

WALKABILITY EVALUATION IN SHARED TRANSACTION SPACES TOPOLOGIES: OFFICE BUILDINGS IN IRAQ AS A CASE STUDY

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Abstract. People usually spend most of their time in office buildings. People as users in local office buildings (employees and visitors), especially in shared transaction spaces, suffer from overcrowding and density among them to complete their administrative transactions. The study aims to evaluate walkability concerning the spatial configuration topologies, where distance, simplicity, accessibility, and space density were determined as variables for pedestrian-friendly walkability within these spaces. The space syntax method was used as a quantitative analysis method using the DepthmapX program through three different syntactic maps (Axial map, Angular segment map, and Visibility graph analysis). Utilizing four shared transaction space typologies, the investigation was carried out on three samples of local office buildings in Iraq (U-shape, linear, opposite linear and L-shape). The study concluded that the way to evaluate walkability is by comparing its variables in the different topologies of spaces, identifying the pros and cons of design and use of the present buildings and giving feedback about future designs.

Keywords: Walkability, shared transaction spaces, typology, office buildings, space syntax.

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Received: 7 December 2022;

Accepted: 21 March 2023;

Published: 4 August 2023.

1. Introduction

The design patterns of office buildings differ according to the different work methods and employment patterns. The design of office spaces often goes back to the general patterns: the cellular office, the group office, and the open office (Hua *et al.*, 2011). These patterns contribute in various ways to support employees' collaboration, participation, and productivity. The spaces within these types range from private and public, as the diversity of spaces in the workplace ensures multiple options for occupants in where/when/how they work (Becker, 2005). Private staff spaces include meetings, copying/printing and kitchen/coffee, while the circulation area and Transactional work areas are public common spaces for different users: employees, visitors, maintenance and delivery employees with different walking paths and preferences (Ranne & Nousu, 2017). These shared work areas contain many service activities (Gordeeva & Zinchenko, 1982) such as walking, sitting and many others.

People spend about 90% of their time indoor buildings (Klepeis *et al.*, 2001). Walking is the main form of movement within these buildings (Fu *et al.*, 2021). For this, walkability is an important aspect in the process of analysing spatial planning when designing buildings (Shin & Lee, 2019). Previous literature touched on the walkability of pedestrian paths in urban studies (Koohsari *et al.*, 2016; Zaleckis *et al.*, 2022), and in

How to cite (APA):

Al-Dawoodi, M.H.A., Al-Moqaram, A.M.H. (2023). Walkability evaluation in shared transaction spaces topologies: Office buildings in Iraq as a case study. *New Design Ideas*, 7(2), 324-342.

moving from one space to another (Shin & Lee, 2019), but the walkability within one space (space-object walkability) was not addressed. As Jin-Kook Lee et al. (2018) defined walkability as “a measure at which the path is well-functioning for pedestrians in the building” (Lee *et al.*, 2018).

The transactional workspaces in the local office reality refer to specific service places provided by the state to visitors in retirement, tax, housing and others. The conduct of visitors' business within office transaction spaces in the local reality suffers from many organizational obstacles in addition to design obstacles, which create an atmosphere of density and crowding as users suffer from difficulty in movement and intersection of movement paths. Thus, three samples of local office buildings will be selected, and transaction spaces will be studied in terms of counter-service shape design, and path patterns within a particular space. The study aimed to evaluate walkability in shared transaction spaces, achieving this aim requires the evaluation of the spatial factors of the existing local office buildings which are considered obsolete buildings with high occupancy density and high utilization trying to improve their design and use. The study sheds light on the research questions related to the nature of the relationship between research variables, which focused on:

1) Which spatial factors most affect walkability, which contributes to the benefit of the design and use of space?

2) The pros and cons of each design of the spatial configuration topologies of the shared transactional spaces and the patterns of movement paths enhance the walkability within them.

The spatial syntax methodology was used to quantitatively measure the levels of walkability represented by distance, simplicity, accessibility, and space density.

2. Literature review

Previous literature has addressed walkability at both urban and building scales. Walkability is a compound concept measured using a range of indicators rather than a single one (Maghelal & Capp, 2011). At the urban scale, Cervero and Kockelman (1997) identify three built environments indicators in which pedestrians' travel is influenced: Density (accessibility to jobs density), Diversity (land-use mix), Design (intersection and site design). Later Ewing and Cervero (2001) expanded to also include new variables: Destination (jobs accessibility), Distance (transit). Other authors have expanded the walkability platform to include other environmental aspects, Leslie et al. (2007) studied Dwelling density, Street connectivity, Land use mix and Net retail area, using Geographic Information Systems data (GIS). Dewulf et al. (2012) used an index constructed based on street connectivity, Residential density and Land use mix, the Data collected by a survey of 1164 respondents were objectively measured through (GIS). Grasser et al. (2017) suggested that walkability should be measured by: Dwelling density, Population density and Intersection density, GIS-based walkability was measured using both established measures and alternative measures. Koohsari et al. (2016) examined associations between the full walkability index and walking for transport, and the collected data was calculated using geographic information systems and space syntax software. McCormack et al. (2021) captured the relationship between the topological structure of urban forms and walkability indices by using Space syntax models, measuring street integration and walkability and Neighborhood-specific leisure and transportation walking. Zaleckis et al. (2022) introduce a walkability compass, a four-spatial indicator-designed tool (Gravity,

Reach, Straightness, and Population density) for city walkability assessment and comparison, this study uses space syntax as a background theory and its spatial indexes to explain the walkability. Domeneghini et al. (2022) conducted a study to investigate walkability behaviors and drivers in urban areas, she used a questionnaire to collect data from the residents of the elected area.

