Supplementary Materials

Schedule-Aware Transit Service Intensity and Urban Equity in the Greater Toronto Area

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Table S1. Municipal accessibility and socioeconomic summary

(a) Schedule-aware transit service-intensity metrics

Municipality	Hexes	Med. peak	Mean peak	Any svc. (%)	≥12 dep/h (%)	≥30 dep/h (%)
Toronto	814	196.0	221.2	96.7	95.6	94.3
Newmarket	47	39.0	46.8	95.7	87.2	61.7
Mississauga	376	52.0	60.4	89.6	77.7	63.6
Ajax	86	30.0	38.1	79.1	73.3	51.2
Richmond Hill	128	49.0	55.4	85.2	70.3	57.0
Markham	280	36.2	49.5	70.7	62.1	54.6
Vaughan	345	19.5	36.2	68.4	56.8	43.2
Aurora	67	14.0	20.7	70.1	56.7	23.9
Oshawa	179	14.0	30.3	60.9	52.5	37.4
Brampton	343	7.0	15.6	71.4	39.9	15.5
Whitby	193	0.0	17.6	49.7	38.9	24.4
Pickering	288	0.0	7.9	25.3	16.3	7.6
Oakville†	179	0.0	2.3	16.8	6.7	1.1
Whitchurch-Stouffville	270	0.0	2.3	11.1	6.7	3.0
East Gwillimbury	312	0.0	1.5	19.2	4.8	0.3
Georgina	762	0.0	1.0	7.5	4.2	0.5
Clarington	788	0.0	1.5	10.8	4.2	1.5
King	432	0.0	0.8	6.0	2.8	0.7
Halton Hills†	357	0.0	0.6	8.1	2.2	0.0
Milton†	470	0.0	0.6	3.8	2.1	0.2
Burlington†	237	0.0	0.5	6.3	1.3	0.0
Uxbridge	533	0.0	0.2	3.6	0.8	0.2
Scugog	657	0.0	0.1	3.2	0.3	0.0
Brock	599	0.0	0.0	2.8	0.0	0.0
Caledon	893	0.0	0.4	8.0	0.7	0.0

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(b) Socioeconomic context and weekend retention

Municipality	WKND ret. (%)	Income ($)	Low-inc. (%)
Toronto	92.8	110,000	10.3
Newmarket	61.9	128,000	7.2
Mississauga	73.5	126,500	7.2
Ajax	77.3	140,500	4.5
Richmond Hill	93.8	130,000	11.7
Markham	75.0	119,000	9.4
Vaughan	75.0	149,000	5.5
Aurora	—	146,000	7.8
Oshawa	78.6	121,000	8.5
Brampton	62.5	126,000	5.6
Whitby	—	146,000	5.0
Pickering	—	143,000	5.9
Oakville	—	148,000	8.6
Whitchurch-Stouffville	—	149,000	8.3
East Gwillimbury	—	132,000	5.8
Georgina	—	113,000	8.2
Clarington	—	126,000	6.0
King	—	149,000	6.5
Halton Hills	—	145,000	6.7
Milton	—	160,000	4.6
Burlington	—	166,000	5.7
Uxbridge	—	133,000	6.2
Scugog	—	—	—
Brock	—	—	—
Caledon	—	152,000	4.3

Notes: Med. peak = median weekday peak departures per hour at 800 m. Any svc. = share of hexagons with ≥1 departure per hour during weekday peak. WKND ret. = ratio of median Saturday midday to median weekday midday accessibility among hexagons with non-zero weekday service. Income = census median after-tax household income. Low-inc. = share of population in low-income bracket. — = not reported because median weekday midday accessibility is zero. †Halton municipalities: local transit GTFS feeds were unavailable; values reflect GO Transit coverage only and understate actual local service. These municipalities are excluded from the municipal-level correlation analysis.

