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TRANSPORT FINDINGS

Comparison of the Person Flow on Cycle Tracks vs Lanes for Motorized Vehicles

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Transport Findings

We compare the person flow on cycle tracks and lanes for motorized traffic on seven streets in Santiago, Chile. In peak periods, we find that most streets have a higher person flow rate per lane using motor vehicles than riding bicycles. However, when the consumption of road space is considered, the conclusion is reversed as most cycle tracks achieve a greater person flow per meter of width than the lanes for motor vehicles in the same street. An analysis of transport capacity for car and cycle lanes provides results in line with our empirical findings.

RESEARCH QUESTION AND HYPOTHESIS

Cycling improves riders' health and counteracts traffic externalities such as congestion and pollution. City authorities are, therefore, actively seeking ways to increase bicycle use in cities. Even though well-designed cycle tracks enhance riders' comfort (Blanc and Figliozzi 2016) and safety (Rossetti et al. 2018; Ling et al. 2020), the provision of cycling infrastructure remains a complex issue given the limited road space available in cities. Because of this, it is common for planners to design new cycle lanes that occupy space previously allocated to car traffic, parking, and sidewalks. In this paper, we analyze the intensity of cycle lane use by comparing the person flow in cycle lanes with the person flow in the adjacent motor vehicle lanes. The objective is to provide empirical evidence to ascertain the efficiency of the use of road space. This is achieved by determining whether cycle lanes are used by a greater number of travelers than the lanes for motor vehicles, first in absolute numbers (flow), and then as a function of the road space (width) allocated to lanes for bicycles and motorized traffic. A variable that measures the flow per unit of road width is used, in line with the flux concept proposed by Levinson *et al.* (2017). Simple as it is, such a comparison is usually missing in the assessment of cycle lanes after they are introduced on roads.

METHODS AND DATA

The study is carried out in seven streets that have exclusive cycle tracks in Santiago, Chile. Travelers on bicycles and inside motor vehicles are counted, either during the morning peak period (8 AM to 10 AM) or during the afternoon peak period (5:30 PM to 8:00 PM). Only one location per street is observed. In three cases, the sites observed are at the intersection of two cycle tracks. The fourth site is on Andrés Bello Avenue, which is likely to have the highest bicycle flow rate in the city. Though the site selection is arbitrary, the aim is to represent a variety of situations including newer cycle tracks (no more

Table 1: Description of the counting locations. MV: motor vehicles

Street	Intersection	Municipality	Number of MV lanes	MV road width (m)	Cycling lane width (m)	Measurement period	Days of data collection
Eleuterio Ramírez	Arturo Prat	Santiago	1	4.5	1.6	8:00 - 10:00 h	3, 4, 5 April 2017
Arturo Prat	Eleuterio Ramírez	Santiago	2	5.3	2.0	8:00 - 10:00 h	3, 4, 5 April 2017
Rosas	Teatinos	Santiago	1	4.5	2.4	17:30 - 20:00 h	17, 18, 24 April 2017
Teatinos	Rosas	Santiago	2	6	2.4	17:30 - 20:00 h	17, 18, 24 April 2017
Pocuro	Ricardo Lyon	Providencia	2	6	2.0	8:00 - 10:00 h	4, 10, 11 April 2017
Ricardo Lyon	Pocuro	Providencia	2	5.8	2.6	8:00 - 10:00 h	4, 10, 11 April 2017
Andrés Bello	Pedro de Valdivia	Providencia	7	21	2.6	17:30 - 20:00 h	4, 10, 11 April 2017

than two years old, such as Arturo Prat and Eleuterio Ramírez), more mature cycle tracks (between three and five years old, such as Rosas, Teatinos and Ricardo Lyon), and older cycle tracks (more than five years old, such as Pocuro and Andrés Bello). Five of the cycle tracks are on-street; Pocuro and Andrés Bello are off-street. All streets are one-way for motor vehicles, whereas all cycle tracks are bidirectional. There is no public transport on the streets selected. The description of each site is shown in Table 1, and three cycle tracks (two on-street and one off-street) are shown in Figure 1: Eleuterio Ramírez (top), Rosas (middle) and Andrés Bello (bottom).

