, household composition, education, income,

employment, language and cultural background, indigenous status, disability status, and housing tenure. These indicators can help provide a comprehensive understanding of the demographic and socio-economic characteristics of the population, informing decision-making and policy development when deciding to implement FTS schemes.

A second limitation is that the current methodology employs relative values in the analysis, which results in urban areas exhibiting lower proportions of low-income individuals and those in need of assistance compared to rural areas. This approach may not fully capture the benefits experienced by these groups in urban settings. Despite the lower proportions observed in urban areas, it is important to consider the overall population size, which is typically higher in urban centres. Consequently, the absolute number of low-income individuals and those requiring assistance might be greater in urban areas than the proportions would suggest. This implies that, in terms of sheer numbers, the benefits offered by social programs and services in urban areas could potentially be more substantial than those in rural areas, even though the relative proportions might be lower.

To gain a more accurate understanding of the economic and social benefits across different regions, it might be helpful to consider both relative and absolute measures in the analysis. This is one of the highlights of this method, it permits the disaggregation of the data using the Census data to its more granular form. Therefore, it is an approach that could provide a more comprehensive assessment of the benefits derived by low-income individuals and those requiring assistance, allowing for more effective policy evaluation and decision-making.

6. Conclusions

The present study aimed to examine the relationship between patronage and the socio-demographics of its users. This study has shown that the association of operational data with Census data represents a valuable tool for the post-evaluation and assessment of FTS schemes. This is because it enables the inference of economic and social benefits using data already collected (Census data). The implications of these results are relevant to policymakers to evaluate and assess FTS schemes.

For example, policymakers could decide to continue or stop an FTS scheme based on the economic and social benefits for its users.

While patronage may be higher in urban areas, the needs of rural areas might be more substantial, making FTS schemes potentially more crucial in these regions. The current study sets the stage for future research, which could involve examining the local implications of FTS schemes across various statistical areas using longitudinal datasets. This would enable a more in-depth understanding of the evolution of FTS schemes over time and their impacts on specific communities. Furthermore, future research could investigate the benefits of FTS for different demographic groups within regions, making use of other social indicators from the Census, thus allowing for a more nuanced assessment of how these schemes serve diverse populations.

By exploring these avenues in future research, scholars and policymakers can gain a more comprehensive understanding of the implications of FTS schemes and develop more targeted and effective strategies to address the unique transportation needs of different communities.

CRedit authorship contribution statement

Miguel Loyola: Methodology, Formal analysis, Writing – original draft. **John D. Nelson:** Conceptualization, Methodology, Writing – review & editing. **Geoffrey Clifton:** Writing – review & editing. **Chinh Q. Ho:** Formal analysis, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix. Patronage per scheme and selected socio-demographics from the Census data

Scheme	ID_SA1	Scheme percent of passengers	Med Household Income Weekly	Avg. Number motor vehicles/Total dwellings	Median Age	Ave Household Size	Assistance Index	Number of passengers
Urban 1	M01A	29%	2,420	386	30	3	1.8%	28,692
	M01B	19%	2,314	509	32	3	2.6%	18,577
	M01C	17%	1,562	52	42	4	1.7%	16,303
	M01D	10%	2,509	554	32	3	2.0%	9,943
	M01E	4%	2,607	839	32	4	2.4%	3,535
	M01F	3%	2,829	638	32	4	1.9%	2,686
Urban 2	P03A	30%	0	0	0	0	0.0%	57,724
	P03B	7%	0	0	0	0		12,863
	P03C	3%	1,625	205	50	2	4.4%	5,649
	P03D	3%	1,783	140	40	2	2.1%	5,479
Urban 3	SBSC006A	20%	1,720	237	29	3	2.2%	10,556
	SBSC006B	9%	2,338	186	42	2	3.5%	4,680
	SBSC006C	7%	1,467	354	31	3	7.5%	3,776
	SBSC006D	4%	1,315	313	26	3	0.7%	2,059
	SBSC006F	4%	0	0	54	0	24.6%	1,986
	SBSC006E	4%	1,440	200	28	2	0.0%	1,987
	SBSC006G	4%	2,845	124	49	3	3.9%	1,898
	SBSC006H	3%	1,583	96	37	3	4.3%	1,683
	SBSC006I	3%	1,700	1,712	30	2	0.7%	1,635
	SBSC006J	3%	2,076	543	36	2	1.7%	1,523
	SBSC006L	3%	2,100	176	42	3	2.2%	1,393
	SBSC006K	3%	2,307	152	38	3	2.7%	1,398
Rural 1	R06E	35%	1,399	208	37	2	2.8%	21,659
	R06F	11%	667	158	30	3	7.5%	6,846
	R06G	8%	920	199	45	2	6.2%	4,982
	R06H	7%	1,470	114	33	2	1.3%	4,311

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Scheme	ID_SAI	Scheme percent of passengers	Med Household Income Weekly	Avg. Number motor vehicles/Total dwellings	Median Age	Ave Household Size	Assistance Index	Number of passengers
	R06I	6%	739	146	45	2	8.3%	3,964
	R06J	6%	808	146	33	3	5.3%	3,498
	R06K	5%	1,163	125	36	3	5.6%	2,822
	R06L	4%	670	154	63	2	26.8%	2,604
	R06N	4%	789	75	34	3	4.6%	2,546
	R06M	4%	819	87	40	3	2.6%	2,553
Rural 2	R07A	19%	839	163	34	2	10.6%	4,060
	R07B	8%	865	303	50	2	10.0%	1,688
	R07C	7%	720	141	56	2	26.0%	1,426
	R07D	6%	1,094	171	45	2	4.2%	1,202
	R07E	3%	1,508	248	35	3	2.9%	715
	R07F	3%	1,086	134	44	2	5.1%	599
	R07G	3%	1,018	189	48	2	6.3%	564
Rural 3	R08A	13%	1,237	158	36	3	4.2%	2,492
	R08B	11%	783	170	48	2	5.1%	2,079
	R08C	10%	837	163	53	2	17.7%	1,986
	R08D	9%	918	95	47	3	9.6%	1,764
	R08E	8%	682	258	67	2	9.6%	1,550
	R08F	6%	1,597	131	48	2	4.5%	1,099
	R08H	4%	1,177	186	44	3	5.8%	832
	R08G	4%	537	4	47	1	0.0%	834
	R08I	4%	1,228	193	37	3	4.2%	789
	R08J	4%	1,511	208	47	3	4.1%	759
	R08K	4%	1,169	116	36	3	4.2%	704
	R08L	3%	1,235	97	44	3	3.9%	591
	R08M	3%	1,111	133	43	2	3.9%	507
Rural 4	R09A	13%	771	197	47	2	14.6%	2,739
	R09B	10%	783	179	51	2	18.6%	2,121
	R09C	7%	845	167	54	2	5.1%	1,392
	R09D	6%	751	153	48	2	6.3%	1,297
	R09E	5%	844	136	45	2	6.9%	1,060
	R09F	5%	1,035	175	39	3	6.8%	1,036
	R09G	4%	1,014	158	44	2	5.0%	857
	R09H	4%	691	225	48	2	8.8%	834
	R09I	4%	859	144	41	2	6.8%	813
	R09J	4%	578	155	76	1	17.5%	801
	R09K	3%	1,256	161	35	3	2.2%	736
	R09M	3%	853	120	61	2	8.1%	660
	R09L	3%	888	262	65	2	6.6%	668
	R09N	3%	705	137	52	2	13.9%	628

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