Table S2. Spearman correlation robustness across samples, catchments, and temporal windows

Variable	Sample	ρ	n	n_{eff}	p (CR-adj.)
Weekday peak, 800 m — CT-linked hexagons (Clifford–Richardson adjusted)					
Median income	Hex(CT)	−0.321	8379	745	$< 10^{-15}$
Low-income share	Hex(CT)	0.284	8379	745	$< 10^{-14}$
Renter share	Hex(CT)	0.372	8379	745	$< 10^{-15}$
Population density	Hex(CT)	0.694	8379	745	$< 10^{-15}$
Unemployment rate	Hex(CT)	0.513	8379	745	$< 10^{-15}$
Visible minority	Hex(CT)	0.561	8379	745	$< 10^{-15}$
Weekday peak, 800 m — Tract level (1 CT = 1 obs.)					
Median income	CT	−0.745	1144	—	$< 10^{-200}$
Low-income share	CT	0.550	1144	—	$< 10^{-90}$
Renter share	CT	0.540	1144	—	$< 10^{-87}$
Population density	CT	0.739	1144	—	$< 10^{-198}$
Unemployment rate	CT	0.331	1144	—	$< 10^{-30}$
Visible minority	CT	0.185	1144	—	$< 10^{-9}$
Weekday peak, 400 m — CT-linked hexagons					
Median income	Hex(CT)	−0.302	8379	745	$< 10^{-14}$
Low-income share	Hex(CT)	0.264	8379	745	$< 10^{-12}$
Renter share	Hex(CT)	0.343	8379	745	$< 10^{-15}$
Population density	Hex(CT)	0.614	8379	745	$< 10^{-15}$
Unemployment rate	Hex(CT)	0.486	8379	745	$< 10^{-15}$
Visible minority	Hex(CT)	0.525	8379	745	$< 10^{-15}$
Weekday peak, 1000 m — CT-linked hexagons					
Median income	Hex(CT)	−0.331	8379	745	$< 10^{-15}$
Low-income share	Hex(CT)	0.294	8379	745	$< 10^{-15}$
Renter share	Hex(CT)	0.383	8379	745	$< 10^{-15}$
Population density	Hex(CT)	0.711	8379	745	$< 10^{-15}$
Unemployment rate	Hex(CT)	0.529	8379	745	$< 10^{-15}$
Visible minority	Hex(CT)	0.579	8379	745	$< 10^{-15}$
Saturday midday, 800 m — CT-linked hexagons					
Median income	Hex(CT)	−0.318	8379	745	$< 10^{-15}$
Low-income share	Hex(CT)	0.288	8379	745	$< 10^{-14}$
Renter share	Hex(CT)	0.370	8379	745	$< 10^{-15}$
Population density	Hex(CT)	0.672	8379	745	$< 10^{-15}$
Unemployment rate	Hex(CT)	0.499	8379	745	$< 10^{-15}$
Visible minority	Hex(CT)	0.527	8379	745	$< 10^{-15}$
Weekday peak, 800 m — Municipal (n = 19, excl. Halton, Scugog, Brock)					
Median income	Muni.	−0.423	19	—	0.071
Low-income share	Muni.	0.443	19	—	0.058
Renter share	Muni.	0.482	19	—	0.037
Population density	Muni.	0.862	19	—	< 0.001
Unemployment rate	Muni.	0.756	19	—	< 0.001
Visible minority	Muni.	0.752	19	—	< 0.001

Notes: Hex(CT) = CT-linked hexagons (each tract repeated across its constituent hexagons); CT = tract-level aggregation (one observation per tract); Muni. = municipal aggregation. All coefficients are Spearman rank correlations (ρ). For Hex(CT) rows, n_{eff} is the Clifford–Richardson [1] effective sample size derived from the observed Moran's $I = 0.84$; the reported p-values are computed from a Student's t approximation evaluated at n_{eff} rather than n, and are upper-bounded at 10^{-15} for legibility (the underlying numerical p is smaller). For CT and Muni. rows, nominal p-values are reported because spatial dependence is materially reduced after one-CT-one-observation or municipal aggregation. The tract-level rows guard against pseudo-replication arising from the repetition of CT attributes across hexagons within each tract: the income and density gradients are stronger in magnitude at the tract grain than at the hex grain, indicating that the hex-level coefficients are not artifacts of the repeated-CT structure.

