Supplementary Information for

Urban Access Across the Globe: An International Comparison of Different Transport Modes

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This PDF file includes:

Supporting Information Text

1. Accessibility Data Sources

Table S1. Cities Covered; in Alphabetical Order

Africa(2)	Brazil(20)		Canada(10)	China(7)	Europe(18)		Oceania(11)	United States(49)		
Douala	Belem	Sao Goncalo	Calgary	Beijing	Amsterdam	Wroclaw	Adelaide	Atlanta	Jacksonville	Providence
Nairobi	Belo Horizonte	Sao Luis	Edmonton	Guangzhou	Bratislava		Auckland	Austin	Kansas City	Raleigh
	Brasilia	Sao Paulo	Halifax	Kunming	Bucharest		Brisbane	Baltimore	Las Vegas	Richmond
	Campinas		London	Shanghai	Budapest		Canberra	Birmingham	Los Angeles	Riverside
	Campo Grande		Montreal	Shenzhen	Eindhoven		Christchurch	Boston	Louisville	Sacramento
	Curitiba		Ottawa	Xiamen	Gdansk		Darwin	Buffalo	Miami	Salt Lake City
	Duque de Caxias		Quebec	Xian	Groningen		Hobart	Charlotte	Milwaukee	San Antonio
	Fortaleza		Toronto		Kielce		Melbourne	Chicago	Minneapolis	San Diego
	Goiania		Vancouver		Krakow		Perth	Cincinnati	Nashville	San Francisco
	Guarulhos		Winnipeg		London		Sydney	Cleveland	New Orleans	San Jose
	Maceio				Paris		Wellington	Columbus	New York	Seattle
	Manaus				Rotterdam			Dallas	Oklahoma City	St. Louis
	Natal				The Hague			Denver	Orlando	Tampa
	Porto Alegre				Tilburg			Detroit	Philadelphia	Virginia Beach
	Recife				Utrecht			Hartford	Phoenix	Washington
	Rio de Janeiro				Vienna			Houston	Pittsburgh	
	Salvador				Warsaw			Indianapolis	Portland	

Data from a total of 117 cities from 16 countries: Australia, Austria, Brazil, Cameroon, Canada, China, France, Hungary, Kenya, Netherlands, New Zealand, Poland, Slovakia, the United Kingdom, the United States, and Romania are collected in this comparison. Table S1 provides a list of cities covered. African cities are grouped as 'Africa', and European cities as 'Europe' in later analysis, instead of using individual nationalities; Australian and New Zealand cities are grouped as 'Oceania'.

Africa - Access by transit and walking are measured for Douala, Cameroon and Nairobi, Kenya. Because we were not able to obtain job count data for these two cities, the job numbers are estimated by redistributing the entire working population (1) (assuming 60% of the population in the workforce) to work locations, based on an index for the intensity of local business activities (2). The transit access to jobs are calculated using 8:00 am departure time.