The data is drawn from on-field measurements recorded by a single observer with a video camera. The counting of passengers inside motor vehicles is done in real-time by the observer, while cyclists are counted using the recorded videos. The data collection took place over three working days at each point; thus, there are 6 hours of recording for morning peak locations and 7.5 hours for afternoon peak locations, as detailed in Table 1. The flow of motor vehicles is represented per lane. The weather conditions during the data collection were mild (around 20°C) with no rain.

We calculate the person flow (q_i) and the person flow per meter (m) of road width f_i, for motor vehicles ($i = a$) and bicycles ($i = b$), for flows aggregated every 30 minutes ($0.5h$). Based on these indicators, we built the following ratios to compare the flows of bicycles vs. motor vehicles:

$$Q = \frac{q_b}{q_a} = \frac{cycle\ lane\ flow\ [pax/(0.5h)]}{motorized\ vehicles\ flow\ [pax/(0.5h)]} \quad (1)$$

$$F = \frac{f_b}{f_a} = \frac{cycle\ lane\ flow\ per\ lane\ width\ [pax/(0.5h)/m]}{motorized\ vehicles\ flow\ per\ lane\ width\ [pax/(0.5h)/m]} \quad (2)$$

Figure 1a: On-street cycle track Eleuterio Ramirez

Figure 1b: On-street cycle track Rosas

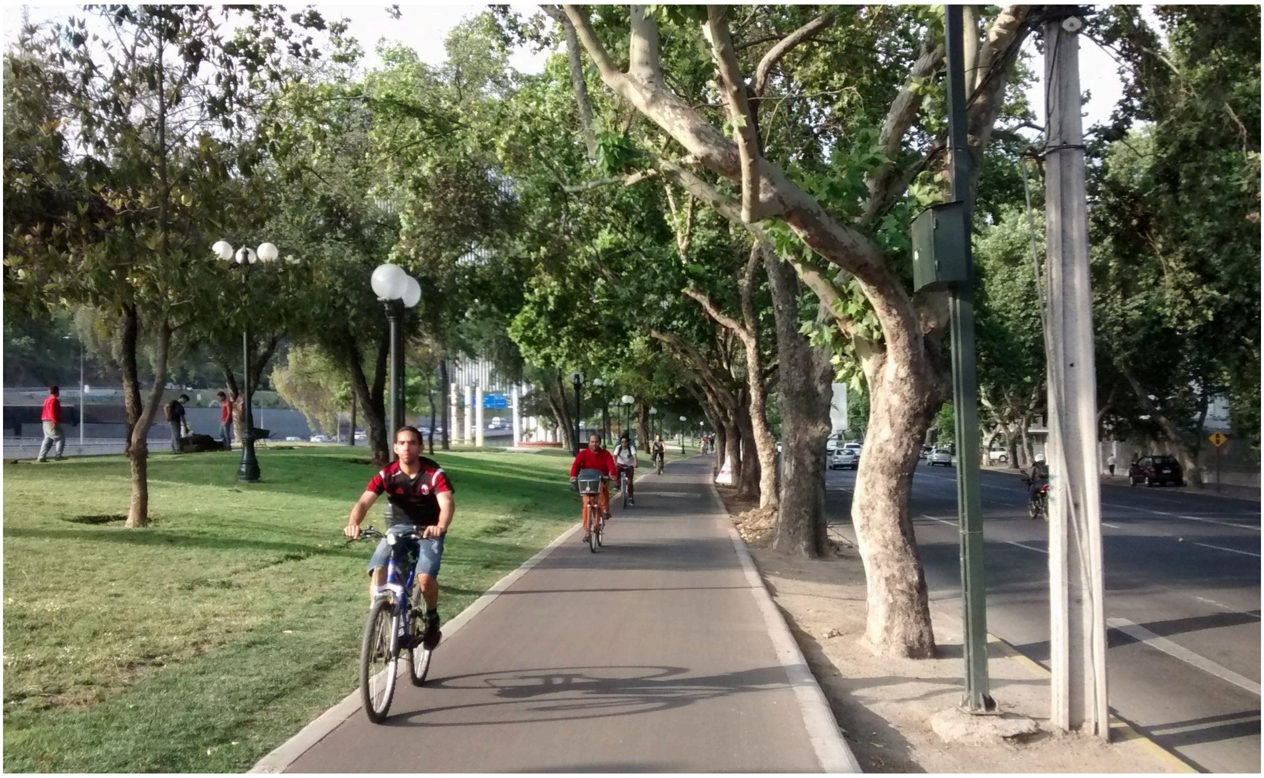

Figure 1c: Off-street cycle track Andrés Bello

FINDINGS

The measurements of person flow are presented in Tables 2 and 3. Because cycle tracks are bidirectional and motorized traffic is unidirectional in all cases, we calculate bicycle flow in the same direction as motor vehicles (*b1*), counterflow (*b2*), and total (*btot*). Figure 2 presents the calculation of indices Q and F for motor vehicles relative to bicycles running in the same direction as motor vehicles (indices Q_1 and F_1) and total (in both directions, indices Q_{tot} and F_{tot}).

