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GATE (Ground-Floor Architectural Typology at the Street Edge): A Multi-Resolution Morphometric Framework for Resolving Urban Vitality in a Mid-Sized Turkish City

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Abstract

Urban vitality research treats food-and-beverage venues as aggregate point-of-interest counts and existing morphometric classification frameworks operate at the building, block or neighbourhood scale, leaving the commercial ground-floor interface without a programme-specific typology. This study develops GATE (Ground-floor Architectural Typology at the street Edge), a 22-variable morphological framework operating at the venue–street–interface scale, and applies it to 85 interfaces across eleven commercial arteries in the core of a mid-sized Turkish city. Ward hierarchical clustering yields a single dendrogram read at macro (k = 3) and micro (k = 7) resolutions, validated through Kruskal–Wallis tests that separate 17 and 19 of the 22 variables, respectively. Three macro types emerge: narrow-fronted apartment-ground-floor venues, detached garden-plot pavilion venues and vertically organised transparent-fronted venues. Space Syntax Integration, Choice and Shannon diversity produce no significant relationship with pedestrian density in the aggregate. Type stratification points to a resolution-dependent moderator effect: the apartment-ground-floor type shows negative Integration and positive Choice coupling, while the transparent vertical type shows positive Integration coupling, producing a directional pattern consistent with Simpson's paradox. GATE provides one of the first programme-specific venue-level morphological frameworks and establishes an explicit quantitative mapping of the Panerai–Castex analytical typology with future multi-city applications to test its generalisability.

Keywords: urban morphology; food-and-beverage venues; ground-floor typology; Ward hierarchical clustering; urban vitality; Space Syntax

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1. Introduction

Food-and-beverage venues rank among the primary indicators of urban vitality. However, no morphological taxonomy classifies the architectural forms of these venues. Urban vitality research employs them as density counts, POI (point-of-interest) proxy variables, or land-use categories [1–3]. Morphometric classification frameworks operate at the building, block, or neighbourhood scale [4–6]. The typomorphological tradition provides a rigorous qualitative classification procedure [7,8]. Although Turkish mid-sized cities are shown to exhibit urban patterns distinct from both European and East Asian contexts, these cities remain insufficiently represented in the morphometric clustering literature [9,10]. The moderating effect of morphological classification on vitality relationships has not yet been empirically established. The dependence of this effect on typological resolution has likewise not been systematically tested.

Urban vitality research and morphometric classification use food-and-beverage venues without distinguishing between their architectural forms. Small-scale food-and-beverage density is used as a block-level indicator of vitality in Shenzhen. The same study reveals that the effect of building typology on vitality is more determining than that of building density [1]. Similarly, restaurant POI counts are employed as dependent variables in street-block vitality models of Chinese metropolises [2]. A systematic review covering 191 urban vitality studies identifies food-and-beverage density as one of the principal design-dimension correlates of pedestrian activity and documents the limited attention paid to research focused on developing cities and small- and mid-sized urban centres [3]. All of this work treats food-and-beverage venues as a single analytical category that does not observe internal differences. Morphometric clustering operates at the building level through footprint geometry and volume [6], at the neighbourhood level through morphological tessellation cells [4], or at the grid level through regular spatial partitions [5]. None of these scales captures the individual commercial venue. Programme-specific attributes such as kitchen visibility, mezzanine arrangement and outdoor-seating capacity require venue-level field measurement. Existing restaurant taxonomies define categories through service format and price segment without reference to building form [11].

The typomorphological tradition supplies the epistemological structure for morphological classification but lacks a quantitative counterpart. The analytical typology formalised by Panerai and Castex [7,12] unfolds sequentially through inventory, comparison and clustering. The numerical taxonomy of urban form draws on biological systematics and therefore applies hierarchical clustering to morphometric characters [4,13]. Caliskan, Mashhoodi and Akay [14] develop a framework that describes the building fabric through measurable indicators. Araldi and Fusco [15] subsequently adapt this approach to the street level, jointly evaluating morphological attributes perceived from the pedestrian perspective through a network-sensitive clustering method. These quantitative approaches have not established an explicit mapping between their analytical steps and the sequential Panerai–Castex procedure. The present study makes establishing that mapping one of its distinguishing contributions.

Morphometric clustering research concentrates in two geographical corridors—one Western, one Eastern. In Western Europe, Prague, Amsterdam, London, French metropolitan areas, Rotterdam and Spanish cities form one empirical cluster [4,13,15–18]. In East Asia, the cities of Seoul, Taipei, Shenzhen, Wuxi and Beijing form another major cluster [1,2,5,19–21]. Turkish urban morphology research covers residential fabric typology in Ankara, where consecutive development generations have produced different typological compositions within the same urban fabric. The absence of effective development control has gradually converted this typological diversity into spatial fragmentation [10] and neighbourhood typologies in Istanbul [22]. Commercial ground-floor morphology in Turkish mid-sized cities has not been studied. Space-syntax analysis of the historical cores of fourteen Turkish cities from the seven geographical regions of Turkey confirms that the traditional urban fabrics of Turkey exhibit organic rather than gridded configurations and produce comparatively high intelligibility and synergy values [9]. A comparative analysis of eight fortified Roman-origin towns from Anatolia and Italy further shows that the two peninsulas diverge in block size and segment length, with the Roman legacy persisting in the Italian fabric while Islamic tradition reshaped the Anatolian pattern [23]. Apartment transformation in Anatolian cities follows a route distinct from that of the metropolitan centres; traditional spatial codes partially persist through the transition from detached dwelling to multi-storey apartment block [24]. Peri-urbanisation dynamics in Turkish mid-sized cities produce building-fabric patterns distinct from metropolitan growth models [25]. Ottoman-period urban morphological transformation is documented at the city scale in the Thrace region [26]. The broader geographical context of the study area shares this regional legacy. The contemporary commercial ground-floor morphology of the region has not yet been examined in the literature. This morphological specificity requires a context-specific assessment because frameworks developed for European or East Asian cities cannot be transferred directly.

Morphology–vitality research establishes consistent correlations between built-environment variables and pedestrian activity [27–29]. Street-intersection density, building density and mean block size emerge as dominant predictors in Chinese cities [30]. Morphological variables yield stable results when explaining urban vitality from the city scale down to the dense street scale, with an explanatory power higher than that of transport variables [31]. These studies treat morphological variables individually. Morphological classification—the cluster to which a venue, building or block belongs—offers a categorical moderator that may alter the direction and strength of variable-level vitality relationships.

Reviewing the literature, this study addresses the identified gaps through GATE (Ground-floor Architectural Typology at the Street Edge). GATE is a 22-variable morphological framework applied to 85 venue-street interfaces (83 physical venues) on eleven commercial streets in Kirklareli, a Turkish mid-sized city. GATE variables are organised into three dimensions adapted from the multi-level morphological data model of Kropf—Spatial Configuration, Volumetric Scale and Urban Placement [8]. Ward hierarchical clustering yields a single dendrogram read at macro (k = 3) and micro (k = 7) resolution levels. Kruskal–Wallis tests and Spearman correlations are used to validate the emerging types. Differentiated vitality relationships are then tested with Space Syntax network metrics.

The study pursues three objectives. The first is to develop a theoretically grounded morphological classification of food-and-beverage venues at multiple resolution levels, to provide the first operational (applicable, measurable and classifiable) venue-level typological framework for commercial ground-floor uses, and to extend the numerical taxonomy of Fleischmann et al. [4] from programme-blind building classification to programme-specific venue classification. The second is to identify the variables that produce the strongest separation between types at each resolution level. The third is to test whether morphological classification moderates vitality relationships with Space Syntax network metrics across resolution levels, to respond to the methodological gap identified by Doan and Zhang [3], and to provide one of the first morphometric analyses of commercial ground-floor forms in a mid-sized Turkish city [10,22,32].

2. Theoretical Framework

2.1. Typological Foundations and the Epistemological Position of GATE

Architectural typology classifies buildings through their spatial organisation, dimensional attributes, functional configuration and construction system. The fundamental distinction between type and model articulated by Quatremere de Quincy (1755–1849) separates a structural logic (a generative organising principle) from a fixed object to be copied. A type produces formally distinct variants that share a structural logic, whereas a model commands identical repetition [33]. Cluster types derived from GATE exist in Quatremere's sense as generative structural definitions that account for the variation within each cluster.

Urban morphology investigates the physical structure of cities through systematic analysis of streets, plots, buildings and their multi-scalar interrelationships [34,35]. Kropf's compositional definition of type [8] holds that the specific type of any building element depends on its position within a composition, its outline including access points, and its internal structure. The variable architecture of GATE translates this compositional definition into measurable dimensions. Urban Placement captures position through building–building, building–plot and building–public-space relations. Spatial Permeability captures the outline and access configuration through facade transparency, number of entrances and ground-level relation. Volumetric Scale captures the internal dimensional structure through width, depth, height and capacity. GATE measures 22 variables across the plot, building, interior and facade scales and produces a multi-scalar morphological profile for each venue (Table 1).

Table 1. GATE variable list (n = 85, 22 morphological variables).

No	Dim.	Type	Variable	Min	Max	Mean	SD/n(%)
V1	SC	Scale	Ground-floor facade width (cm)	260	3400	782	561
V2	VS	Scale	Ground-floor depth (cm)	190	3310	1065	622
V3	VS	Scale	Ground-floor ceiling height (cm)	210	425	283	41
V4	SC	Scale	Facade transparency ratio (%)	0	100	64	20
V5	VS	Scale	Interior capacity (seats)	0	222	47	50
V6	VS	Scale	Outdoor capacity (seats)	0	89	10	22
V7	VS	Scale	Shop storeys	1	3	1.3	0.5
V8	UP	Scale	Total building storeys	1	8	4.6	2.2
V9	SC	Scale	Number of entrances	1	3	1.2	0.5
V10	SC	Scale	Number of shop facades	1	4	1.8	1.0
V11	SC	Binary	Awning (0 = No/1 = Yes)				n(0) = 63, 74.1%
V12	SC	Binary	Ground-level relation (0 = Raised/1 = Flush)				n(0) = 23, 27.1%
V13	SC	Binary	Interior level break (0 = None/1 = Present)				n(1) = 18, 21.2%
V14	UP	Binary	Green-space presence (0 = None/1 = Present)				n(1) = 16, 18.8%
V15	VS	Binary	Kitchen-counter visibility (0 = Open/1 = Hidden)				n(0) = 79, 92.9%
V16	VS	Binary	Mezzanine (0 = None/1 = Present)				n(0) = 11, 12.9%
V17	UP	Binary	Building floor (0 = Ground/1 = Mezzanine)				n(0) = 19, 22.4%
A2	UP	Dummy	A2—adjacent, no garden, direct public				n = 25, 29.4%
A3	UP	Dummy	A3—attachment on pavement, direct public				n = 6, 7.1%
A4	UP	Dummy	A4—two front gardens, indirect public				n = 3, 3.5%
A5	UP	Dummy	A5—detached, gardens on four sides				n = 5, 5.9%
A6	UP	Dummy	A6—semi-detached, front/side/rear gardens				n = 8, 9.4%

SC = Spatial Configuration; VS = Volumetric Scale; UP = Urban Placement. For scale variables, Min, Max, Mean and SD are reported on raw values. Reference category A1 = adjacent, with rear garden, direct public (n = 38, 44.7%).

The typomorphological tradition reads building types through their historical formation and tracks diachronic and diatopic transformations of the urban fabric that develops from base types [36–38]. A posteriori classification follows a fundamentally different logic. It groups existing buildings on the basis of morphological similarity without tracing the typological process [39]. GATE operates within this second framing. Cluster types are derived from current field measurements, and no claim is made about historical formation or typological evolution. The analytical typology of Panerai and Castex [7,12] formalises the procedural structure for a posteriori type production through the sequential stages of inventory, comparison and clustering. GATE implements this procedure quantitatively, though with a modified ordering. The 22-variable standardised field-measurement protocol constitutes the inventory stage. Ward hierarchical clustering constitutes the clustering stage. As a final step, Kruskal–Wallis tests and cross-tabulations test at the comparison stage whether the identified types differentiate on individual variables. This mapping preserves the epistemological structure of the Versailles school while replacing qualitative description with quantitative measurement and expert judgement with algorithmic assignment.