Brazil - Access is measured for 20 Brazilian cities (3). Travel time estimates were calculated between centroids of hexagonal grid of 357 meters (short diagonal). Estimates for transit consider the median travel time of multiple departures every 15 minutes between 6am and 8am on a typical business day between September and October 2019. Travel times were estimated using OpenTripPlanner. A walking speed of 3.6 km/h and a cycling speed of 12 km/h are used. The employment data comes from the Annual Report on Social Information (RAIS), a dataset organized by the Brazilian Ministry of Labor and Employment. A notable amount of informal jobs are not captured by official records (4), so an underestimation of jobs, and therefore an underestimation of the access to jobs is likely.
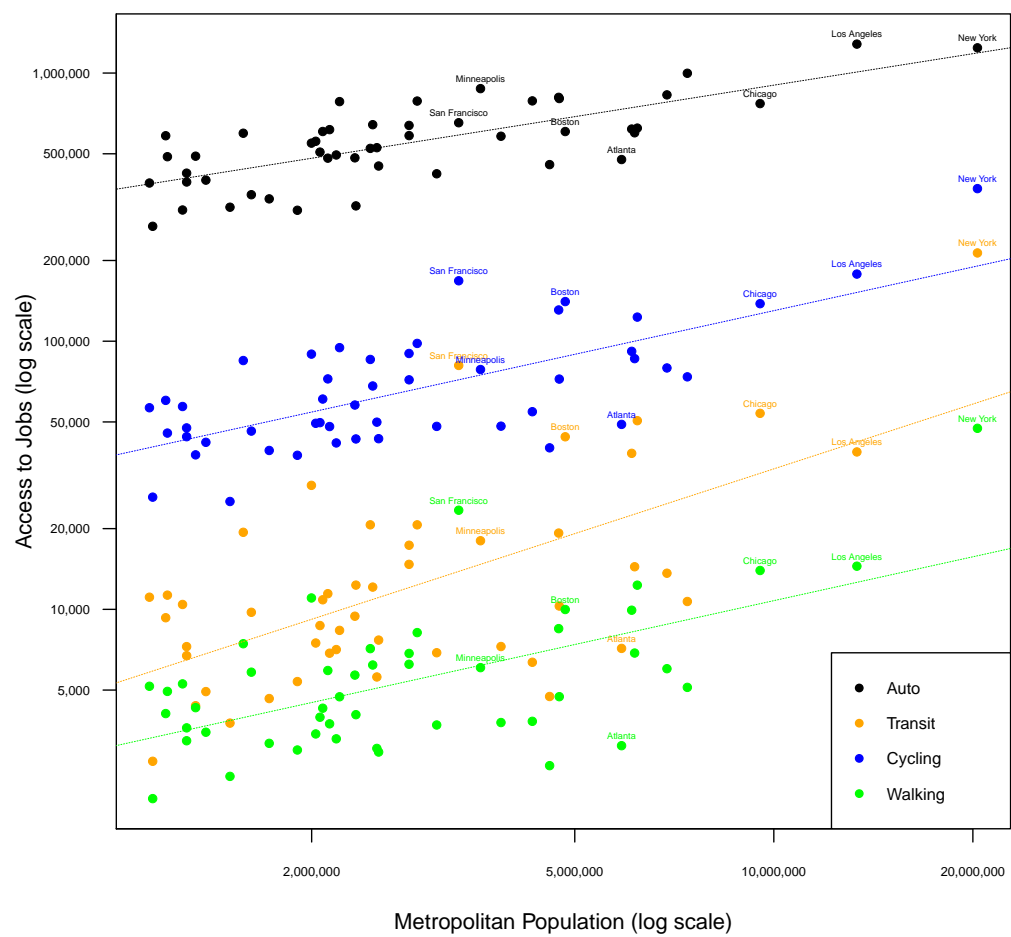
Canada - Access measures for 10 Canadian cities are based on city administrative boundaries, and travel times are calculated between census tract centroids. Job numbers come from the census data; automobile travel times are estimates using the Google API for 8:00 AM departure time on Tuesday, March 14, 2017. The transit travel times estimated from GTFS data uses the same trip departure time. Access by transit and by automobile are included for Canadian cities.
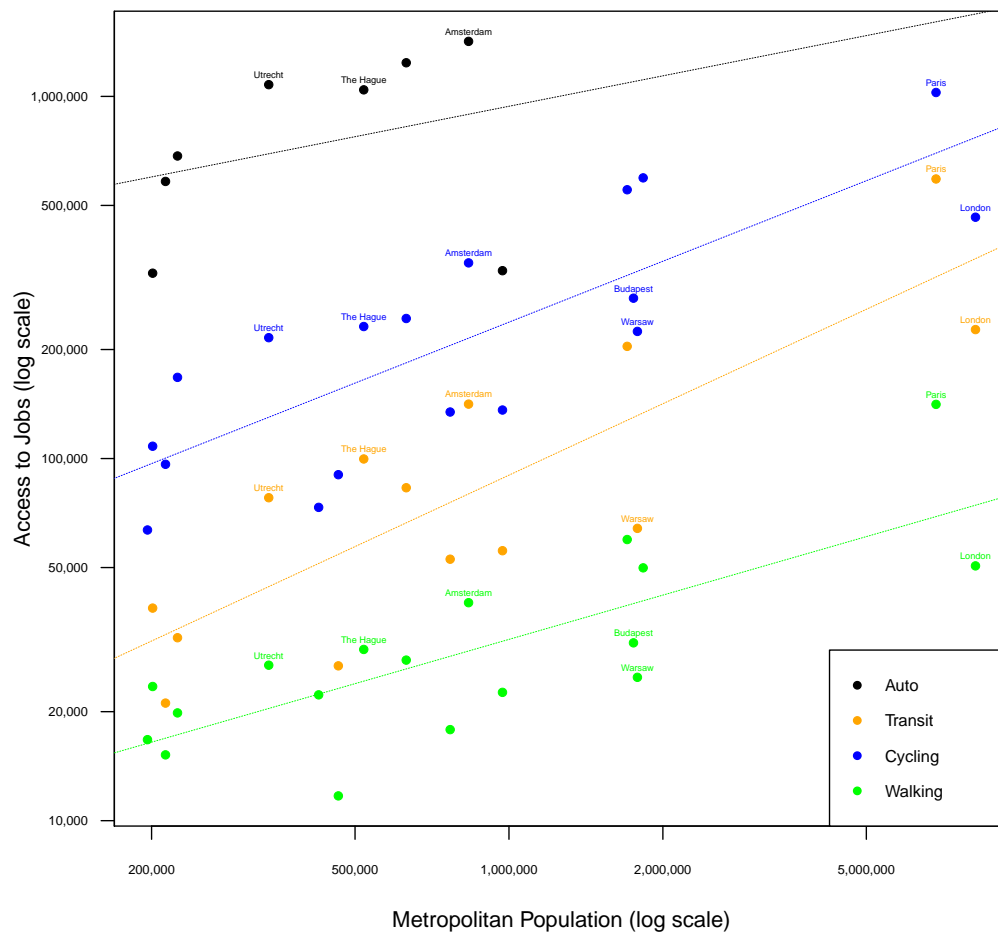
China - City boundaries for the 7 Chinese cities are demarcated by 'Major Urban Area' (MUA) with 'continuous high population density' covering on average 77% of the population within the administrative boundaries. The city population numbers for Chinese cities correspond to the population within each MUA. The jobs and resident workers locations are based on the mobile phone data from the China Unicom (a mobile carrier) for November 2019, and the number of jobs and resident workers are inferred from the market share of the China Unicom (29.6%). The Gaode map API is used to estimate travel time between zones, for 8:00 am departure time on a Wednesday in November 2019. The accessibility is calculated at the resolution of 1 kilometer (0.62 mile) grids.