Table S3. General Transit Feed Specification (GTFS) feed metadata

Agency	Feed source	Stops in GTA	Routes	WK peak dep/h
TTC	open.toronto.ca	9423	230	70,063.0
GO Transit	metrolinx.com	731	44	1677.0
MiWay	miway.ca	3142	69	9417.0
YRT/Viva	yrt.ca	4792	124	14,056.5
Brampton Transit	brampton.ca	2969	73	1816.0
Durham Region Transit	durham.ca	1969	39	5956.5
Total		**23,026**	**579**	**102,986.0**

Notes: WK peak dep/h = total departures per hour during weekday morning peak (07:00–09:00). Saturday midday values are omitted for brevity. Feeds represent Fall 2023 scheduled service (October–November 2023 sign-up period). All feeds were downloaded between October and December 2023; GTFS feeds are mutable, and the values reported here reflect scheduled service at the time of download. Local Halton Region transit operators (Oakville Transit, Burlington Transit) are omitted due to the lack of publicly accessible GTFS feeds during data collection; GO Transit stations within Halton are captured via the Metrolinx feed. Route counts reflect unique routes per feed after clipping to the GTA study area.

Table S4. Spearman partial correlations controlling for population density

Variable	ρ (bivariate)	ρ (partial)	p (partial)	n
Median income	-0.321	-0.214	< 0.001	8379
Low-income share	0.284	0.227	< 0.001	8353
Renter share	0.372	0.239	< 0.001	8359
Unemployment rate	0.513	0.207	< 0.001	8359
Visible minority	0.561	0.242	< 0.001	8359

Notes: Bivariate = standard Spearman ρ between each variable and weekday peak accessibility (800 m). Partial = Spearman partial correlation after controlling for population density using a rank-residual procedure (see Supplementary Note S4). All correlations computed on the CT-linked hexagon sample. Sample sizes vary slightly across variables (n = 8,353–8,379) because a small number of census tracts have missing values for individual socioeconomic indicators. The p-values reported here are nominal and subject to the same effective-sample-size caveats as Table S2: strong spatial autocorrelation (Moran's $I = 0.84$) reduces the effective n to approximately 745, so the reported p-values should be read as descriptive indicators rather than formal inferential tests. The substantial reduction in magnitude from bivariate to partial confirms that population density mediates much of the observed association.

Table S5. Area-weighted versus population-weighted accessibility statistics

Note: This table is reproduced from Table 2 of the main text for supplementary completeness.

Zone	Zero-service (%)		$\geq$12 dep/h (%)		Mean dep/h	
	Area	Pop.	Area	Pop.	Area	Pop.
Overall	70.6	16.4	22.6	75.5	27.4	121.8
Urban Core	1.3	0.1	97.8	99.7	256.5	294.3
Inner Suburban Ring	12.8	5.8	78.1	88.4	85.1	114.1
Outer Suburban Ring	71.9	36.2	16.6	46.3	7.4	22.8
Fringe Ring	90.8	40.2	4.7	49.8	2.2	26.8

Notes: Area-weighted statistics treat each H3 hexagon equally. Population-weighted statistics weight each hexagon by its apportioned census-tract population (or census-subdivision population for hexagons outside tract geography). The difference between the two perspectives is largest in the Outer Suburban and Fringe rings, where large tracts of sparsely inhabited land inflate the area-weighted zero-service share.

Figure S1. Lorenz curve of population-weighted weekday peak transit service intensity