2.2. The Street Edge as an Analytical Scale

The typological procedure summarised in Table 2 requires a unit of analysis. Morphometric studies typically adopt units such as the building, the morphological cell (tessellation-based plot proxy), the street segment or the street block [4,5]. GATE takes the individual commercial venue as its unit of analysis. This unit is defined at the ground-floor section located at the street edge. The section in question is the interface where the interior meets the public street.

Table 2. Mapping of the Panerai–Castex analytical typology onto the GATE quantitative protocol.

Stage	Panerai–Castex	GATE Quantitative Application	Tool	Output
1	Inventory	22-variable standardised field measurement	Laser meter+ observation form	Raw data (85 × 22)
2	Clustering	MinMax normalisation → Ward clustering (squared Euclidean)	SPSS	Dendrogram—k = 3, k = 7
3	Comparison	Kruskal–Wallis tests + Cramer V cross-tabulations	SPSS	Tables 4–6
4	Vitality test	-	Spearman correlations (type subsamples)	Tables 8 and 9

Lynch [40] introduces the edge as a structuring element of the urban mental image. His edges operate at the metropolitan scale as perceptual boundaries between different urban phases. Gehl [41] carries the concept to the street scale by distinguishing soft edges from hard edges. Soft edges are transparent, permeable, active, interactive, human-scaled active ground floors that invite pedestrians to linger. Hard edges are empty and impermeable surfaces that push pedestrians to move quickly. This binary distinction shows that the ground-floor interface directly modulates the way pedestrians move, depending on its configuration. Mobile eye-tracking experiments have confirmed this claim empirically. Pedestrians engage visually with ground-floor edges more than with upper floors, and on non-pedestrianised streets (owing to vehicular traffic) this engagement concentrates on the walked side [42,43]. Gehl's binary framework cannot differentiate within the "soft" category. Simpson et al. [44] address this limitation by decomposing the street edge into three sub-scales of subdivision. Plinths are architecturally-spatially defined objects and design units. Morphologically defined building ground floors match this definition. Segments are regionally defined facades belonging to single users. Micro-segments are smaller spatial units separated by columns. Eye-tracking data show that segments and micro-segments drive pedestrian visual engagement, while plinths do not produce a direct effect. The building ground floor is not the correct unit for studying ground-floor activation; the segment captures the scale at which engagement operates. GATE's unit of analysis corresponds exactly to this regional segment. Each venue represents a bounded portion of the street edge defined by its entrance, facade, awning or adjacent outdoor space. Kickert and Karssenberg [45] show how interactive facades—ground-floor interfaces that engage pedestrians through programme visibility and spatial permeability—shape urban street life.

Recent micro-scale urban vitality research confirms the segment as an analytically productive unit. Micro-level behavioural mapping in Shanghai shows that vitality concentrates at specific points. These points correlate with small shops and residential entrances [46]. Fine-grained mixed-use measurement at the street level produces stronger vitality correlations than traditional district-level indices and confirms that analytical resolution matters for detecting vitality patterns [47]. Transitional edges position street edges as an integration of the social, spatial and material dimensions. Thwaites et al. [48] conceptualise urban street edges as a socio-spatial transition zone. Along the Edge designates attributes experienced by the pedestrian moving horizontally along the street frontage. Across the Edge designates the perpendicular transition from the street into the building, capturing the spatial gradation from public to private and from outside to inside. Within the Edge acknowledges that the edge itself has depth and volume. GATE's Spatial Permeability captures across-edge attributes, its Volumetric Scale captures within-edge attributes, and its Urban Placement captures along-edge attributes. The "E" in GATE marks this analytical position and locates the framework at the street edge, where cell morphology intersects with pedestrian behaviour.

2.3. Urban Vitality and the Ground-Floor Interface

Urban vitality denotes the capacity of the built environment to attract and sustain human activity in public spaces [49,50]. Montgomery's triadic framework decomposes a sense of place into activity (the volume and diversity of pedestrian presence), image (the perceptual quality of place) and form (the physical configuration that enables or suppresses the first two). Gehl [41,51] classifies the activities that constitute vitality as necessary (commuting, daily errands), optional (leisure walking, sitting, socialising) and social (chance encounters, planned meetings). Optional and social activities depend on environmental quality and accumulate where urban spaces invite staying rather than passing [41,52].

Space Syntax theory provides the configurational framework for measuring how street-network properties produce pedestrian movement [53]. The theoretical distinction between Integration (to-movement potential) and Choice (through-movement potential) was formalised by Hillier and Iida [54]. Streets with high Integration attract destination-directed visits. Streets with high Choice generate transit movement. Peponis et al. [55] confirmed this distinction in commercial retail environments, showing that high-Choice locations generate incidental pass-by trade while high-Integration locations generate deliberate destination visits. The temporal dimension of this distinction has received limited but meaningful attention. Weekend movement patterns differ from weekday patterns, with purposive weekday trips giving way to weekend leisure trips [56]. The combination of configurational position and temporal context therefore produces different vitality outcomes on the same street at different times of the day and week.

The relationship between morphology and vitality has been studied at several scales. Block-level analyses in Chinese metropolises show that morphological attributes are the most dominant predictors of urban vitality. Gradient boosting further reveals that the effect of these variables on vitality is non-linear and varies at specific threshold values [2,30]. Urban types are classified on the basis of two variables—network centrality and building density—and these types produce distinctly differentiated pedestrian movement patterns at the neighbourhood scale [57]. Jacobsian-criteria work in Barcelona positions mixed use, building-age diversity, small block size and population density as primary neighbourhood-scale vitality generators [58]. A vital built environment contributes to strengthening community ties [59]. Turkish literature has addressed vitality research in the metropolitan context, mapping Jacobsian criteria in Kayseri through GIS layering [60] and re-evaluating urban density and vitality in post-pandemic Istanbul [61]. The strength and direction of morphology–vitality relationships vary between cities; context-specific tools are therefore needed in place of universal variable lists [2].

The ground-floor interface is the scale at which morphological attributes shape pedestrian behaviour. Transparent facades form the soft edges that function as invitations to pedestrians [41]. The visibility of food preparation increases the active and inviting dimension of the venue [62]. The fragmented structure of the ground-floor interface shapes pedestrian visual engagement relative to plinths [44]. Vitality indices applied comparatively in Barcelona, Santiago, Chengdu and Quito fail to capture ground-floor activation quality [63]; the corrective indicators proposed correspond to GATE variables. In Tehran, morphological descriptors of social interaction—the public–private space ratio, network connectivity, fabric grain and pattern structure [64]—correspond to GATE's Urban Placement variables. The transformation of the public–private interface into a site of activation supports vitality mechanisms in specific urban contexts [65]. Oliveira's MORPHO methodology [66] demonstrates the value of multi-criteria morphological assessment. GATE extends this multi-criteria approach to the venue scale by incorporating programme-specific dimensions. A block-level study of vitality in Shenzhen reveals that building typology exerts a stronger effect than building density, with block-type and strip-type categories producing higher vitality than point-type [1]. The Singapore study by Chen et al. [67] shows that morphological types alone carry sufficient information to explain vitality—meaningful results can be produced without recourse to individual variables—indicating that typological classification carries explanatory power beyond variable-based analysis. Whether venue-level classification produces a comparable effect on vitality relationships has not yet been tested. This study addresses that question by testing whether GATE types show differentiated relationships with Space Syntax metrics across resolution levels.

This study documents the commercial ground-floor food-and-beverage morphology of Kirklareli, a mid-sized city in Turkey's northwestern Thrace region. Field data, rather than historical interpretation, defines the morphological conditions of the study context. The commercial core concentrates 83 food-and-beverage venues (85 venue-street interfaces) on eleven arteries. Commercial activity in the city has a compact structure organised around a single centre. The vast majority of venues operate within the structural envelope of multi-storey apartment buildings (average number of building storeys 3.6); the structural limits of these buildings constrain the dimensional attributes of the venues. Dimensional diversity is nonetheless observed within this compact core. Across the 85 interfaces, for example, facade width varies between 260 cm and 3400 cm and interior capacity ranges from 0 to 222 seats. The general commercial ecology consists of individually operated venues with varied morphological configurations. The study context thus differs from metropolitan centres, where chain formats and planned commercial zones dominate the commercial ground-floor layout.

3. Study Area, Data and Methods

3.1. Study Area and Data Collection

Kirklareli (central population approximately 115,000) is located in Turkey's northwestern Thrace region, 40 km south of the Bulgarian border and 200 km west of Istanbul. The commercial core consists of a hierarchical street system in which food-and-beverage activity is concentrated. The eleven arteries selected for this study were identified through criteria of commercial continuity and complete enumeration. All food-and-beverage venues operating on these arteries during the research period were included without any eligibility screening beyond the requirement that on-site consumption be the primary service mode. The 83 physical venues investigated comprise fast-food outlets (n = 37, 43.5%), cafes (n = 20, 23.5%), restaurants (n = 15, 17.6%) and patisseries/bakeries (n = 13, 15.3%).

Two corner venues (venue-interfaces 1 and 8) present distinct morphological interfaces to two different arteries, with each facade constituting a separate observation unit, yielding n = 85 venue-street interfaces (Figure 1).

Figure 1. Kirklareli venues, eleven commercial arteries and 85 venue-street interfaces (red lines: locations and red dots: arteries).

Space Syntax axial-map analysis was performed in depthmapX version 0.8.0 (Figure 2) [68]. t and global Choice were computed at radius Rn. Values for the eleven streets are reported as network-characterisation variables (Integration range 0.59 to 1.00; normalised Choice range 0.00 to 0.91). Axial-map analysis is not used as a selection criterion; its function is to characterise the network context within which type-level vitality relationships operate.

Morphological field measurements were taken with a Bosch GLM 50C laser distance meter (±1.5 mm accuracy, purchased in Istanbul, Turkey). Pedestrian counts followed a manual observer-based screen-line procedure, combining the direct-observation tradition of public-space research [52] with the screen-line counting methodology codified in the Highway Capacity Manual [69]. Trained observers recorded all pedestrians crossing an imaginary line at the mid-point of each street segment (passing pedestrian only). Observations covered three days in the first week of October 2025 (one weekend day, two weekdays) across four one-hour periods (08:30–09:30, 12:00–13:00, 17:00–18:00, 20:00–21:00). All observation days took place under sunny or partly cloudy conditions (daytime high +18 °C, nighttime low +10 °C). This time window was selected to observe under optimal outdoor-activity conditions and to avoid pedestrian suppression. What is measured here is short-term pedestrian density under favourable weather conditions during a single week in early October, rather than urban vitality in its broader temporal and behavioural sense.

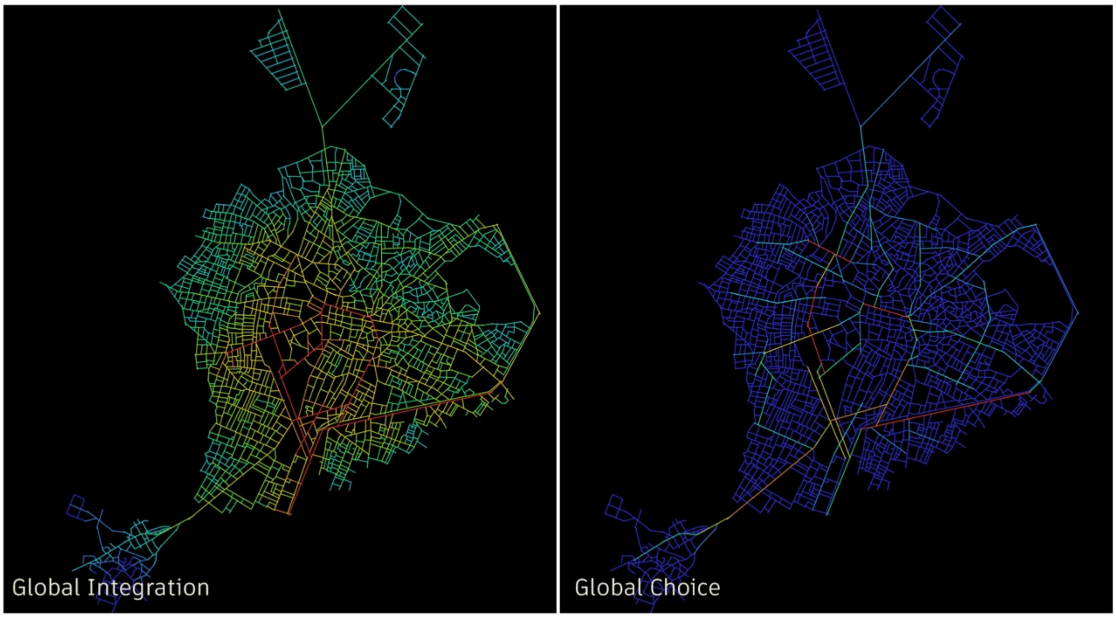

Figure 2. Spatial network systems, global integration and global choice maps of Kırklareli province (In the axial map, warm colors (red, orange) indicate high values, and cool colors (blue, green) indicate low values.).