Table 2: Person flow in bicycles and motor vehicles

Street	Period	Persons in motor vehicles (q_a)	Bicycle riders in cycle lanes		
			Same direction (q_{b1})	Counterflow (q_{b2})	Total (q_{btot})
Rosas	17:30 - 18:00	274	90	63	153
	18:00 - 18:30	284	133	223	
	18:30 - 19:00	293	176	90	266
	19:00 - 19:30	276	194	70	264
	19:30 - 20:00	271	164	52	216
	Total	1398	757	365	1122
Teatinos	17:30 - 18:00	250	45	49	94
	18:00 - 18:30	204	48	89	137
	18:30 - 19:00	188	46	97	143
	19:00 - 19:30	206	47	72	119
	19:30 - 20:00	229	36	53	89
	Total	1077	222	360	582
Andrés Bello	17:30 - 18:00	284	86	169	255
	18:00 - 18:30	259	114	318	432
	18:30 - 19:00	298	140	331	471
	19:00 - 19:30	254	143	326	469
	19:30 - 20:00	211	120	207	327
	Total	1306	603	1351	1954
Eleuterio Ramírez	8:00 - 8:30	420	90	31	121
	8:30 - 9:00	393	82	31	113
	9:00 - 9:30	409	85	22	107
	9:30 - 10:00	393	62	16	78
	Total	1615	319	100	419
Arturo Prat	8:00 - 8:30	84	10	28	38
	8:30 - 9:00	89	9	30	39
	9:00 - 9:30	90	16	19	35
	9:30 - 10:00	99	14	14	28
	Total	362	49	91	140
Ricardo Lyon	8:00 - 8:30	364	216	32	248
	8:30 - 9:00	373	235	26	261
	9:00 - 9:30	288	151	25	176
	9:30 - 10:00	320	95	59	154
	Total	1345	697	142	839
Pocuro	8:00 - 8:30	339	184	151	335
	8:30 - 9:00	333	118	166	284
	9:00 - 9:30	313	77	106	183
	9:30 - 10:00	353	60	83	143
	Total	1338	439	506	945

Street	Period	Persons in motor vehicles (q_a)	Bicycle riders in cycle lanes		
			Same direction (q_{b1})	Counterflow (q_{b2})	Total (q_{btot})
Average flow [veh/h] All streets		526	193	177	370

Table 3: Person flow in bicycles and motor vehicles, divided by the width of lanes (meters).