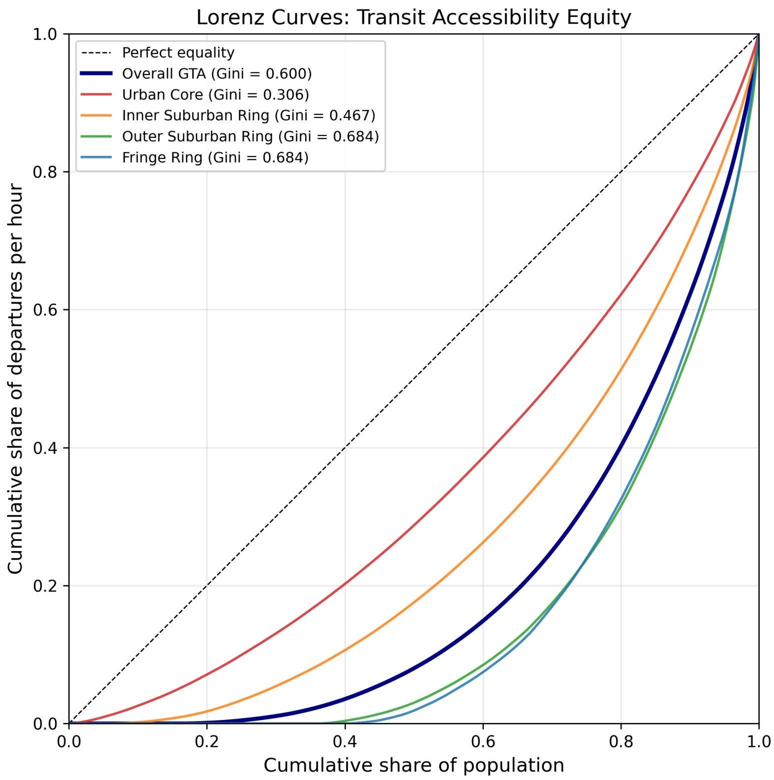

Figure S1. Lorenz curve of population-weighted weekday peak transit service intensity across the GTA. The diagonal represents perfect equality. Curves are shown for the full region (Gini = 0.60) and for each distance ring. The departure of the overall curve from the diagonal indicates substantial distributional inequality: the most service-deprived half of the population accounts for a small fraction of total accessible departures.

Supplementary Note S1. Service band classification rationale

These five service bands translate raw hexagon-level frequencies into highly interpretable policy categories:

- **None (0 dep/h):** No scheduled departures within 800 m during the analysis window.
- **Low (>0, <4 dep/h):** Service present but below Metrolinx's frequent-transit threshold of 15-minute headways [2].
- **Moderate (4–11 dep/h):** Meets the frequent-service threshold but below 5-minute headways.
- **High (12–29 dep/h):** Cumulative departure density equivalent to 5-minute headways or better; consistent with high-quality urban bus corridors.
- **Very High (≥30 dep/h):** Cumulative departure density equivalent to an average headway of 2 minutes or better, assuming perfectly staggered arrivals; in practice, overlapping routes do not produce evenly spaced headways, so this represents an upper-bound equivalence. Characteristic of rapid-transit corridors with multiple converging routes.

A boundary of 4 dep/h explicitly aligns with Metrolinx's standard for anchoring a 15-minute frequent-transit continuum. Because the accessibility measure aggregates departures across all stops within 800 m, these thresholds reflect cumulative boarding-opportunity density rather than single-route headways. The 12 dep/h threshold is consistent with the TTC's competitive service-coverage guidelines for major corridors [3], while the 30 dep/h marker isolates the most intensively served locations.

Supplementary Note S2. Distance ring justification

The four distance rings are centred on Union Station (43.6454° N, 79.3807° W) and defined as follows:

- **Urban Core (<15 km):** Approximately coincides with the City of Toronto boundary and TTC's primary service coverage area.
- **Inner Suburban Ring (15–30 km):** Captures the inner suburban municipalities (Mississauga, Brampton, Vaughan, Markham) where GO Transit corridors, municipal BRT, and Viva rapid transit operate.
- **Outer Suburban Ring (30–45 km):** Represents the middle suburban municipalities and the practical extent of regular GO Transit commuter rail service from Union Station.
- **Fringe Ring (>45 km):** The exurban periphery where transit service is minimal or absent.

Rather than relying on strict mathematical optimization, these robust distance thresholds were explicitly selected to reflect the natural evolutionary stages of the region's urban fabric and its highly layered transit infrastructure hierarchy.