3.2. Variable Framework

GATE organises 22 morphological variables into three measurement categories. Scale variables (10) consist of continuous and discrete count measurements with physically defined equal intervals (centimetres, number of seats, number of storeys). Binary variables (7) consist of two-valued morphological attributes (presence/absence, open/closed). Dummy variables (5) represent the nominal plot–building–public space relation (A1–A6), with A1 as the reference category. The six-category plot–building–public space relation is a re-coding of three nominal variables (building–building, building–plot and building–public) previously observed separately (Table 1). Operation category, a nominal variable without natural ordering, is excluded from the clustering input.

Code descriptions: A1 = adjacent arrangement, with rear garden, direct public; A2 = adjacent, no garden, direct public; A3 = attachment on pavement, direct public; A4 = adjacent, two front gardens, indirect public; A5 = detached, gardens on four sides, indirect public; A6 = semi-detached, front/side/rear gardens, indirect public.

MinMax normalisation maps all variables into the [0, 1] interval. The 22 variables consist of ten scale measurements with physically defined equal intervals and twelve binary measurements (7 binary + 5 dummy) (Table 1). All scale variables have a fixed physical unit and the distance between adjacent values is constant. No ordinal variable is included in the clustering. This decision removes the equal-interval assumption that affects mixed-type Ward clustering applications.

3.3. Analytical Procedure

The procedure implements the analytical typology of Panerai and Castex [7,12] via a quantitative protocol (Table 2). The inventory stage corresponds to the 22-variable standardised field-measurement protocol defined in Table 1. The comparison stage corresponds to the Kruskal–Wallis tests and cross-tabulations that assess possible differentiations of the identified types on individual variables. The clustering stage corresponds to Ward

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hierarchical clustering. All clustering and statistical analyses were performed in SPSS (version 29).

MinMax normalisation maps all variables into the [0, 1] interval while preserving proportional distances. MinMax is preferred to Z-score standardisation because Z-score encodes extreme values as outliers beyond multiple standard deviations and produces a disproportionate effect on Euclidean distance calculations. MinMax scaling normalises variables into the 0–1 range while preserving the discriminability of the original distribution without distortion.

After MinMax normalisation, each scale variable contributes a proportional squared difference within [0, 1] to the squared Euclidean distance, and every scale variable thus contributes equally to the clustering decision. Binary and dummy variables take only 0 or 1. Two observations sharing a category contribute 0 to the distance and two observations differing contribute 1, under the logic of a simple matching distance. Because all scale variables have physically defined equal intervals and all remaining variables are binary, no variable in the clustering requires the equal-interval assumption that affects mixed-type Ward applications with ordinal variables.

With 85 observations for 22 variables, the observation-to-variable ratio of 3.9 is well below the simulation-derived benchmark of 70 observations per variable proposed for reliable market-segmentation clustering [70], reflecting that the present study aims not at a predictive segmentation but at an exploratory typological description of an existing, spatially bounded commercial-centre population. Gower distance was considered as an alternative for handling the nominal plot variable but was not adopted because 94% of the variables are scale or binary. Ward's ESS-minimisation property requires Euclidean distance, and simulation studies show that Euclidean-based methods outperform Gower on data sets dominated by continuous variables [71]. Ward hierarchical clustering produces a single dendrogram that supports multi-resolution reading through horizontal cut-lines. Rather than selecting a single optimal k, the dendrogram is read at the macro (k = 3) and micro (k = 7) resolution levels.

Kruskal–Wallis tests assess possible differentiations of the identified types on individual GATE variables at each resolution level. Pearson chi-square tests with Cramer V complement the Kruskal–Wallis results for the operation category. Spearman correlations within each type test the relationship between three network-context variables (Space Syntax Integration, Space Syntax Choice and Shannon land-use entropy) and pedestrian density. Shannon normalised entropy (0 to 1) characterises the functional diversity of each street and provides a complementary contextual variable to the configurational metrics. It enters the analysis as a vitality-side variable rather than as a clustering input.

4. Results

4.1. Dendrogram Structure and Type Profiles

Ward hierarchical clustering applied to the 22 MinMax-normalised morphological variables produces a clearly interpretable dendrogram structure. The analysis covers all 85 venue-street interfaces and uses squared Euclidean distance. The macro typology resolution (k = 3) was determined by inspecting the Ward agglomeration schedule. The merge from four to three clusters produced the third-largest proportional increase in the agglomeration coefficient ($\Delta = 0.614$, $\Delta\% = 13.6\%$), indicating a substantial loss of within-cluster homogeneity at this step and supporting k = 3 as a structurally grounded partition. The micro-typology resolution (k = 7) was selected on the basis of morphological interpretability rather than a data-driven optimum. The agglomeration schedule does not identify k = 7 as a prominent cut point ($\Delta = 0.058$, $\Delta\% = 1.8\%$). However, the seven-subtype solution captures within-type variation—such as the mezzanine, ground-elevation and green-space distinctions among Type A and Type C venues—that remains invisible at the macro level. The micro-typology is therefore treated as an exploratory refinement throughout the analysis (Table 3, Figure 3).

Table 3. Summary of GATE typological classification: descriptive labels and key identifying features.

Code	Descriptive Label	Parent Macro Type	n	Key Identifying Features
Type A	Narrow-front apartment-ground-floor type	-	55	Attached-row, narrow facade (V1 = 0.08), shallow depth (V2 = 0.19), small interior capacity (V5 = 0.09), strong awning presence (V11 = 82%), multi-storey building (V8 = 0.71), no outdoor seating, no green space
Type B	Detached garden-pavilion type	-	9	Detached plot, widest facade (V1 = 0.43), deepest plan (V2 = 0.53), tallest ceiling (V3 = 0.65), full green coverage (V14 = 100%), multi-facade (V10 = 1.00), multiple entrances (V9 = 0.50), single-storey building (V8 = 0.00)
Type C	Vertical transparent-front type	-	21	Attached-row, medium facade (V1 = 0.20), multi-floor venue (V7 = 0.50), ground-level relation (V12 = 62%), interior level break (V13 = 57%), mezzanine (V16 = 29%), green space present (V14 = 33%), multi-storey building (V8 = 0.71)
Subtype 1	Awning-dominant corner-plot variant	A	27	Near-absolute awning (V11 = 96%), dual-facade corner position (V10 = 0.33), no mezzanine, no green space, smallest interior capacity (V5 = 0.08)
Subtype 2	Mezzanine vertical variant	A	10	Absolute upper-floor position (V17 = 100%), mezzanine (V16 = 40%), absolute awning (V11 = 100%), multi-storey building (V8 = 0.71)
Subtype 3	Pure attached-row variant	A	18	Pure A2 parcel relation (A2 = 100%), mid-level awning (V11 = 50%), no mezzanine, multi-storey building (V8 = 0.71)
Subtype 4	Garden destination type	B	9	Identical to Type B macro profile
Subtype 5	Pure elevated-interface variant	C	12	Absolute ground elevation (V12 = 100%), single entry (V9 = 0.00), no mezzanine, medium capacity (V5 = 0.27)
Subtype 6	Hybrid green multi-storey variant	C	4	Absolute interior level break (V13 = 100%), strong green (V14 = 75%), highest outdoor capacity (V6 = 0.53), multi-floor venue (V7 = 0.50), highest building (V8 = 0.79)
Subtype 7	Mezzanine transparent vertical variant	C	5	Absolute mezzanine (V16 = 100%), highest transparency (V4 = 0.81), high interior level break (V13 = 80%), twin plot
Total			85	

Note: All continuous values are MinMax-normalised medians (0–1 range). Binary values are percentage of venues with the feature present.

Macro Level (k = 3)

Cutting the dendrogram at the higher distance level (Figure 4) partitions the data set into three main clusters. These clusters represent the fundamental morphological organisations of food-and-beverage venues (Figure 5).

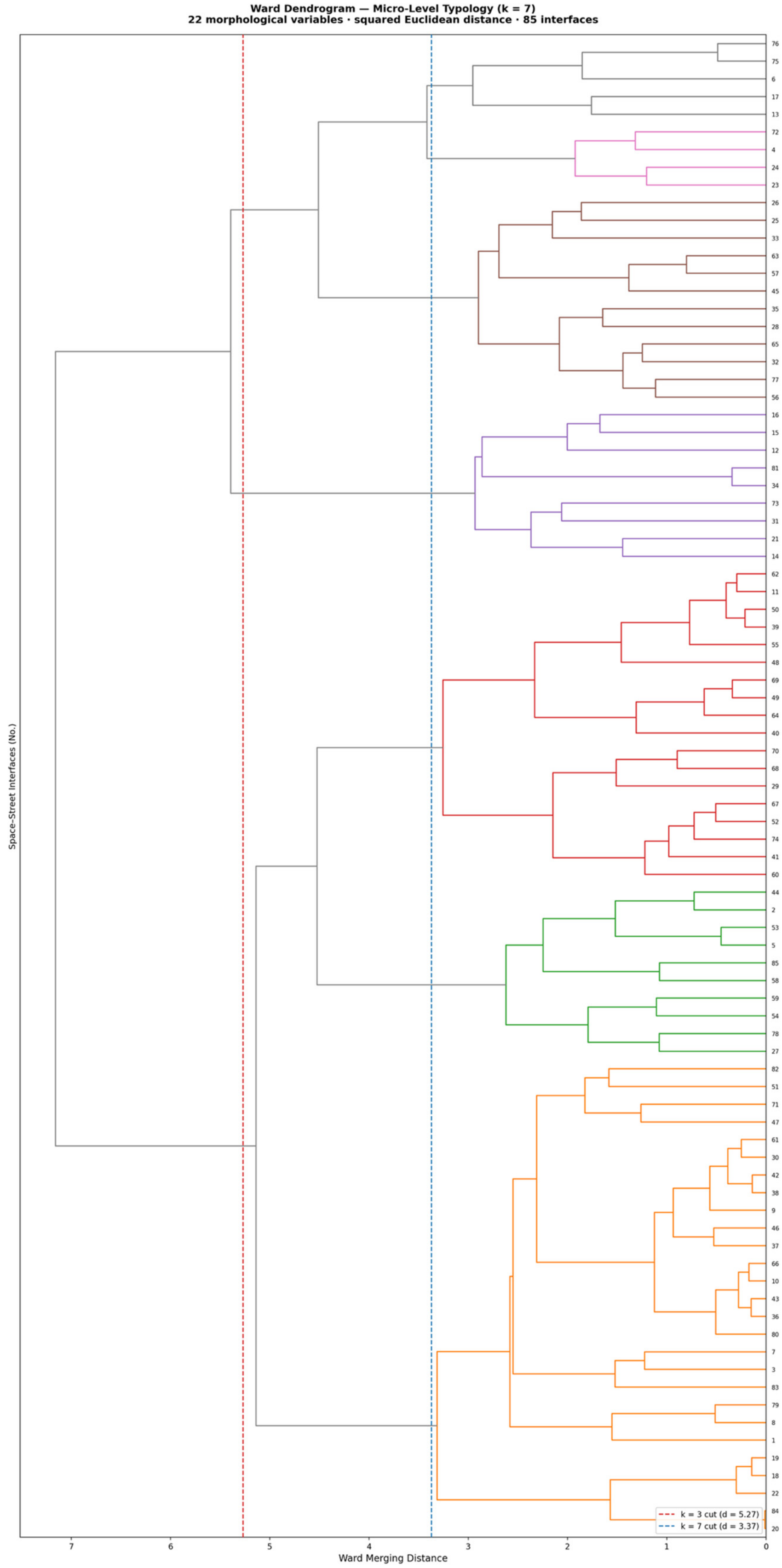


Figure 3. Ward hierarchical clustering dendrogram—venue codes (n = 85, 22 variables). The red dashed line indicates the k = 3 macro cut; the blue dotted line indicates the k = 7 micro cut.