Street	Period	Persons in motor vehicles (q_a)	Bicycle riders in cycle lanes		
			Same direction (q_{b1})	Counterflow (q_{b2})	Total (q_{btot})
Rosas	17:30 - 18:00	61	75	53	64
	18:00 - 18:30	63	111	75	93
	18:30 - 19:00	65	147	75	111
	19:00 - 19:30	61	162	58	110
	19:30 - 20:00	60	137	43	90
	Total	311	631	304	468
Teatinos	17:30 - 18:00	83	38	41	39
	18:00 - 18:30	68	40	74	57
	18:30 - 19:00	63	38	81	60
	19:00 - 19:30	69	39	60	50
	19:30 - 20:00	76	30	44	37
	Total	359	185	300	243
Andrés Bello	17:30 - 18:00	95	66	130	98
	18:00 - 18:30	86	88	245	166
	18:30 - 19:00	99	108	255	181
	19:00 - 19:30	85	110	251	180
	19:30 - 20:00	70	92	159	126
	Total	435	464	1039	752
Eleuterio Ramírez	8:00 - 8:30	9	113	39	76
	8:30 - 9:00	87	103	39	71
	9:00 - 9:30	91	106	28	67
	9:30 - 10:00	87	78	20	49
	Total	275	399	125	262
Arturo Prat	8:00 - 8:30	32	10	28	19
	8:30 - 9:00	34	9	30	20
	9:00 - 9:30	34	16	19	18
	9:30 - 10:00	37	14	14	14
	Total	137	49	91	70
Ricardo Lyon	8:00 - 8:30	126	166	25	95
	8:30 - 9:00	129	181	20	100
	9:00 - 9:30	99	116	19	68
	9:30 - 10:00	110	73	45	59
	Total	464	536	109	323
Pocuro	8:00 - 8:30	113	184	151	168
	8:30 - 9:00	111	118	166	142
	9:00 - 9:30	104	77	106	92
	9:30 - 10:00	118	60	83	72
	Total	446	439	506	473

Street	Period	Persons in motor vehicles (q_a)	Bicycle riders in cycle lanes		
			Same direction (q_{b1})	Counterflow (q_{b2})	Total (q_{btot})
Average flow [veh/h-m] All streets		154	169	151	160