Europe - 18 European cities are covered in this paper. Automobile access is based on 2014 TomTom speed data (5) for Netherlands. Netherlands transit and automobile travel time are based on morning peak (6:00 am - 9:00 am) schedule and traffic condition. OpenStreetMap provides the road network for Paris and London; transit access is based on the median total travel time for trips departing between 7:30 and 8:30 am, calculated from OpenStreetMap and GTFS inputs following (6). For Paris, population inputs are 200-meter grid cells from the French National Institute of Statistics and Economic Studies, and job inputs are based on the 2019 SIRENE database (7). The London population and job data are from the 2011 UK census. The Warsaw, Wroclaw, Gdansk, Kielce, and Krakow data are based on aggregated transport zones using 8:00 am trip departure time and job numbers between 2015 to 2017; Bratislava, Bucharest, Budapest, Vienna use 2011 job numbers.
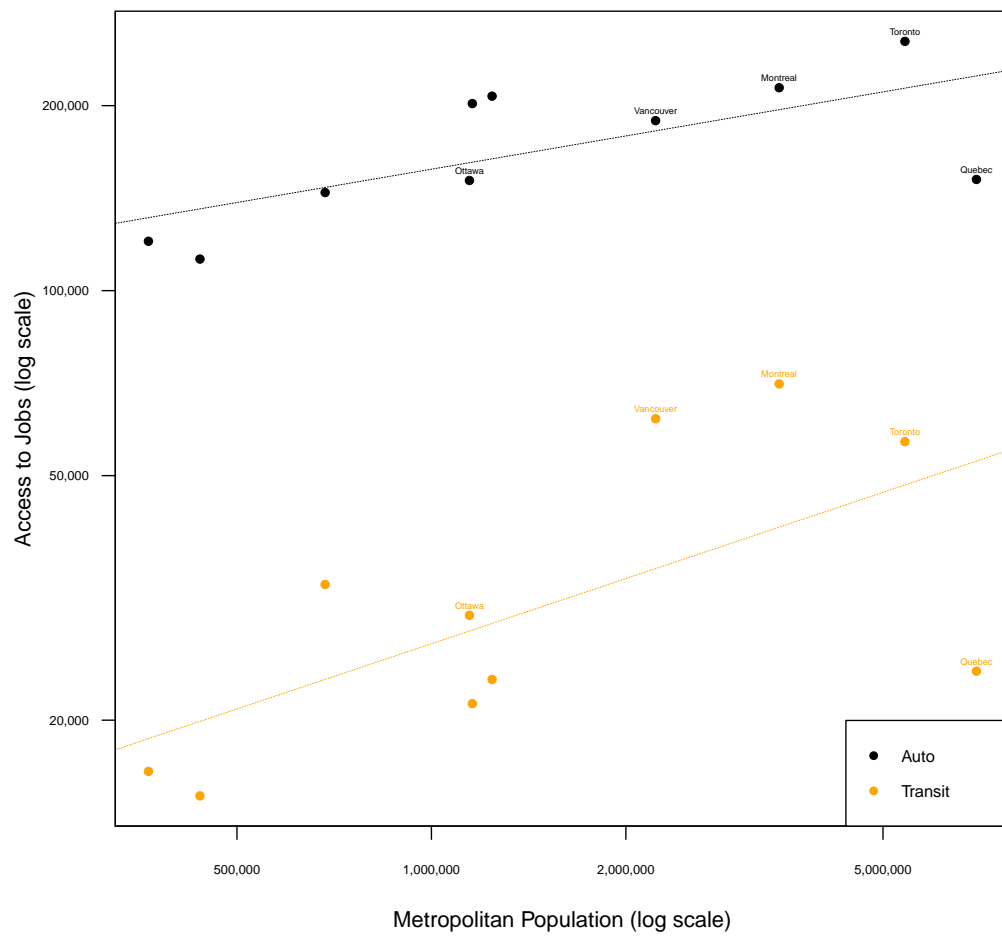
Oceania - Access measure for the 8 Australian cities and 3 New Zealand cities are based on census job numbers from the respective countries, and travel time estimations for departure time of 8:00 AM Wednesday (June 13, 2018 for Australia and Dec. 4, 2019 for New Zealand). Access by all four modes of transport: automobile, transit, walking and cycling are covered. The geographical boundaries of Australian cities are based on the Greater Capital City Statistical Areas, and the New Zealand cities on the Territorial Authority; both boundaries envelop the majority of commute ties with the urban core. The Australian cities are subdivided using 2016 Statistical Area Level 2 (SA2s) (8), and 2016 census is used for population and job numbers; subdivision of the New Zealand cities uses the 2013 areal units and 2013 census data for (9). The Australian access measure uses Google API for travel time estimates between SA2 zonal centroids; walking and cycling speeds are assumed to be 3 mph (4.8 km/h) and 12 mph (19.2 km/h) respectively by default, and adjusted by Google for terrain and travel distance. New Zealand automobile travel times are obtained from TomTom API, and transit, walking and cycling travel times are calculated using the OpenTripPlanner. A walking speed of 4.8 km/h and a cycling speed of 18 km/h are used.