Supplementary Note S3. Data sources and analytical procedure

All primary data are publicly available:

- General Transit Feed Specification (GTFS) feeds: agency open-data portals (see Table S3)
- Census boundaries and profiles: Statistics Canada, 2021 Census of Population
- Census subdivision (CSD) boundaries: Statistics Canada, 2021 Census Boundary Files

The analysis was implemented in Python 3.13 with GeoPandas, Shapely, H3-Py, pandas, NumPy, SciPy, statsmodels, and matplotlib, and comprises three stages: (i) download and harmonization of GTFS feeds, census profiles, and spatial boundary files; (ii) generation of the H3 hexagonal grid and computation of schedule-aware service intensity, distance-ring assignment, and socioeconomic joins; and (iii) inferential and robustness analytics covering spatial autocorrelation, partial and tract-level correlations, population-weighted statistics, route-direction deduplication, network-distance sensitivity, cross-resolution checks for the modifiable areal unit problem, and Gini/Lorenz inequality measures. The procedure is fully reproducible from the public data sources listed above.

Supplementary Note S4. Spatial autocorrelation and partial correlation methods

Global Moran's I was computed using queen-contiguity spatial weights derived from the H3 hexagonal grid. For each hexagon, its six immediate H3 neighbours that fall within the study area were used as spatial neighbours. The resulting weight matrix was row-standardized, and significance was assessed using 999 random permutations.

Spearman partial correlations were computed using a rank-residual procedure [4]. For each pair of variables (X, Y) with control variable Z (population density), all three variables were ranked. The ranks of X and Y were separately regressed on the ranks of Z using ordinary least squares, and the Pearson correlation of the resulting residuals was taken as the partial Spearman correlation coefficient. This approach is a well-known approximation to partial rank correlation [4] and isolates the association between X and Y that is not linearly attributable to Z in rank space.

Supplementary Note S5. Route-direction deduplication sensitivity analysis

The primary accessibility measure sums all scheduled departures at all stops within the 800 m catchment, which means that a single route with stops every 200–300 m can contribute its frequency multiple times when several of its stops fall within the same hexagon's catchment. To assess the sensitivity of the results to this stop-adjacency inflation, we computed a deduplicated accessibility measure in which each unique route–direction pair is counted only once per hexagon: for each (route, direction) combination appearing at any stop within the catchment, the maximum departure frequency across stops was retained and summed.

The deduplication substantially reduces absolute values in the core but preserves the spatial pattern and ring hierarchy (Table S6). The Spearman rank correlation between the original and deduplicated measures across all hexagons is $\rho = 0.97$, and the service-band classification is largely unchanged outside the Very High band in the Urban Core. The key finding—that the major break occurs between the Inner and Outer Suburban Rings and that the Fringe is predominantly unserved—is robust to deduplication.

Table S6. Original vs. deduplicated median accessibility by distance ring.

Zone	Original (dep/h)	Deduplicated (dep/h)
Urban Core	234.25	65.50
Inner Suburban Ring	59.50	24.50
Outer Suburban Ring	0.00	0.00
Fringe Ring	0.00	0.00

Note: Deduplicated values are exact medians under the maximum-frequency-per-(route, direction)-pair specification described above. Under a mean-per-(route, direction)-pair variant the deduplicated medians are slightly lower but the qualitative pattern is unchanged. The Spearman rank correlation between the primary and max-deduplicated hexagon-level series is $\rho = 0.97$.

Supplementary Note S6. Euclidean versus network-distance catchment: two complementary sensitivity analyses

The primary analysis uses Euclidean (straight-line) distance to define the 800 m walking catchment. In suburban environments with cul-de-sac street patterns, stormwater ponds, highways, and other barriers, the actual network walking distance to a transit stop can be 1.4–1.8× the Euclidean distance [5, 6]. We therefore quantify the magnitude of this bias through two complementary sensitivity analyses.

Path B: Literature-factor scaling across the full GTA. We estimate the effect of replacing the Euclidean catchment with a network-distance equivalent of 800 m by interpolating each hexagon's accessibility between the 400 m and 800 m fields already computed in the primary pipeline. Specifically, for a network-to-Euclidean factor f, the network-equivalent Euclidean radius is $800/f$ m; the corresponding accessibility is approximated by linearly interpolating between the 400 m and 800 m sums by the fractional position of $800/f$ relative to those endpoints. Table S7 summarizes the result for $f = 1.4$ (literature lower bound for suburban environments) and $f = 1.8$ (literature upper bound for cul-de-sac-dominant subdivisions).