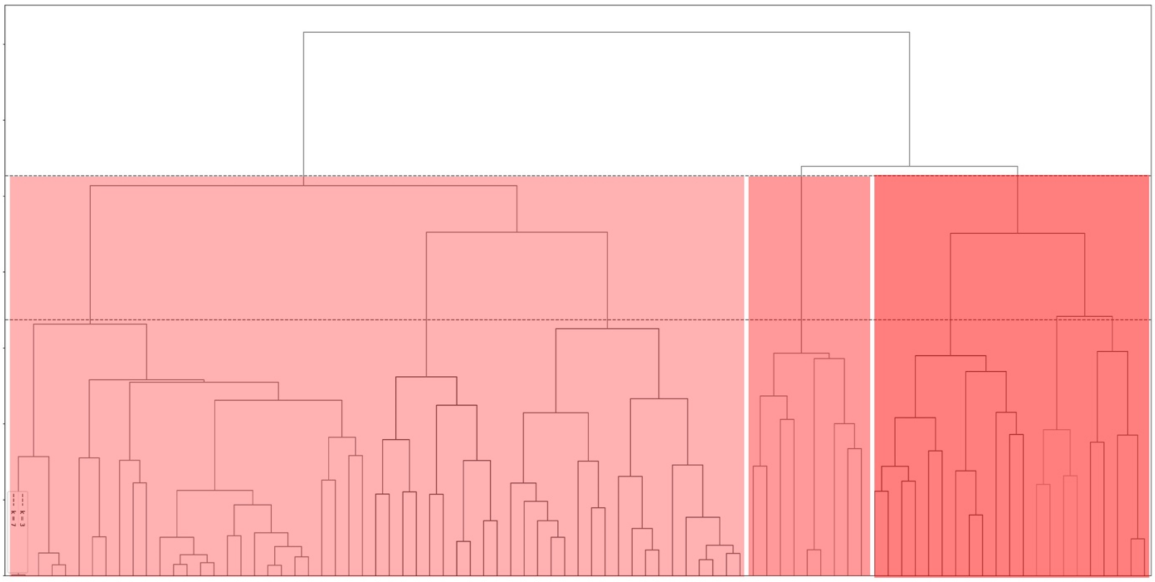


Figure 4. Macro (k = 3) resolution groups (Light pink, medium pink, and dark pink represent Type A, Type B, and Type C, respectively).

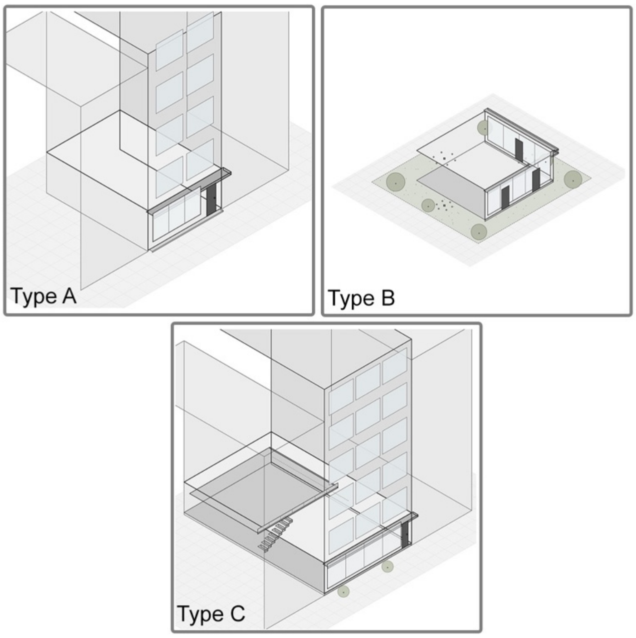
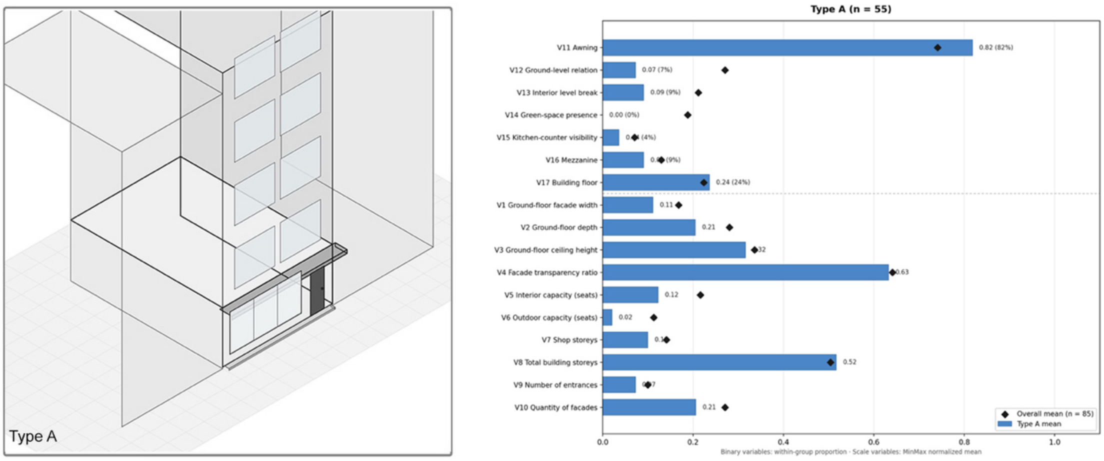


Figure 5. Macro (k = 3) types (Type A, Type B and Type C).

Type A: Narrow-front apartment-ground-floor type (n = 55)

Type A constitutes the dominant type of the data set (65%) (Figure 6a). This type consists of commercial units with relatively narrow facades (V1 = 0.11), single-storey configurations and limited interior capacity (V7 = 0.1, V5 = 0.12). In terms of ground-level relation, almost all members are located at street level (V12 = 0.07) and there is no interior level break (V13 = 0.09). Outdoor-space use is negligible (V6 = 0.02). Facade transparency is at a moderate level (V4 = 0.63); the number of entrances is typically single (V9 = 0.07), and number of facades is limited to one or two. Mezzanine and gallery arrangements are rarely observed. The awning element is strongly represented (V11 = 0.82). Buildings are predominantly located on the ground floors of mid-height buildings (V8 = 0.52) on adjacent-arrangement plots and establish direct contact with public space. The green-space component has no representation in this type (V14 = 0.00) (Figure 6b). These attributes indicate that Type A represents the typical small-scale food-and-beverage venues commonly seen in the city centre. This type is represented by venues 10, 30 and 7.

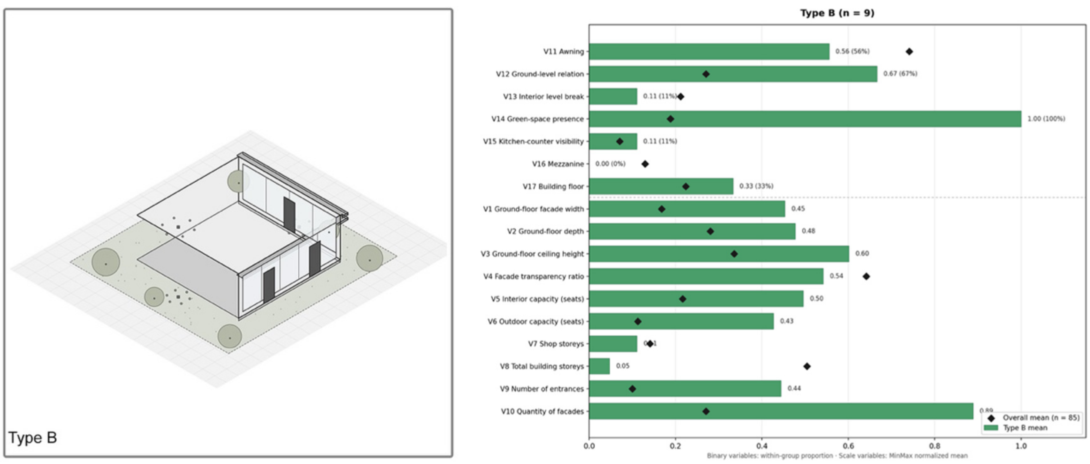


(**a**) (**b**)

Figure 6. (**a**) Type A; (**b**) Type A variable profile.

Type B: Detached garden-pavilion type (n = 9)

Type B (Figure 7a) forms the smallest cluster (10.6%) of the data set. In morphological terms this type differs from the other two types on almost all parameters. Facade width (V1 = 0.45), venue depth (V2 = 0.48) and ceiling height (V3 = 0.60) have the highest values in the data set. Interior capacity (V5 = 0.49) and outdoor capacity (V6 = 0.43) are also markedly above the other clusters. In terms of ground-level relation, most members are flush with the street (V12 = 0.67). The green-space component is represented at the maximum level (V14 = 1.00). The number of facades is high (V10 = 0.89), indicating that most members are located in a detached configuration. Multiple-entrance arrangement is also a defining attribute of this type (V9 = 0.44). The building is generally single-storey (V8 = 0.05) (Figure 7b). In urban-placement terms, venues are predominantly located on detached or garden plots and establish indirect contact with public space. This type is represented by venues 14, 15 and 73.

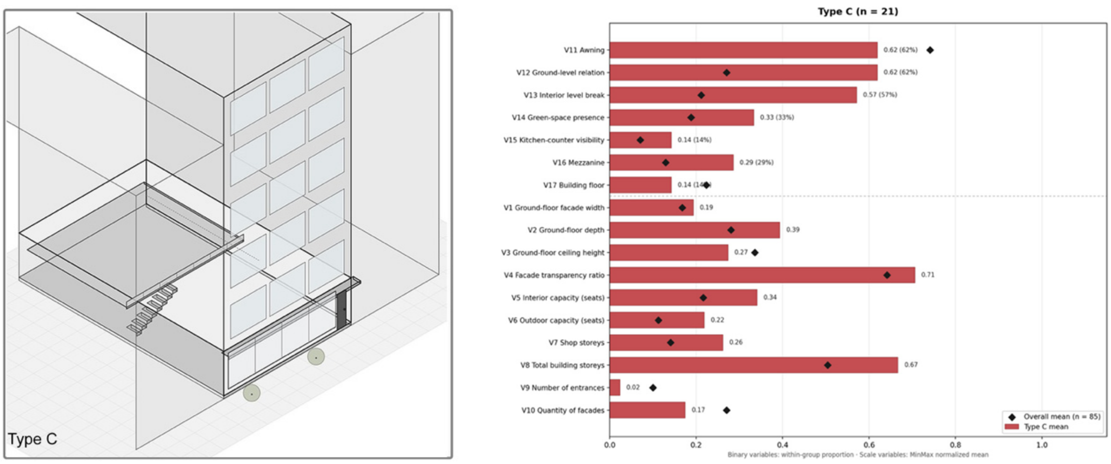


(**a**) (**b**)

Figure 7. (**a**) Type B; (**b**) Type B variable profile.

Type C: Vertical transparent-front type (n = 21)

Type C (Figure 8a) is a cluster in which spatial organisation is defined through vertical growth. In terms of ground-level relation, most members are flush with the street (V12 = 0.62). An interior level break is present (V13 = 0.57). Building height is the highest among the three types (V8 = 0.67). A significant share of the venues feature open mezzanines or multi-storey use. Facade transparency is at its highest level (V4 = 0.71) (Figure 8b). Facade width is close to the mean, while venue depth produces above-average values. Facade configuration may include multiple entrances and facades. This type is represented by venues 4, 35 and 6.



(**a**) (**b**)

Figure 8. (**a**) Type C; (**b**) Type C variable profile.

Micro Level (k = 7)

Cutting the dendrogram (Figure 9) at the lower distance level partitions the data set into seven sub-clusters. This resolution level reveals the morphological diversity within the macro types in detail (Figure 10). The dominant Type A at the macro level splits into several subtypes that differentiate on facade order, plot relation, spatial capacity and mezzanine/gallery use. Type B venues largely preserve their integrity at the micro level. Type C venues split into different subtypes based on mezzanine and gallery organisation, showing that vertical spatial organisation generates typological diversity.