United States - Travel time for the 49 US metropolitan statistical areas include 2017 automobile, transit, and cycling access, and 2014 walking access. Access measures are based on census block centroids. The US data comes from the Access Observatory at the University of Minnesota (10). Automobile uses a 8:00 am Wednesday morning as trip departure time, adjusted for traffic using loop detectors, and Tom Tom data (10); transit access uses transit schedules from GTFS data, and minutely averaged from 7:00 to 9:00 am, on a Wednesday schedule; walking access is calculated using the OpenStreetMap (10). Walking speed is assumed to be 5 km/h. Labor and employment comes from the 2015 (2012 for walking) US Census Bureau's Longitudinal Employer-Household Dynamics (LEHD) data (11).

2. Access to Jobs by Modes of Transport in Different Countries

SupplementaryFigure S1. Access to Jobs by Modes of Transport in US

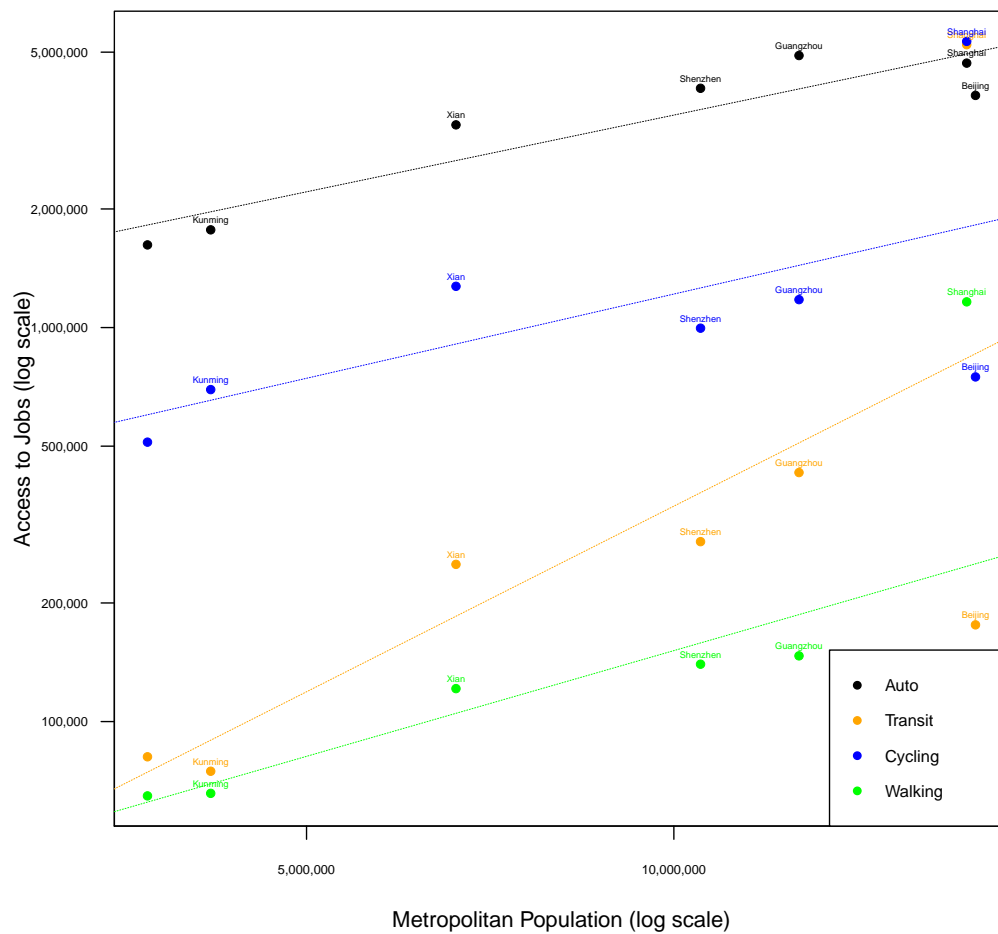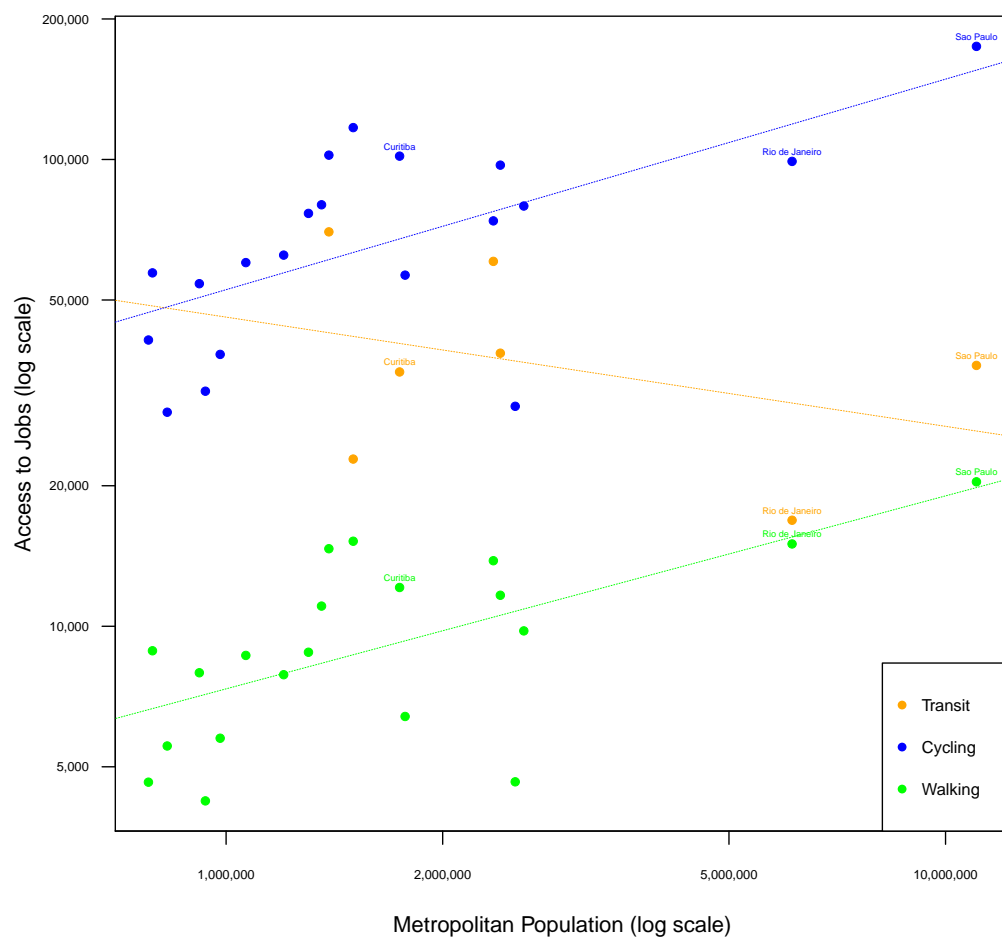**SupplementaryFigure S2.** Access to Jobs by Modes of Transport in Europe
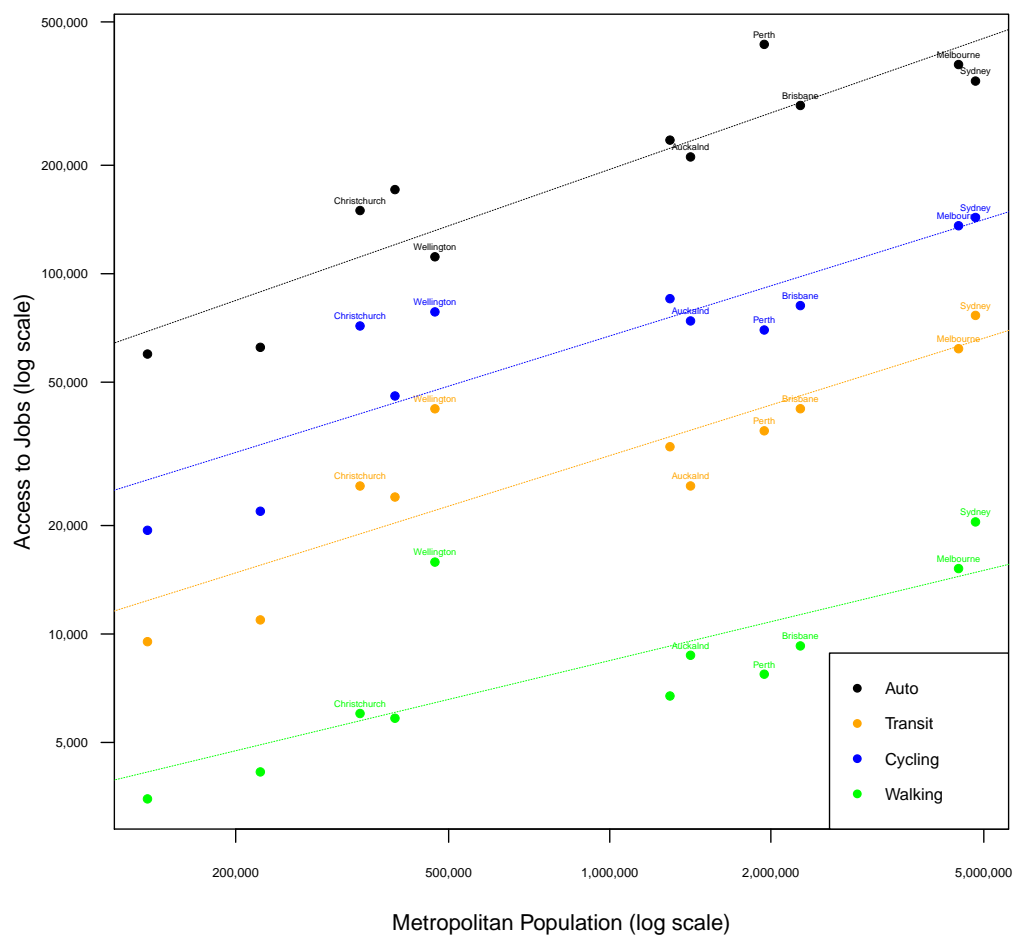
SupplementaryFigure S3. Access to Jobs by Modes of Transport in Canada