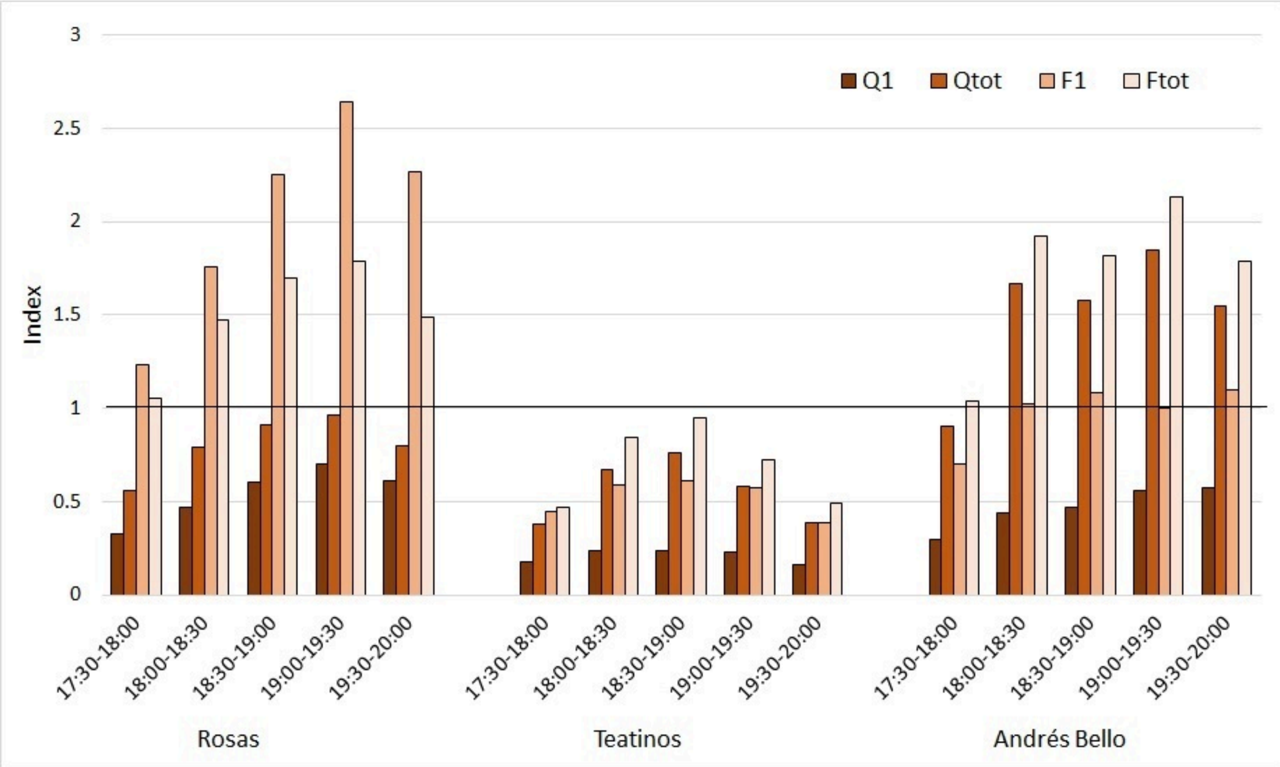

Figure 2a: Ratio of person flow in bicycles to person flow in motor vehicles (Q indexes) and ratio of person flow in bicycles to person flow in motor vehicles per lane width (F indexes)