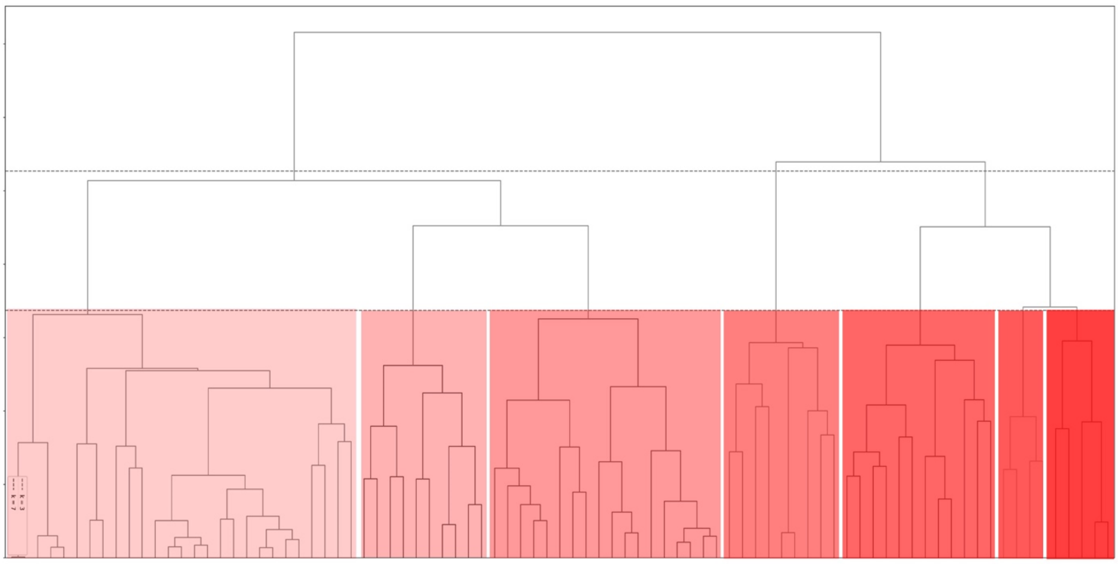


Figure 9. Dendrogram micro cut at k = 7 (from light pink to dark pink, respectively: Subtype 1, Subtype 2, Subtype 3, Subtype 4, Subtype 5, Subtype 6, and Subtype 7).

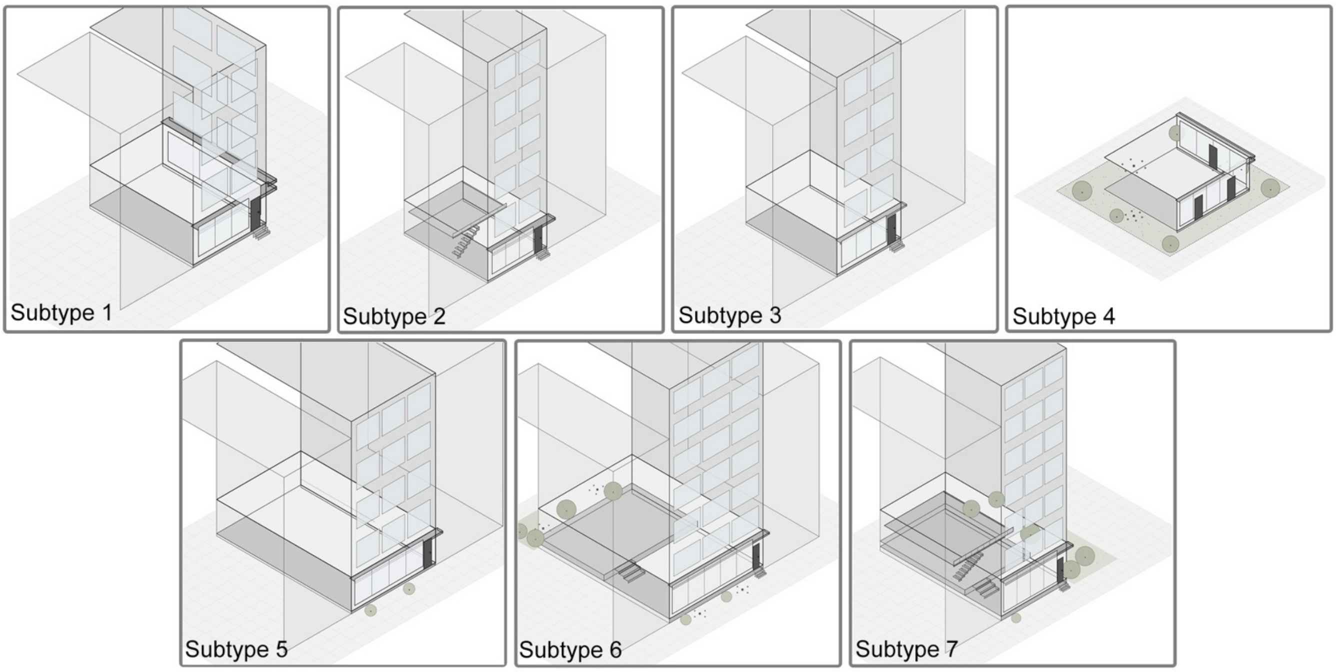
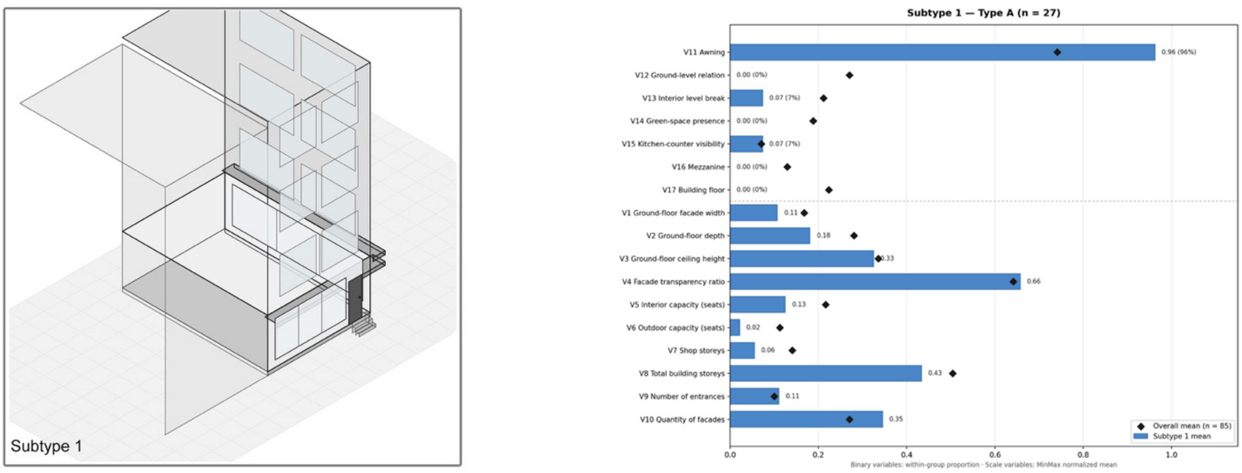


Figure 10. Micro-level (k = 7) type overview.

Subtype 1: Awning-dominant corner-plot variant (n = 27, parent A)

This is the most homogeneous and most populous subgroup of Type A (Figure 11a). Awning is represented at a near-absolute level (V11 = 0.96). Ground level is above street level (V12 = 0.00). Interior level-break values are essentially zero (V13 = 0.07). Green-space and mezzanine elements are absent. The plot–building–public relation is represented in a relatively balanced manner (A2 = 0.11, A3 = 0.11, A4 = 0.11). The number of facades (V10 = 0.35) is the highest among Type A subvariants—this is the Type A variant that permits corner-plot or two-facade positioning. Building height (V8 = 0.43) is at a medium-low level. Interior and outdoor capacity values are below the overall average (V5 = 0.12, V6 = 0.02) (Figure 11b). Subtype 1 represents the most standard and most common morphological form of the Kirklareli street fabric.

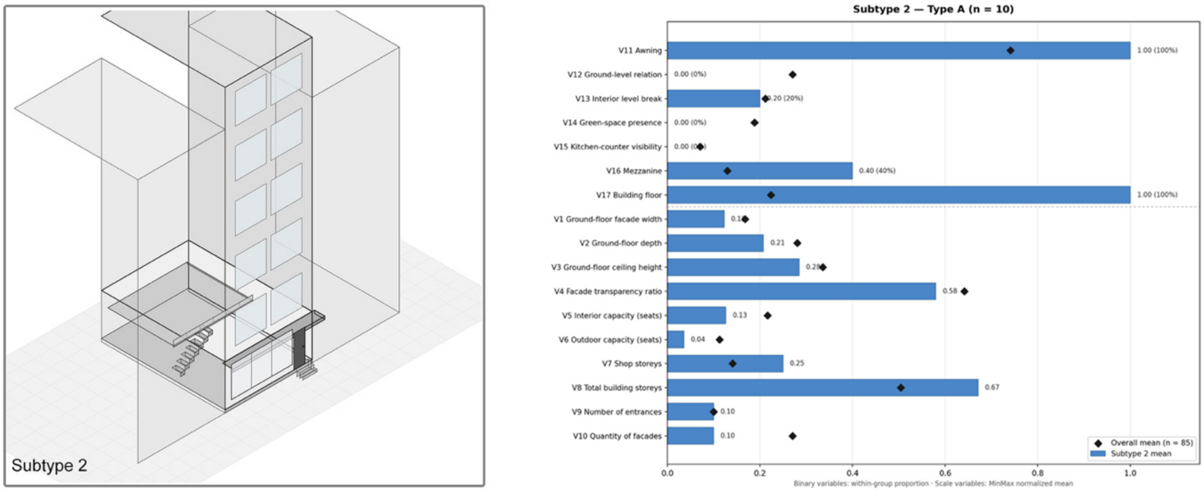


(**a**) (**b**)

Figure 11. Subtype 1 (**a**); Subtype 1 variable profile (**b**).

Subtype 2: Mezzanine vertical variant (n = 10, parent A)

This group shares the small-scale profile of Type A (V1 = 0.12, V5 = 0.13) (Figure 12a). The position of the commercial area within the building is absolutely differentiated (V17 = 1.00, all two-storey). The total number of building storeys is the highest among the Type A subvariants (V8 = 0.67). In the plot–building–public relation, combinations of A2 (0.40) and A6 (0.20) are represented in a mixed manner. Awning is absolute (V11 = 1.00) (Figure 12b).

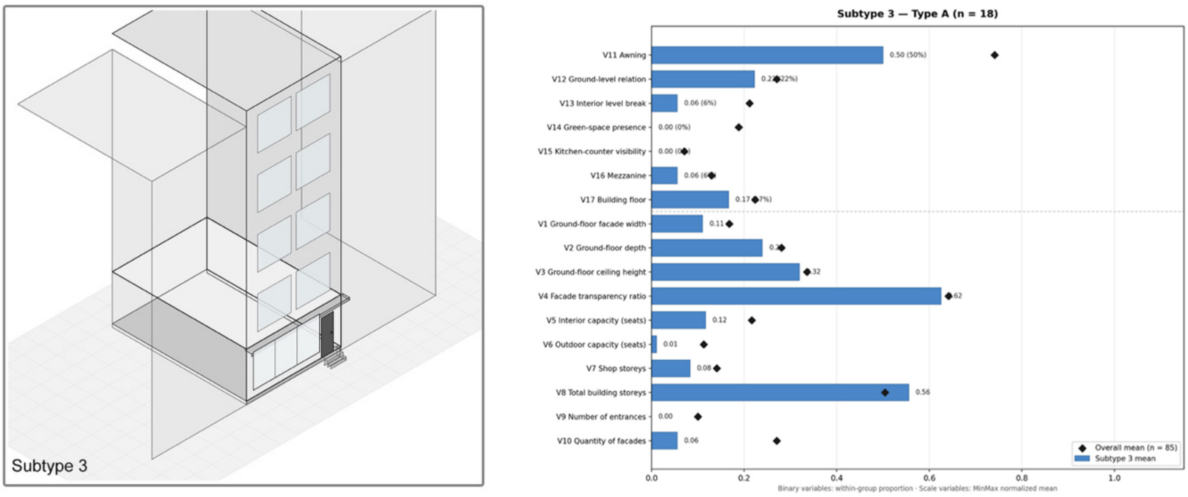


(**a**) (**b**)

Figure 12. Subtype 2 (**a**); Subtype 2 variable profile (**b**).