SupplementaryFigure S4. Access to Jobs by Modes of Transport in China

SupplementaryFigure S5. Access to Jobs by Modes of Transport in Brazil

SupplementaryFigure S6. Access to Jobs by Modes of Transport in Oceania

3. List of Access to Jobs for Global Cities

Table S1. Global Comparison and Ranking of Access by City and by Mode; Cities Ranked Total Population

City	Abbre.	Country	Population	30-minute Access by Mode				Ranking (total number of cities)				
				Auto	Transit	Walk	Bike	Pop.(117)	Auto(85)	Transit(100)	Walk(107)	Bike(105)
New York	NYC	United States	20,320,876	1,241,973	213,407	47,338	370,753	1	10	7	12	12
Beijing	PEK	China	17,668,140	3,883,735	175,992	68,091	749,505	2	4	9	6	6
Shanghai	PVG	China	17,377,756	4,690,249	5,223,556	1,162,225	5,325,416	3	2	1	1	1
Los Angeles	LAX	United States	13,353,907	1,282,378	38,647	14,490	178,007	4	9	34	36	19
Guangzhou	CAN	China	12,663,510	4,903,020	428,610	146,829	1,177,428	5	1	3	2	3
Sao Paulo	GRU	Brazil	11,039,463	-	36,211	20,394	174,709	6	-	39	26	20
Shenzhen	SZX	China	10,516,429	4,048,766	286,226	139,854	996,439	7	3	4	4	5
Chicago	CHI	United States	9,533,040	769,483	53,831	13,965	138,051	8	22	27	37	25
London	LCY	Europe	8,173,940	-	227,080	50,539	463,959	9	-	6	10	11
Dallas	DAL	United States	7,399,662	998,369	10,699	5,118	73,646	10	14	74	77	57
Quebec	YQB	Canada	6,976,500	151,692	24,032	-	-	11	77	49	-	-
Houston	HOU	United States	6,892,427	829,147	13,639	6,008	79,485	12	16	66	68	51
Paris	CDG	Europe	6,843,111	-	591,617	141,135	1,025,302	13	-	2	3	4
Xian	XIY	China	6,629,000	3,269,548	250,626	121,247	1,272,791	14	5	5	5	2
Washington	DC	United States	6,216,589	623,387	50,551	12,310	123,007	15	27	29	39	30
Miami	MIA	United States	6,158,824	598,727	14,419	6,872	86,122	16	32	65	60	44
Rio de Janeiro	GIG	Brazil	6,119,114	-	16,873	15,010	99,070	17	-	61	34	35
Philadelphia	PHI	United States	6,096,120	618,294	38,185	9,929	91,685	18	28	37	46	40
Atlanta	ATL	United States	5,884,736	475,950	7,152	3,102	48,958	19	48	87	101	80
Toronto	YYZ	Canada	5,407,200	254,472	56,794	-	-	20	69	25	-	-
Boston	BOS	United States	4,836,531	605,308	44,014	9,988	140,544	21	31	31	45	24
Sydney	SYD	Australia	4,823,991	342,597	76,617	20,470	143,253	22	59	16	25	23
Phoenix	PHX	United States	4,737,270	803,505	10,290	4,725	72,251	23	18	76	79	60
Nairobi	NBO	Africa	4,735,000	-	59,342	22,124	-	24	-	24	24	-
San Jose	SJC	United States	4,727,357	811,889	19,254	8,476	130,769	25	17	58	53	29
Riverside	UCR	United States	4,580,670	455,652	4,732	2,613	40,028	26	49	96	105	94
Melbourne	MEL	Australia	4,485,211	380,754	61,932	15,192	135,879	27	57	21	33	27
Detroit	DET	United States	4,313,002	787,536	6,349	3,824	54,598	28	19	92	90	75
Kunming	KMG	China	4,172,752	1,770,296	74,815	65,740	695,971	29	6	17	7	7
St. Louis	STL	United States	3,867,046	581,284	7,268	3,784	48,217	30	37	85	91	81
Xiamen	XMN	China	3,703,521	1,621,125	81,403	64,777	511,925	31	7	13	8	10
Douala	DLA	Africa	3,663,000	-	45,386	45,333	-	32	-	30	13	-
Minneapolis	MSP	United States	3,600,618	875,049	18,029	6,063	78,421	33	15	59	66	52
Montreal	YUL	Canada	3,453,700	213,894	70,498	-	-	34	71	18	-	-
San Francisco	SFO	United States	3,337,685	652,817	81,215	23,428	168,044	35	24	14	21	21
Tampa	TPA	United States	3,091,399	421,134	6,891	3,705	48,126	36	53	89	93	82
Denver	DEN	United States	2,888,227	786,345	20,665	8,191	98,129	37	20	56	54	36
Baltimore	BWI	United States	2,808,175	584,586	17,344	6,850	71,781	38	34	60	61	61
Salt Lake City	SLC	United States	2,807,338	637,938	14,721	6,242	90,009	39	26	64	64	42
Salvador	SAL	Brazil	2,592,926	-	-	9,775	79,494	40	-	-	47	50
Charlotte	CLT	United States	2,525,305	450,125	7,682	2,937	43,300	41	50	83	104	89
Brasilia	BSB	Brazil	2,522,601	-	-	4,643	29,599	42	-	-	81	100
Orlando	ORL	United States	2,509,831	526,926	5,596	3,030	49,906	43	40	93	102	77
San Diego	SAN	United States	2,473,974	642,021	12,109	6,202	68,083	44	25	68	65	64
Portland	PWM	United States	2,453,168	523,784	20,606	7,137	85,511	45	41	55	59	45
Fortaleza	FOR	Brazil	2,405,275	-	38,465	11,653	97,250	46	-	36	42	37
Belo Horizonte	CNF	Brazil	2,352,062	-	60,496	13,818	73,873	47	-	23	38	56