Table S7. Predicted band-shift under literature-factor network-distance scaling.

Zone	% hexes changing band	% "High" dropped	% "Very High" dropped
$f = 1.4$ *(network-equivalent radius 571 m)*			
Urban Core	3.3%	50.0%	2.2%
Inner Suburban Ring	25.5%	63.2%	20.7%
Outer Suburban Ring	14.8%	70.5%	49.7%
Fringe Ring	4.3%	71.3%	50.4%
$f = 1.8$ *(network-equivalent radius 444 m)*			
Urban Core	16.7%	50.0%	15.9%
Inner Suburban Ring	49.7%	92.3%	49.2%
Outer Suburban Ring	20.7%	86.5%	80.2%
Fringe Ring	5.7%	90.2%	78.9%

The pattern is consistent: between 70.5% and 86.5% of currently-classified "High" hexagons in the

Outer Suburban Ring would lose at least one band under network-distance reclassification, and 49.7–80.2% of currently-classified "Very High" hexagons in the same ring would also drop. The bias is therefore concentrated in precisely the rings where the equity claim is strongest, and acts in the direction of understating the regional gradient.

Path A: Empirical network shortest-path estimate for Pickering (representative sub-analysis). The Path A analysis is presented as a representative sub-analysis for one outer-suburban municipality; it is not a GTA-wide network-distance robustness test, and a full regional empirical network-distance computation remains a worthwhile direction for further work. To confirm the literature-factor estimate empirically at this representative scale, we constructed a walkable street graph from publicly available OpenStreetMap road-network data for Pickering, an outer-suburban municipality with mixed grid and cul-de-sac patterns ($n = 288$ hexagons). Motorway and trunk segments were excluded as non-walkable; the resulting graph contains approximately 69,800 nodes and 74,200 edges. Each H3 centroid and each transit stop within a 2 km bounding-box buffer of the municipality was snapped to its nearest graph node, and a single-source shortest-path search bounded by an 800 m network cutoff was run from each centroid; the network-distance service intensity was then computed by summing scheduled departures per hour at all reachable stops. Table S8 compares the Euclidean and network-distance specifications.

Table S8. Pickering network-distance vs. Euclidean service intensity (800 m, weekday peak).

Statistic	Value
Hexagons in Pickering	288
Hexagons with non-zero accessibility (Eucl.)	73
Hexagons with non-zero accessibility (Net.)	68
Mean dep/h (Eucl.)	7.91
Mean dep/h (Net.)	2.92
Ratio (Net./Eucl.)	0.37
% hexagons changing band	14.2%
% hexagons dropping to a lower band	12.8%

The empirical network-distance result corroborates Path B: in Pickering, replacing the Euclidean catchment with shortest-path network distances reduces the mean weekday peak intensity by approximately two-thirds and shifts the band assignment of roughly one in seven hexagons. The two sensitivity analyses agree on direction and approximate magnitude: outer-suburban service availability is overstated by Euclidean catchments. The Pickering subset validates the Path B approximation; a GTA-wide empirical network-distance computation, which requires sustained graph traversal across tens of thousands of centroid–stop pairs, would be a worthwhile direction for further work.

Supplementary Note S7. Modifiable Areal Unit (MAUP) cross-resolution sensitivity, Mississauga

To address the modifiable areal unit problem associated with the choice of H3 resolution 8, we re-tessellated the City of Mississauga at the parent resolution 7 (approximate cell area 5.16 km^2) and at the child resolution 9 (approximate cell area 0.105 km^2), recomputed the schedule-aware service-intensity measure within an 800 m walking catchment using the same procedure as the primary analysis, and compared the resulting ring-equivalent statistics. Mississauga was selected as a representative inner-suburban municipality with substantial municipal-bus service (median 52 dep/h at H3 resolution 8) and well-defined polygonal boundaries. The result is summarized in Table S9.

Table S9. MAUP cross-resolution sensitivity in Mississauga.