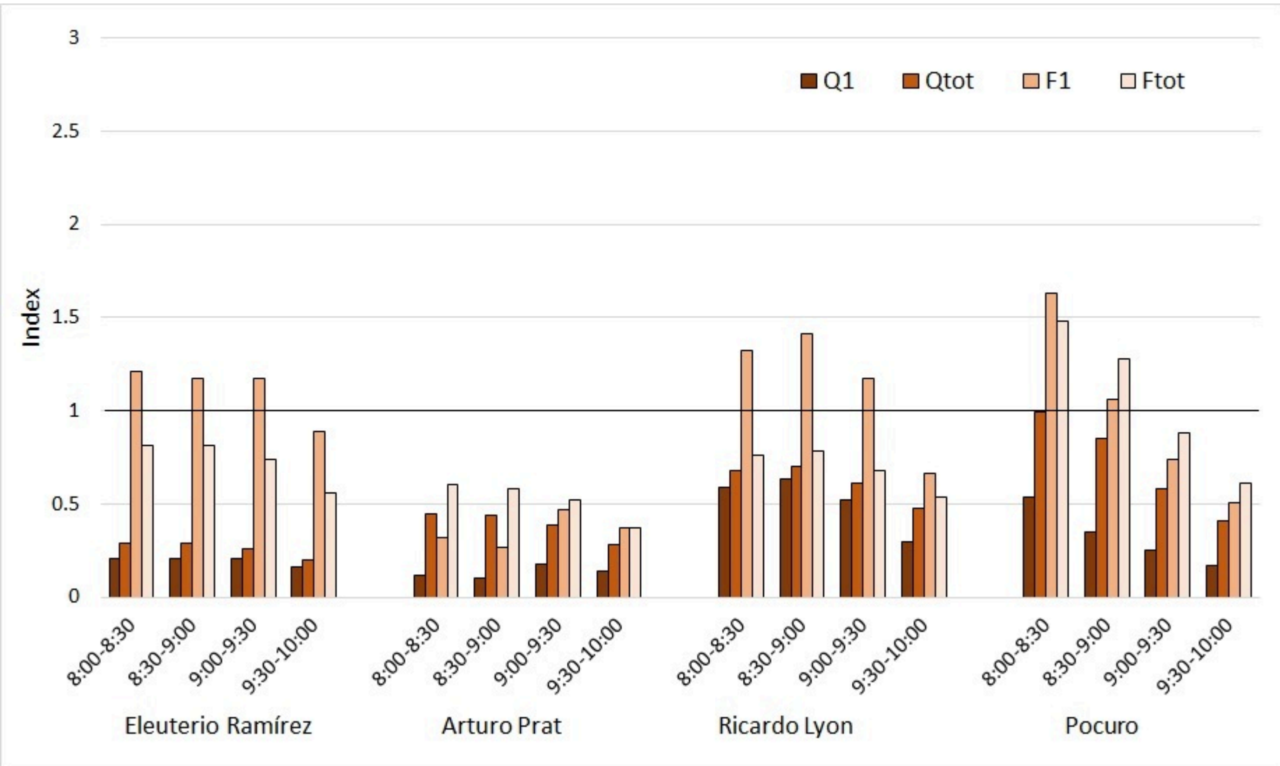

Figure 2b: Ratio of person flow in bicycles to person flow in motor vehicles (Q indexes) and ratio of person flow in bicycles to person flow in motor vehicles per lane width (F indexes)

When only considering bicycle flows in the same direction as motor vehicles, Q_1 ranges from 0.10 to 0.70, with mean and median values of 0.35 and 0.30, respectively. When including total bicycle flow for the cycle track, the Q index ranges from 0.20 to 1.85, with mean and median values of 0.72 and 0.61, respectively. In other words, in the seven streets observed, for every 100 people traveling in motor vehicles, 72 people ride bicycles. Andrés Bello is the only street in which more people per lane travel by bicycle than by motor vehicle (see the second column in Figure 2: in the period 18:00-20:00 hours, between 55% and 85% more people travel on the cycle lane than on each motor vehicle lane).

The F index portrays a different picture, with five out of the seven streets experiencing a higher flow rate of people riding bicycles than using motor vehicles, per meter of road width. The minimum, maximum, mean, and median values for F_1 are 0.27, 2.64, 1.03, and 1.02, respectively. If cyclists traveling in a counterflowing direction are also accounted for, the same four indices are 0.37, 2.13, 1.02, and 0.81 respectively (F_{tot}). Therefore, on average, for every 100 people traveling in motor vehicles, 102 people ride bicycles, per unit of road width.

In synthesis, on the streets observed, lanes for motor vehicles typically have a higher person flow rate; however, several cycle tracks do have a larger person flow per meter of width. The question is whether these results are generalizable. In principle, these findings are site-specific. However, we can determine whether such results hold in general, with cycle tracks and lanes for motor vehicles running at full capacity.

On the one hand, the base saturation flow has been estimated to be between 1933 and 2292 pcu/h-lane in Santiago (Gibson, Bartel, and Coeymans 1997; UOCT 2011), where "pcu" stands for passenger car unit. Car occupancy rates in our data are between 1.3 and 1.6 pax/veh, depending on the street observed. Thus, the maximum person flow in cars is estimated to be between 2513 and 3667 pax/h-lane. On the other hand, the saturation flow for bicycles has been estimated as 2000 bicycles/h for the 1-meter wide cycle lane in Pocuro street in Santiago (Seriani, Fernandez, and Hermosilla 2015). Then, when comparing a 1-meter wide cycle lane with a 3-meter wide car lane at full capacity, the person flow in the cycle lane is found to be between 55% and 80% of the person flow in the car lane.[1] However, if the flow per unit of road width is considered, a cycle lane has a capacity that is between 164% and 239% of the person flow capacity of the car lane. In conclusion, for very high flow rates of bicycles and cars, the empirical result of our paper is also obtained: car lanes move more people than cycle tracks, but the opposite result is found if the road space (width) required by bicycles and cars is considered.

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1 The bicycle saturation flow rate would have to be in the range 2500-3700 bicycles/h for a 1-meter wide lane in order to equal the person flow of cars on a 3-meter wide lane. Bicycle saturation flows in that range have indeed been estimated in other countries (Allen et al. 1998).

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