Pittsburgh	PIT	United States	2,333,367	319,641	12,317	4,048	43,204	48	63	67	88	90
Sacramento	SMF	United States	2,324,884	482,910	9,430	5,687	57,812	49	46	79	73	70
Brisbane	BNE	Australia	2,270,800	293,131	42,196	9,267	81,576	50	67	32	48	48
Vancouver	YVR	Canada	2,223,300	189,074	61,885		-	51	75	22	-	-
Las Vegas	LAS	United States	2,204,079	782,690	8,350	4,721	94,625	52	21	82	80	39
Cincinnati	CVG	United States	2,179,082	494,927	7,080	3,290	41,750	53	43	88	98	92
Kansas City	KS	United States	2,128,912	615,321	6,864	3,742	48,058	54	29	90	92	83
Austin	AUS	United States	2,115,827	481,581	11,444	5,916	72,355	55	47	69	69	59
Columbus	CMH	United States	2,078,725	605,435	10,857	4,280	60,860	56	30	73	84	67
Cleveland	CLE	United States	2,058,844	507,302	8,703	3,961	49,704	57	42	81	89	78
Indianapolis	IND	United States	2,028,614	556,698	7,491	3,431	49,420	58	38	84	97	79
Seattle	SEA	United States	1,998,463	547,963	29,003	11,028	89,512	59	39	45	44	43
Perth	PER	Australia	1,943,858	433,116	36,638	7,735	69,796	60	51	38	57	63
Nashville	BNA	United States	1,903,045	307,872	5,380	2,989	37,552	61	66	94	103	98
Bucharest	OTP	Europe	1,830,000	-	-	49,914	595,760	62	-	-	11	8
Warsaw	WAW	Europe	1,783,321	-	64,153	24,884	224,453	63	-	20	19	17
Manaus	MAO	Brazil	1,773,375	-	-	6,409	56,528	64	-	-	63	73
Budapest	BUD	Europe	1,752,000	-	-	30,980	277,248	65	-	-	15	14
Curitiba	CWB	Brazil	1,742,355	-	35,062	12,109	101,670	66	-	40	40	34
Virginia Beach	VB	United States	1,725,246	339,490	4,649	3,165	39,133	67	60	97	100	95
Vienna	VIE	Europe	1,703,000	-	204,094	59,755	552,437	68	-	8	9	9
Providence	PVD	United States	1,621,122	351,809	9,751	5,831	46,220	69	58	77	71	85
Milwaukee	MKE	United States	1,576,236	596,519	19,383	7,444	84,722	70	33	57	58	47
Jacksonville	JAX	United States	1,504,980	316,042	3,765	2,383	25,254	71	64	99	106	103
Recife	REC	Brazil	1,501,976	-	22,814	15,212	117,033	72	-	52	31	31
Auckalnd	AKL	New Zealand	1,415,550	210,934	25,761	8,729	73,950	73	72	47	51	55
Porto Alegre	POA	Brazil	1,389,410	-	69,973	14,660	102,172	74	-	19	35	33
Oklahoma City	OKC	United States	1,383,737	398,760	4,936	3,482	41,976	75	54	95	96	91
Belem	BEL	Brazil	1,357,180	-	-	11,047	79,980	76	-	-	43	49
Raleigh	RDU	United States	1,335,079	489,859	4,371	4,300	37,660	77	44	98	83	97
Goiania	GYN	Brazil	1,301,592	-	-	8,798	76,650	78	-	-	50	54
Adelaide	ADL	Australia	1,295,714	234,902	33,095	6,729	85,267	79	70	42	62	46
Richmond	RIC	United States	1,294,204	392,485	6,719	3,615	44,048	80	55	91	94	88
Louisville	SDF	United States	1,293,953	423,448	7,263	3,236	47,502	81	52	86	99	84
New Orleans	MSY	United States	1,275,762	308,564	10,429	5,274	57,088	82	65	75	75	72
Calgary	YYC	Canada	1,241,300	207,264	23,298	-	-	83	73	51	-	-
Hartford	BDL	United States	1,210,259	487,649	11,300	4,944	45,444	84	45	70	78	87
San Antonio	SAT	United States	1,203,105	583,812	9,306	4,087	60,172	85	35	80	87	68
Guarulhos	GUA	Brazil	1,202,298	-	-	7,875	62,396	86	-	-	56	66
Edmonton	YEG	Canada	1,156,900	201,568	21,279	-	-	87	74	53	-	-
Birmingham	BHM	United States	1,149,807	268,251	2,713	1,969	26,215	88	68	100	107	102
Ottawa	YOW	Canada	1,145,100	151,116	29,631	-	-	89	78	44	-	-
Buffalo	BUF	United States	1,136,856	389,028	11,101	5,167	56,477	90	56	71	76	74
Campinas	VCP	Brazil	1,065,137	-	-	8,661	60,132	91	-	-	52	69
Sao Luis	SLZ	Brazil	981,172	-	-	5,757	38,236	92	-	-	72	96
Wroclaw	WRO	Europe	971,244	330,210	55,659	22,613	136,140	93	61	26	22	26
Sao Goncalo	QSD	Brazil	935,758	-	-	4,226	31,886	94	-	-	85	99
Maceio	MCZ	Brazil	917,872	-	-	7,951	54,188	95	-	-	55	76
Amsterdam	AMS	Europe	833,624	1,419,003	141,369	39,996	346,991	96	8	10	14	13
Duque de Caxias	DDC	Brazil	828,198	-	-	5,541	28,747	97	-	-	74	101
Natal	NAT	Brazil	790,017	-	-	8,862	57,158	98	-	-	49	71
Campo Grande	CGR	Brazil	779,885	-	-	4,635	41,048	99	-	-	82	93
Krakow	KRK	Europe	767,348	-	52,733	17,843	134,432	100	-	28	28	28
Winnipeg	YWG	Canada	684,600	144,413	33,259	-	-	101	80	41	-	-
Rotterdam	RTM	Europe	629,606	1,238,582	83,064	27,761	243,655	102	11	12	17	15
The Hague	EHGV	Europe	519,988	1,042,759	99,730	29,710	231,517	103	13	11	16	16