H3 res.	Cell area (km^2)	n cells	Median dep/h	Any svc. (%)	$\geq$12 dep/h (%)
7 (parent)	5.16	66	41.25	87.9	68.2
8 (primary)	0.74	376	52.00	89.6	77.7
9 (child)	0.105	2632	50.00	88.8	76.9

The qualitative pattern is preserved across all three resolutions: the share of cells reaching 12 dep/h ranges from 68.2% to 77.7%, and the share of cells with any scheduled service ranges from 87.9% to 89.6%. Resolution 7 returns slightly lower percentages, consistent with the larger cell footprint averaging a wider range of local service densities; resolution 9 is essentially indistinguishable from the resolution-8 baseline. The municipal ranking of Mississauga—as a stronger-than-average suburban transit municipality—is therefore not an artifact of the H3 grain. A GTA-wide cross-resolution analysis at H3 resolutions 7 and 9 would be a useful extension of this study.

Supplementary Note S8. Ring-threshold and Halton-exclusion robustness

To verify that the central Inner-to-Outer Suburban Ring break is not an artifact of either the specific 15/30/45 km thresholds chosen for the primary analysis or the incomplete local-feed coverage in Halton Region, we recomputed the area-weighted ring statistics under two alternative threshold specifications and under exclusion of the four Halton municipalities (Oakville, Burlington, Halton Hills, Milton).

Table S10. Halton-excluded ring statistics, weekday peak departures-per-hour at 800 m.

Zone	***n* hex**	**Median**	**Mean**	**Any svc. (%)**	**≥12 dep/h (%)**
(a) With Halton (primary specification)					
Urban Core	460	234.25	256.5	98.7	97.8
Inner Suburban Ring	1372	59.50	85.1	87.2	78.1
Outer Suburban Ring	2428	0.00	7.4	28.1	16.6
Fringe Ring	5375	0.00	2.2	9.2	4.7
(b) Without Halton (Oakville, Burlington, Halton Hills, Milton excluded)					
Urban Core	460	234.25	256.5	98.7	97.8
Inner Suburban Ring	1348	61.00	86.5	88.2	79.2
Outer Suburban Ring	1878	0.00	9.2	33.2	20.2
Fringe Ring	4706	0.00	2.5	10.0	5.3

Table S11. Distance-ring threshold sensitivity, weekday peak departures-per-hour at 800 m.

Zone (under scheme)	***n* hex**	**Median**	**Mean**	**Any svc. (%)**	**≥12 dep/h (%)**
(a) Primary thresholds 15/30/45 km					
Urban Core	460	234.25	256.5	98.7	97.8
Inner Suburban Ring	1372	59.50	85.1	87.2	78.1
Outer Suburban Ring	2428	0.00	7.4	28.1	16.6
Fringe Ring	5375	0.00	2.2	9.2	4.7
(b) Alternative thresholds 10/25/40 km					
Urban Core	211	288.00	304.4	97.6	97.2
Inner Suburban Ring	1052	114.50	141.2	95.8	91.2
Outer Suburban Ring	2067	0.00	17.7	47.8	32.8
Fringe Ring	6305	0.00	2.4	9.9	5.4
(c) Alternative thresholds 20/35/50 km					
Urban Core	809	183.50	213.2	97.5	95.3
Inner Suburban Ring	1713	16.00	41.3	70.1	54.8
Outer Suburban Ring	2727	0.00	5.5	17.9	11.7
Fringe Ring	4386	0.00	1.4	8.0	3.4

The Halton-excluded recomputation (Table S10, panel b) shifts the Outer Suburban Ring's zero-service share from 71.9% to 66.8% and the Fringe Ring's from 90.8% to 90.0%; the Urban Core and Inner Suburban Ring are essentially unchanged. The Inner-to-Outer break (78.1% vs. 16.6% reaching 12 dep/h in the primary specification) survives the Halton exclusion (79.2% vs. 20.2%) and is therefore not an artifact of incomplete local-feed coverage in Halton.

The alternative ring thresholds (Table S11, panels b–c) compress or expand each ring's footprint while preserving the major Inner-to-Outer step: the share reaching 12 dep/h drops from 91.2% to 32.8%

under (10/25/40 km) and from 54.8% to 11.7% under (20/35/50 km), against 78.1% to 16.6% in the primary specification. The Inner-to-Outer break is therefore robust to defensible alternative threshold schemes.

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