Subtype 3: Pure attached-row variant (n = 18, parent A)

The defining attribute of this sub-cluster (Figure 13a) is its uniform signature on the plot–building–public relation: all members fall in the same category (A2 = 1.00). All members are adjacent, without garden, in direct contact with public space. Awning is moderate (V11 = 0.50). Ground-level offset and interior level-break values reflect the classic Type A signature (V12 = 0.22, V13 = 0.06). Facade dimension and interior-capacity values are also consistent with the overall Type A profile (V1 = 0.11, V5 = 0.12). In contrast to Subtype 2, building height is at a moderate level (V8 = 0.56) and mezzanine is almost absent (V16 = 0.06) (Figure 13b). This group shares the scale attributes of Type A.



(**a**) (**b**)

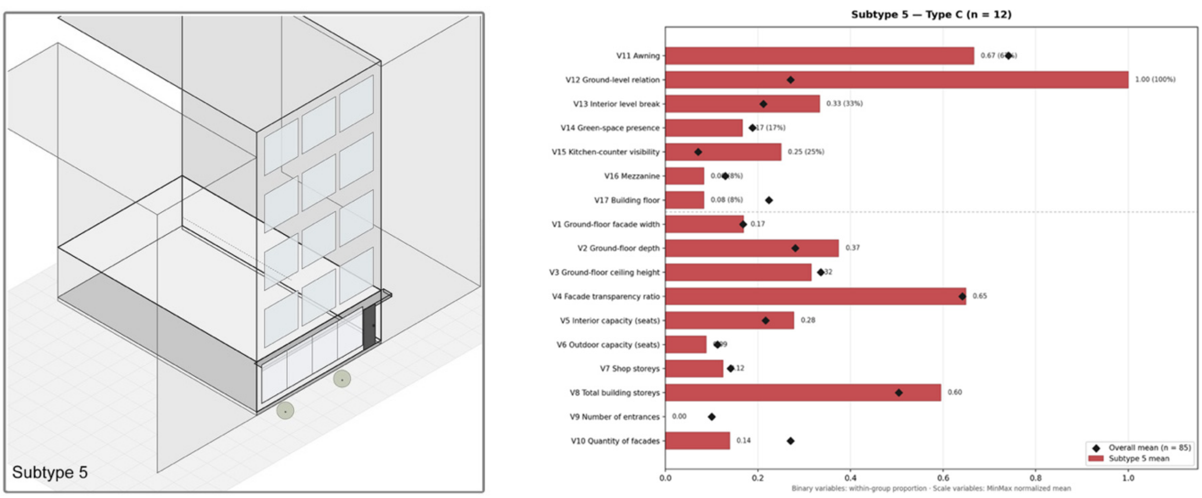
Figure 13. Subtype 3 (**a**); Subtype 3 variable profile (**b**).

Subtype 4: Garden destination type (n = 9, parent B)

This subtype coincides exactly with macro-level Type B. That the sub-cluster does not subdivide at the micro level indicates that Type B has high internal morphological consistency across the 22 variables and that the typology carries a stable and unified character in itself.

Subtype 5: Pure elevated-interface variant (n = 12, parent C)

The ground-level offset variable shows absolute homogeneity (V12 = 1.00): all members are located above the street. (Figure 14a) The interior level-break value is low (V13 = 0.33). The green-space component is limited (V14 = 0.17). Awning is at a moderate level (V11 = 0.67). Transparency (V4 = 0.65) and building height (V8 = 0.60) are close to the main Type C profile. Capacity indicators are at a moderate level (V5 = 0.28, V6 = 0.09). All or nearly all members carry the minimum number of entrances in the sample—a single entrance (V9 = 0.00 after normalisation; raw value 1) (Figure 14b).

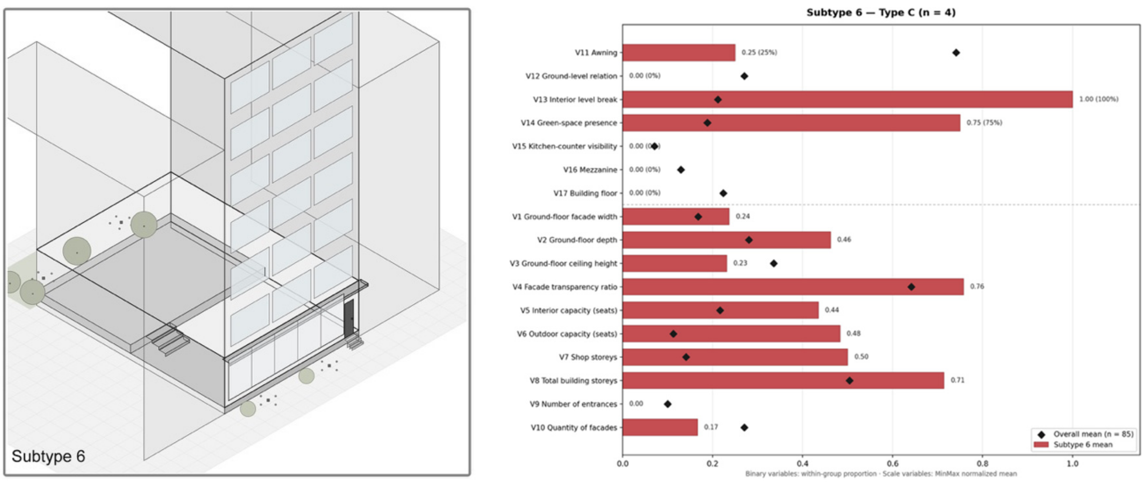


(**a**) (**b**)

Figure 14. Subtype 5 (**a**); Subtype 5 variable profile (**b**).

Subtype 6: Hybrid green multi-storey variant (n = 4, parent C)

A small but morphologically highly distinctive subgroup (Figure 15a). Interior level break is at an absolute level (V13 = 1.00). The green-space component is strongly represented (V14 = 0.75). The A3 plot–building–public label (attachment on the pavement, direct public) is dominant (A3 = 0.50). In venue depth (V2 = 0.46), interior capacity (V5 = 0.43), outdoor capacity (V6 = 0.48) and shop storey count (V7 = 0.50), this subgroup holds the highest values among the subvariants. Building storey count (V8 = 0.71) and transparency ratio (V4 = 0.76) are high (Figure 15b). This subtype can be positioned as a hybrid between Type C and Type B. It inherits the raised ground-level offset and vertical structure from Type C, and the green-space presence and extensive outdoor use from Type B. It constitutes Kirklareli's largest-scale and most programmatically complex interface typology.

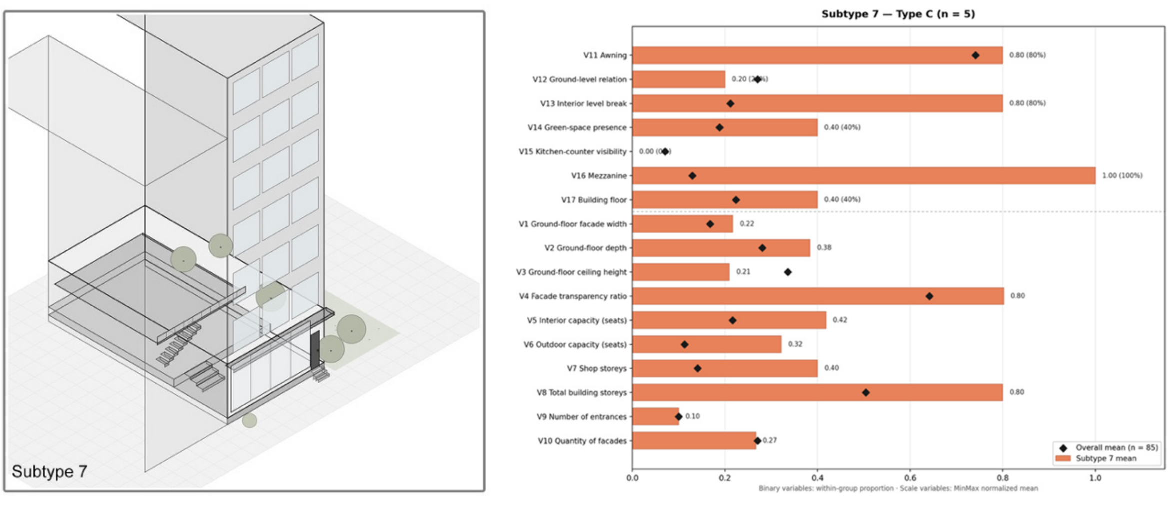


(**a**) (**b**)

Figure 15. Subtype 6 (**a**); Subtype 6 variable profile (**b**).

Subtype 7: Mezzanine transparent vertical variant (n = 5, parent C)

The mezzanine component is present in all members (Figure 16a) (V16 = 1.00). In the plot–building–public relation, the A6 label (semi-detached, front/rear/side gardens, indirect public) is dominantly represented (A6 = 0.80). High values are also observed on the interior level-break (V13 = 0.80), awning (V11 = 0.80), transparency (V4 = 0.80) and building-height (V8 = 0.80) variables. Capacity values are at a moderate level (V5 = 0.41, V6 = 0.32). The number of facades is low (V10 = 0.27) and the number of entrances is limited (V9 = 0.10) (Figure 16b).



(**a**) (**b**)

Figure 16. Subtype 7 (**a**); Subtype 7 variable profile (**b**).

4.2. Variable-Level Differentiation

The types derived are defined through the combination of a large number of morphological attributes. Facade width, venue depth, capacity, number of facades, number of entrances and plot relation, taken together, show that each cluster produces a morphological profile of its own. Hierarchical cluster analysis therefore presents the architectural and urban attributes of street-edge food-and-beverage venues as a multi-dimensional typology. Kruskal–Wallis and Pearson chi-square tests assess whether the types differentiate significantly on individual GATE variables at each resolution level.

Kruskal–Wallis tests were applied to assess whether the types derived at k = 3 differentiate significantly on the scale variables. The results show that nine of the ten scale (ε^2 ranging from 0.154 to 0.271) variables analysed (90%) produce significant differences between types (Table 4). The strongest separations appear on interior capacity (H = 24.214, $p < 0.001$), number of shop facades (H = 23.168, $p < 0.001$) and total building storeys (H = 21.651, $p < 0.001$). An important finding is that facade transparency ratio (H = 2.744, $p = 0.254$) does not produce significant separation between types. This finding shows that facade transparency is not one of the fundamental variables that define spatial typology.

Table 4. Kruskal–Wallis H statistics—k = 3 (df = 2).

No	Variable	Dim.	Type	H	*p*	Result	ε^2	Effect	Dunn Post-Hoc
V1	Ground-floor facade width	SC	Scale	20.053	<0.001	***	0.22	large	A–B ***; A–C *
V2	Ground-floor depth	VS	Scale	18.644	<0.001	***	0.203	large	A–B *; A–C ***
V3	Ground-floor ceiling height	VS	Scale	15.334	<0.001	***	0.163	large	A–B **; B–C ***
V4	Facade transparency ratio	SC	Scale	2.744	0.254	ns	0.009	negl.	n/a
V5	Interior capacity	VS	Scale	24.214	<0.001	***	0.271	large	A–B **; A–C ***
V6	Outdoor capacity	VS	Scale	16.222	<0.001	***	0.173	large	A–B ***
V7	Shop storeys	VS	Scale	9.828	0.007	**	0.095	medium	A–C **
V8	Total building storeys	UP	Scale	21.651	<0.001	***	0.24	large	A–B ***; B–C ***
V9	Number of entrances	SC	Scale	14.661	0.001	**	0.154	large	A–B **; B–C ***
V10	Number of facades	SC	Scale	23.168	<0.001	***	0.258	large	-

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ns = not significant, $\varepsilon^2 = (H - k + 1)/(N - k)$, Effect size thresholds: negligible < 0.01, small < 0.06, medium < 0.14, large ≥ 0.14.

Dunn post-hoc comparisons indicate that the Type A–Type B pair is the primary axis of differentiation, reaching significance on eight of the nine variables, while the Type B–Type C pair diverges specifically on ceiling height and building storeys, confirming that Type B (detached garden-pavilion) constitutes the morphologically most distinct macro group.