Wellington	WLG	New Zealand	471,315	111,423	42,177	15,833	78,351	104	83	33	30	53
Gdansk	GDN	Europe	463,754	-	26,766	11,708	90,241	105	-	46	41	41
London	YXU	Canada	438,200	112,571	15,061			106	82	63	-	-
Bratislava	BTS	Europe	424,428	-	-	22,257	73,315	107	-		23	58
Canberra	CBR	Australia	396,857	171,210	24,000	5,837	45,782	108	76	50	70	86
Halifax	YHZ	Canada	364,700	120,327	16,511	-	-	109	81	62	-	-
Christchurch	CHC	New Zealand	341,469	149,783	25,753	6,016	71,609	110	79	48	67	62
Utrecht	UTC	Europe	338,967	1,077,662	77,956	26,877	215,680	111	12	15	18	18
Eindhoven	EIN	Europe	224,755	684,701	32,006	19,845	167,570	112	23	43	27	22
Hobart	HBA	Australia	222,356	62,479	10,943	4,142	21,917	113	84	72	86	104
Tilburg	EHBK	Europe	212,941	582,446	21,121	15,197	96,425	114	36	54	32	38
Groningen	GRQ	Europe	200,952	324,987	38,645	23,471	108,158	115	62	35	20	32
Kielce	EPKA	Europe	196,335	-	-	16,741	63,501	116	-	-	29	65
Darwin	DRW	Australia	136,828	59,853	9,521	3,486	19,403	117	85	78	95	105

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