Kruskal–Wallis tests at k = 7 show that the majority of scale variables produce significant differences between clusters. Of the ten scale variables analysed, nine (ε^2 ranging from 0.16 to 0.346) (90%) show statistically significant separation between types (Table 5). The strongest separations appear in the number of facades (H = 32.987, $p < 0.001$) and total building storeys (H = 28.822, $p < 0.001$). At this resolution as well, facade transparency ratio (H = 6.916, $p = 0.329$) does not produce a significant difference between types.

Table 5. Kruskal–Wallis H statistics—k = 7 (df = 6).

No	Variable	Dim.	Type	H	*p*	Result	ε^2	Effect	Dunn Post-Hoc
V1	Ground-floor facade width	SC	Scale	21.618	0.001	**	0.2	large	S1–S4 **; S3–S4 *
V2	Ground-floor depth	VS	Scale	20.540	0.002	**	0.186	large	-
V3	Ground-floor ceiling height	VS	Scale	18.481	0.005	**	0.16	large	S1–S4 *; S4–S7 **
V4	Facade transparency ratio	SC	Scale	6.916	0.329	ns	0.012	small	ns
V5	Interior capacity	VS	Scale	25.502	<0.001	***	0.25	large	S1–S4 *; S3–S4 *
V6	Outdoor capacity	VS	Scale	25.562	<0.001	***	0.251	large	S1–S4 **; S1–S6 **; S3–S4 *; S3–S6 *
V7	Shop storeys	VS	Scale	24.370	<0.001	***	0.236	large	S1–S6 **; S1–S7 *; S3–S6 **; S4–S6 *
V8	Total building storeys	UP	Scale	28.822	<0.001	***	0.293	large	S2–S4 **; S3–S4 **; S4–S5 **; S4–S6* *; S4–S7 ***
V9	Number of entrances	SC	Scale	18.838	0.004	**	0.165	large	S3–S4 **; S4–S5 **
V10	Number of facades	SC	Scale	32.987	<0.001	***	0.346	large	S1–S4 ($p = 0.0129$ *); S2–S4 ***; S3–S4 ***; S4–S5 ***

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ns = not significant, $\varepsilon^2 = (H - k + 1)/(N - k)$. Effect size thresholds: negligible < 0.01, small < 0.06, medium < 0.14, large ≥ 0.14.

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Dunn's post-hoc comparisons reveal that Subtype 4 (garden destination type) is the most distinct microgroup.

At k = 3, Pearson chi-square analyses at the macro typology level show that several categorical variables differentiate significantly between clusters. Ground-level relation (chi2 = 30.982, $p < 0.001$), interior level break (chi2 = 21.633, $p < 0.001$) and green-space presence (chi2 = 54.460, $p < 0.001$) produce strong relations between types. The A2 and A5 plot–building–public groups also differ significantly between types (Table 6). At k = 7, more variables produce significant differences at the micro-typology level. Kitchen-counter visibility (chi2 = 61.331, $p < 0.001$), the A3 plot–building–public group (chi2 = 60.596, $p < 0.001$) and interior level break (chi2 = 55.051, $p < 0.001$) show strong separations. Mezzanine presence (chi2 = 8.928, $p = 0.178$) and the A5 group (chi2 = 6.680, $p = 0.351$) do not show significant relations between clusters.

Table 6. Pearson chi-square results—k = 3 (df = 2) and k = 7 (df = 6).

Variable	k = 3 chi2	*p*	V (k = 3)	Effect	k = 7 chi2	*p*	V (k = 7)	Effect
V11 Awning	4.949	0.084	0.241	small	22.958	0.001	0.52	large
V12 Ground-level relation	30.982	<0.001	0.604	large	22.958	0.001	0.805	large
V13 Interior level break	21.633	<0.001	0.504	large	55.051	<0.001	0.619	large
V14 Green space	54.460	<0.001	0.8	large	32.569	<0.001	0.849	large
V15 Kitchen counter	2.879	0.237	0.184	small	61.331	<0.001	0.324	medium
V16 Mezzanine	6.615	0.037	0.279	small	8.928	0.178	0.745	large
V17 Building floor	1.465	0.481	0.131	small	47.179	<0.001	0.743	large
A2	19.318	<0.001	0.477	medium	46.878	<0.001	0.844	large
A3	2.571	0.276	0.174	small	60.596	<0.001	0.422	medium
A4	1.696	0.428	0.141	small	15.138	0.019	0.28	small
A5	16.190	<0.001	0.436	medium	6.680	0.351	0.47	medium
A6	12.129	0.002	0.378	medium	18.771	0.005	0.662	large

Note: Cramér's V effect size: negligible < 0.10, small < 0.30, medium < 0.50, large ≥ 0.50.

4.3. Type-Level Vitality Relationships

In the type-blind analysis (n = 85), no statistically significant relationship is found between Space Syntax Integration and mean pedestrian density (rho = −0.068, $p = 0.534$). The relationship between Choice and pedestrian density is also not significant (rho = 0.171, $p = 0.117$). The relationship between the Shannon diversity index and pedestrian density is weakly negative but does not reach statistical significance (rho = −0.202, $p = 0.064$) (Table 7). These results show that when all venues are evaluated together, network accessibility alone does not explain pedestrian density.

Table 7. Type-blind Spearman correlations (n = 85).

Variable	Spearman rho	*p*	Result
Integration × pedestrian	−0.068	0.534	not significant
Choice × pedestrian	0.171	0.117	not significant
Shannon × pedestrian	−0.202	0.064	not significant

Spearman correlation analysis at the macro typology level shows that the relationship between Space Syntax network metrics and pedestrian density emerges in different directions between morphological types (Table 8). In Type A, a negative and significant relationship is found between Integration and pedestrian density (rho = −0.319, $p = 0.018$), and a positive and significant relationship is observed between Choice and pedestrian density (rho = 0.285, $p = 0.035$). In Type C, a positive and statistically significant relationship is found between Integration and pedestrian density (rho = 0.479, $p = 0.028$). In Type B, the relationship between Integration and pedestrian density is not statistically significant

(p = 0.381), and a strong negative relationship is found between the Shannon diversity index and pedestrian density (rho = −0.697, p = 0.037). Because the sample size of this cluster is low (n = 9), the results require cautious interpretation.

Table 8. Macro-level Spearman correlations (k = 3).

Type	n	Integration (rho)	p	Choice (rho)	p	Shannon (rho)	p
Type A	55	−0.319	0.018 *	0.285	0.035 *	−0.032	0.819
Type C	21	0.479	0.028 *	0.225	0.327	−0.378	0.091
Type B	9	0.333	0.381	−0.197	0.612	−0.697	0.037 *

Note: * $p < 0.05$.

Spearman correlation analyses at the micro-typology level show that the relationship between Space Syntax network metrics and pedestrian density differs between subtypes (Table 9). Subtype 6 and Subtype 7 have relatively low sample sizes (n = 4 and n = 5); the computed correlation coefficients are therefore not sufficient for reliable statistical inference. In Subtype 3, a strong and statistically significant negative relationship is observed between Integration and pedestrian density (rho = −0.680, p = 0.002). In Subtype 4, a significant negative relationship is found between Shannon and pedestrian density (rho = −0.697, p = 0.037); no significant relationship is detected between Integration and Choice variables and pedestrian density. In Subtype 5, the relationships between network metrics and pedestrian density are positive or negative in direction but are not statistically significant.

Table 9. Micro-level Spearman correlations (k = 7).

Subtype	Parent	n	Integration (rho)	p	Choice (rho)	p	Shannon (rho)	p
Subtype 1	A	27	−0.246	0.215	0.323	0.100	−0.038	0.849
Subtype 2	A	10	0.132	0.716	0.582	0.077	−0.006	0.986
Subtype 6	C	4	0.333	0.667	−0.500	0.500	0.333	0.667
Subtype 7	C	5	1.000	-	0.456	0.440	−1.000	-
Subtype 3	A	18	−0.680	0.002 **	0.024	0.923	0.090	0.723
Subtype 4	B	9	0.333	0.381	−0.197	0.612	−0.697	0.037 *
Subtype 5	C	12	0.329	0.297	0.196	0.542	−0.487	0.108

Note: * $p < 0.05$, ** $p < 0.01$.

4.4. Inter-Cluster Vitality Comparison

Table 10 reports the basic descriptive statistics. Mean pedestrian density is 821.27 (SD = 452.32). Space Syntax Integration has a mean of 0.859; values in the data set range between 0.594 and 1.000. The Choice variable shows high variance (mean = 1.293, SD = 1.215).

Table 10. Descriptive statistics (n = 85).

Variable	Mean	SD	Min	Max
Mean pedestrian count	821.27	452.32	140.67	1558.42
Integration	0.859	0.111	0.594	1.000
Choice	1.293	1.215	0.002	5.000

The Kruskal–Wallis test indicates some differences in certain network metrics between clusters at the macro typology level. A statistically significant difference is found between clusters on Choice (H(2) = 7.508, p = 0.023). No significant difference is observed between clusters on pedestrian density (H(2) = 0.447, p = 0.800) and Integration (H(2) = 4.260, p = 0.119) (Table 11).

Table 11. Kruskal–Wallis results between macro types (k = 3).

Variable	H	df	*p*	ε^2	Effect
Pedestrian mean	0.447	2	0.800	0.000	negl.
Integration	4.260	2	0.119	0.028	small
Choice	7.508	2	0.023 *	0.067	medium

Note: * $p < 0.05$.

Kruskal–Wallis analyses at the micro-typology level show that none of the variables examined differ significantly between clusters (Table 12). These results show that urban vitality is not determined solely by individual architectural typologies. The differentiation of the Choice metric at the macro typology level indicates that some morphological arrangements form strong relationships with transit movement flows. The findings suggest that urban vitality is shaped through interactions with network configuration and urban context rather than being directly produced by morphological type.

Table 12. Kruskal–Wallis results between micro types (k = 7).

Variable	H	df	*p*	ε^2	Effect
Pedestrian mean	1.498	6	0.960	0.000	negl.
Integration	5.054	6	0.537	0.000	negl.
Choice	8.439	6	0.208	0.031	small

5. Discussion

5.1. Resolution-Dependent Type-Vitality Moderation: Interpretation of the Main Finding

The resolution-dependent type-vitality moderation that constitutes the main finding of the study must be evaluated across different analytical planes. The transition from the non-significance of the type-blind correlations (rho = −0.068, ns) to the significance of the type-stratified correlations is revealed. A second plane is the different moderating effect produced on the same data by the macro (k = 3) and micro (k = 7) resolutions. Ye et al. [1] showed that in Shenzhen, block typology is five times more powerful as a vitality explanator than density. This finding provides block-scale evidence that typological classification plays a moderating role in vitality relationships. The present study carries the same moderator role to the venue-street interface scale. When, in the type-blind analysis, all 85 venue-interfaces are treated as a single sample, Space Syntax Integration, Choice and the Shannon diversity index do not produce significant relationships with pedestrian density. This non-significance is not measurement-driven; it is the statistical consequence of treating a morphologically heterogeneous sample homogeneously. Oppositely directed relationships from different morphological types mask one another and cancel the mean correlation of the mixed sample. This pattern, known as Simpson's paradox [72], describes how a strong relationship present in subgroups disappears when the groups are combined. In this study, the negative Integration relationship of Type A (rho = −0.319) and the positive Integration relationship of Type C (rho = +0.479) mask each other through mutual neutralisation, constituting a concrete empirical example.

5.2. To-Movement/Through-Movement Asymmetry in Type A

Type A (n = 55) constitutes the widespread morphological type of Kirklareli. In this type, a negative relationship is observed between Integration and pedestrian density (rho = −0.319, $p = 0.018$), and a positive relationship appears between Choice and pedestrian density (rho = +0.285, $p = 0.035$). The oppositely signed and simultaneous significance of the two Space Syntax metrics sharpens the theoretical interpretation. In the space-syntax framework of Hillier and Hanson [53], Integration represents the to-movement potential—the mean directional depth of each street relative to all others as a measure of topological accessibility. Choice represents the through-movement potential—the frequency with which a street lies on the shortest paths [54]. In Type A, that Choice maintains a positive correlation while Integration becomes negative indicates that the spatial organisation of the type is governed by transit traffic rather than destination visits. In other words, Type A venues concentrate on routes that carry the greatest transit movement. The Izmir research of Can and Heath [32] likewise shows that the relationship between socio-spatial structure and movement patterns varies with the urban morphological context. Reflecting the context-specific character of Turkish urban fabric, this sign reversal suggests that the standard apartment ground-floor venues of mid-size scale that define Type A adapt to a commercial pattern organised by transit routes rather than by topological integration. Ye et al. [1] used the density of small-scale food-and-beverage establishments as a proxy for block-level urban vitality in Shenzhen. This methodological choice rests on an implicit assumption that food-and-beverage venues cluster on their own in locations where vitality already exists. The positive Choice relationship of Type A suggests that small standard food-and-beverage venues capitalise on existing transit movement rather than generating vitality, consistent with their treatment in the literature as a proxy for vitality.

5.3. Alignment with the Natural-Movement Hypothesis in Type C

In Type C (n = 21) there is a positive and significant relationship between Integration and pedestrian density (rho = +0.479, p = 0.028); Choice and Shannon variables are not significant. This result stands in clear contrast to the negative relationship observed in Type A (rho = −0.319) and shows that the relationship between network accessibility and vitality depends on morphological type. However, sample size is limited and the results require cautious interpretation. The positive Integration relationship is consistent with the to-movement component of the natural-movement hypothesis developed by Hillier and Hanson [16]. Higher pedestrian densities are observed at accessible locations. The non-significance of Choice suggests that movement is fed by topological centrality rather than by transit routes. The cross-sectional data do not allow the direction of causation to be determined. The morphological attributes of Type C—high transparency (V4 = 0.71), narrow facade (V1 = 0.19), single entrance (V9 close to 0.02) and flush ground-level relation (V12 = 0.62)—provide an explanatory context for this relationship. Tang et al. [73] find a positive relationship between transparent facades and pedestrian draw. Hillnhutter [74] shows that visual stimulation increases on narrow streets. These findings suggest that the narrow and transparent facade of Type C produces a strong visual signal on high-integration axes. However, tension remains with Gehl's [41] framework, in which the active facade is defined through the coupling of visual and physical permeability. Although physical access is limited in Type C, a positive relationship is observed between Integration and pedestrian density. This pattern suggests that visual permeability may operate independently of physical access, although confirmation of this interpretation requires further research. The pattern of Type A stands in sharp opposition to Type C. In Type C, Integration is positive and significant while Choice is non-significant; in Type A, the situation is exactly reversed. In the same network, Type A venues align with transit routes while Type C venues align with topological centres; this situation constitutes the strongest empirical indication of how morphological type conditions the network–vitality relationship.

5.4. Functional-Diversity Paradox in Type B

Type B (n = 9) shows a strong negative relationship between the Shannon diversity index and pedestrian density (rho = −0.697, p = 0.037). Integration and Choice values are non-significant. This type consists of Kirklareli's widest-fronted venues with the highest interior and outdoor seating capacity. The negative coefficient of the Shannon index contradicts the intuitive expectation, because the urban vitality literature generally associates functional diversity positively with pedestrian activity [2,3]. This contradiction raises the hypothesis that Type B venues draw on a singular and powerful functional attractor rather than on functional diversity. This pattern is consistent with the destination typology: when the venue is itself a destination, what is determinative is not environmental diversity but the venue's own morphological capacity. However, this interpretation should be evaluated cautiously because of the limited sample size (n = 9).

5.5. Micro Resolution: Subtype 3 and Subtype 4

Subtype 3 (n = 18) reveals the true source of the negative Integration relationship observed at the macro level across Type A (rho = −0.319). In this subtype, the relationship more than doubles in the negative direction (rho = −0.680, $p = 0.002$). Subtype 4 (n = 9) coincides exactly with macro-level Type B, and the strong negative relationship between Shannon and pedestrian density is also preserved at this level (rho = −0.697, $p = 0.037$). That the Integration and Choice variables remain non-significant indicates that the pedestrian draw of these venues is shaped independently of network position.

5.6. Methodological Implications of Resolution Choice

That macro (k = 3) and micro (k = 7) resolution levels produce different moderation patterns shows that typological resolution is an analytical variable. At the macro level, Kruskal–Wallis analyses performed with k = 3 discriminate 9 of 10 scale variables (90%) at a significant level, with predominantly large effect sizes ($\varepsilon^2 > 0.14$ for 8 of 9 significant variables). At the micro level k = 7, the same discrimination percentage is preserved and the discrimination of categorical variables deepens: kitchen-counter visibility (chi2 = 61.331), plot–building–public relation categories (chi2 = 60.596) and commercial-area location (chi2 = 47.179) reach significance only at the micro resolution. The GATE typology yields morphologically distinguishable groups at the macro level, while the micro-level subtypes should be interpreted as exploratory given their sensitivity to the standardisation method. These results confirm that the clustering stage in the sequential procedure of Panerai and Castex [7] is an analytical decision rather than a merely technical choice. When the research question focuses on the capacity of programme-specific attributes to determine typological separation, micro-level resolution provides a more suitable analytical ground. When the research question aims to examine how vitality relationships with network metrics vary between types, macro-level resolution provides higher statistical power thanks to larger per-variable subgroup samples. Reading a single dendrogram at two resolutions offers this methodological flexibility simultaneously. The building-morphology classification of Fleischmann et al. [4] has no programme-specific dimensions, and the present study operates with a discrimination that goes beyond their approach by treating kitchen-counter visibility, commercial-area location and ground-level offset as structural signals.

5.7. Limited Typological Determinacy of Facade Transparency

In Gehl's active/passive facade distinction [41] and in the interactive-facades framework of Kickert and Karssenberg [45], facade transparency is positioned as a central discriminating variable. In this study, facade transparency ratio (V4) is the only variable that does not produce significant separation between types at either k = 3 (H = 2.744, $p = 0.254$) or k = 7 (H = 6.916, $p = 0.329$). This finding is at first sight at odds with the methodological weight given to facade transparency in the urban vitality literature. The overall transparency mean of the sample is high (mean = 64%, SD = 20). The vast majority of food-and-beverage venues operate under the structural constraint of apartment ground floors. In the commercial cores of mid-sized Turkish cities that display similar morphological patterns, transparency in the context of food-and-beverage venues should be evaluated as an indicator that reflects inter-building similarity rather than facade-level differentiation. The effect of ground-floor transparency on vitality therefore requires context-sensitive evaluation.

5.8. Typological Specificity in the Turkish Mid-Sized Urban Context

This study is the first to document the commercial ground-floor fabric of Kirklareli through morphometric clustering. Topcu [9] showed through space-syntax analysis of the historical cores of fourteen Turkish cities that the traditional urban fabrics of Turkey exhibit organic rather than gridded configurations and produce comparatively high intelligibility and synergy values. Eskidemir and Kubat [23] separately demonstrated through eight fortified Roman-origin Anatolian and Italian towns that the two peninsulas diverge in block size and segment length. The findings of this study show that a distinctive morphological character also extends to the ground-floor commercial venue scale in a mid-sized Turkish setting. A marked dimensional diversity is observed within Type A, which constitutes 65% of the sample. This heterogeneity is consistent with the transformation process identified by Arat [24]. Traditional spatial codes are partially preserved in Turkish cities and produce diversity. Caliskan et al. [10] showed that consecutive development generations form different typological compositions within the same fabric. A similar situation is observed in Kirklareli's commercial core: a single macro type accommodates a broad heterogeneity containing seven distinct micro subtypes.

5.9. Methodological Contribution: Quantitative Implementation of the Panerai–Castex Procedure

The core of the study's methodological contribution lies in implementing the sequential typology procedure formulated qualitatively by Panerai and Castex [7,12] through a quantitative framework. The explicit mapping established in this study between the qualitative procedure of Panerai and Castex and Ward hierarchical clustering constitutes the methodological contribution. The inventory stage is matched with a 22-variable standardised field-measurement protocol, comparison with Kruskal–Wallis and Pearson chi-square tests, and clustering with Ward clustering. This mapping preserves the epistemological structure of the typomorphological tradition while replacing qualitative description with measurable variables. Caliskan, Mashhoodi and Akay's metric-typomorphology approach [14] proposed indicator-level formalisations for building-fabric characterisation, and Araldi and Fusco [15] extended this approach with multi-level street-based fabric assessment. However, these studies did not establish an explicit mapping between their analytical steps and the procedural sequence of Panerai–Castex. The present study fills this gap through a programme-specific variable set and the commercial ground-floor scale, thereby establishing an explicit methodological bridge for positioning morphometric clustering as a quantitative extension of the typomorphological tradition. In parallel, the pedagogical literature in the Turkish academic context frames typomorphology as a systematic context-analysis protocol that proceeds through inventory, comparison and classification of urban elements [75], emphasising the analytical rather than stylistic function of typological reading. GATE's 22-variable inventory and Ward-based classification are consistent with this framing and suggest that the quantitative implementation proposed here may also serve as a reproducible analytical module within typomorphology-based design education.

5.10. Limitations

Pedestrian counts were conducted over a single week under ideal atmospheric conditions to remove the negative effect of weather on pedestrian behaviour. Measurements covering different seasons in future work may reveal the temporal stability of type-level relationships. Space Syntax values are assigned at the street-segment level, and all venues on the same street share the same network metric; this renders within-street positional variation invisible. In Kruskal–Wallis tests, because venues from different streets are compared, the effect of this limitation is negligible. In the Spearman correlations, because multiple venues on the same street enter the analysis as independent observations, the effective sample size corresponds to the number of streets rather than to the number of venues. For this reason, the network–vitality correlations should be interpreted as indicators of street-level relationship patterns rather than as precise effect size estimates at the venue level. Small sample sizes destabilise Spearman correlation coefficients for Type B (n = 9) and some micro subtypes (n = 4–5); the relationships reported for these types should be evaluated as hypotheses to be tested by future research rather than as firm inferences. Whether the study's typomorphological-resolution-dependent moderation pattern also holds in different urban contexts should be tested through multi-city GATE applications.

6. Conclusions

This study developed the GATE (Ground-floor Architectural Typology at the street Edge) framework for the morphological classification of food-and-beverage venues at the street-interface scale, then applied it to 85 venue-street interfaces on eleven commercial arteries of Kirklareli. The 22-variable morphological framework produced through Ward hierarchical clustering a single dendrogram that can be read at two resolution levels—macro (k = 3) and micro (k = 7). Kruskal–Wallis tests confirmed that 17 of the 22 variables at the macro resolution and 19 at the micro resolution produce significant separation between types ($\varepsilon^2 > 0.14$).

The main finding of the study is that morphological type membership reveals the relationship between network accessibility and pedestrian density. In the type-blind analysis, none of Integration (rho = −0.068), Choice (rho = 0.171) or Shannon (rho = −0.202) produced a significant relationship with pedestrian density. When stratified by type, significant relationships emerged: in Type A Integration was negative (rho = −0.319, p = 0.018) and Choice positive (rho = 0.285, p = 0.035); in Type C Integration was positive (rho = 0.479, p = 0.028). This inverse pattern, by masking itself, is consistent with Simpson's paradox in the analysis of type blindness. At the micro resolution, Subtype 3 produced an Integration relationship (rho = −0.680, p = 0.002) and Subtype 4 a Shannon relationship (rho = −0.697, p = 0.037), showing that effects concealed at the macro level become visible only at the micro resolution.

The first contribution of the study to the literature is that GATE provides a context-specific, venue-level operational morphological framework for commercial ground-floor uses. This framework extends the programme-blind building classification of Fleischmann et al. [4] into programme-sensitive venue classification. A second contribution is that the moderating effect of morphological classification on the network–vitality relationship is empirically demonstrated at the venue–street–interface scale. This effect carries the block-scale typological moderator role demonstrated by Ye et al. [1] to a finer unit of analysis. Finally, an explicit methodological mapping is established between the qualitative analytical typology procedure of Panerai and Castex [7,12] and Ward hierarchical clustering as a quantitative protocol.

Future research applying GATE to Turkish cities of different scales and to different geographical contexts will test the generalisability of the resolution-dependent moderation pattern. Pedestrian measurements covering seasonal and temporal variation will further reveal temporal differences in type-level relationships. Finally, automating GATE variables through remote sensing and street-view data will increase the scalability of the framework.

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