Few studies discuss walkability indicators on the building scale. The indicators that were measured in the scale of the building can be counted as distance, accessibility and Pedestrian-friendly circulation environment (Lee *et al.*, 2018), Later the researchers' study was expanded to include simplicity (Shin & Lee, 2019). Another study in building scale walkability measured comfort variables besides all distance, simplicity, and accessibility (Fu *et al.*, 2021).

Although the above studies dealt with a variety of indicators that affect walking and walkability, whether, at the urban level or the level of building circulation and using many tools for measurement, no study has addressed the evaluation of walkability within a single space (different typological spaces walkability). Thus, an evaluation of the walkability of these spaces is carried out using a quantitative method of space syntax analysis to identify the pros and cons of design and use of the present buildings and give feedback about future designs.

3. Different Typological of Shared Spaces and Movement Patterns

The term typology was used to refer to the study of types (Güney, 2007). Typologies are used as tools to evaluate design, architecture, and energy performance (Dascalaki *et al.*, 2011). Typologies enable decreasing the object's complexity and understanding according to relevant characteristics (Casakin & Kreitler, 2012). Shared workspaces are shared offices where a group of individuals with diverse backgrounds locate themselves in the same work environment (Parrino, 2015; Spinuzzi, 2012). A shared workspace is shared by multiple people during office hours. Users are divided into employees (occupants) and applicants (visitors). The shared work environments between different teams are dedicated to social connections (Government Property Agency, 2019). The arrangement of spaces in various work environments means the internal relations of the spaces used by the consumer (Montello, 2007). Sharing physical space in a building in itself in a closed community is sharing sundry facilities within the same building (Rikke Brinkø, 2015). A new direction of research is needed to explore the layouts of a wide scope of shared spaces in terms of workplace scale and layout scale spatial variables (Hua *et al.*, 2010).

The space is static but the user's movements are dynamic. Users' dynamic interaction with their built environment while moving enhances their constant cognition of how they flow within space. Some current design practices oppose or ignore users' flow patterns within interior movement paths, despite the fact that visual floor patterns contain a lot of heuristic and navigational information that draws users forward to find their way, and strongly influence users' direction and ease when they move (Salingaros, 2015). Regulating the flow of users in their movement between spaces is as important as the spaces themselves, as it has a significant impact on social interactions within those spaces (Alexander, 1977), and the matter also influences the design of internal movement paths for shared workspaces, as they are considered public spaces within buildings. Circulation patterns are classified into (Alexander, 1977; Mehaffy *et al.*, 2020):

- Linear, branching hierarchy: Offering little interaction between spaces. Single- and Double-loaded corridors are examples of linear circulation.
- Web network circulation: Provide rich overlapping connections around and across spaces, where these spaces are part of a circuit.

Also, Ching (2014) classified Movement path patterns to: spiral, radial, linear, compound, clustered, and grid.

4. Walkability

The walkable term has been in use since the eighteenth century, an area or a route suitable or safe for walking (Oxford English Dictionary, 2022), while walkability is a more recent term. Walkability in the urban environment was defined by many authors, including Leslie et al. (2006), and Wang and Yang (2019) to the extent that the characteristics of the built environment are or are not beneficial to the occupants of the area who walk for leisure, work and services. Vale (2016) and Adkins (2017) define Walkability as a measure of the friendliness of an area for walking. Shashank and Schuurman (2019), defined walkability as the suitability of the built environment for walking. Later, the concept of walkability inside buildings was studied on the circulation level, By Lee et al. (2018) as “a measure at which the path is well-functioning for pedestrians in the building”. On the same level, Fu (2021) studies walkability at the building circulation level by including objective building environment measurements and subjective user preference. Positive functioning (physical, social, cognitive and mental) performance of the elderly is the result of a positive association of walkability with the walking behaviour of the elderly (Van Holle *et al.*, 2014). This study proposed objective spatial factors that influence walkability (within-space walkability) are four: distance, Simplicity, Accessibility and Density (As shown in Table 1).

Table 1. Scope of within-space walkability features. (Authors)

Distance	Metric distance	- Selecting a destination from an initial point to all-other objects (an endpoint) - Choosing a path, between an initial point and an endpoint - Shortest paths	
Simplicity	Path patterns	Linear pattern	- The path straightness - The number of turns
		Radial pattern	
		Other patterns	
Accessibility	Spatial typology	Linear	The counter-service shape types
		Opposite Linear	
		U shape	
		L shape	
Density	Space density	The space available for the users within a certain distance from the target point	

4.1 Distance: “Distance is the essential relation determining the structure of a spatial layout” (Annunziata & Garau, 2020), such as the egress travel distance (International Code Council, 2017). The importance of physical distance and Preferences vary depending on why a person is walking (Lu et al., 2015). In this study, distance is measured by the metric distance of selecting a destination from an initial point to all-other objects (an endpoint); choosing a path, between an initial point and an endpoint and the shortest paths.

4.2 Simplicity: Simplicity refers to the ability to explain, understand, remember and execute instructions for navigating through a given path (Duckham & Kulik, 2003). The space Syntax approach developed two tools to measure spatial integration: axial analysis and angular segment analysis (Charalambous & Mavridou, 2012). In this study, the simplicity of a path is measured by: the path's straightness and the number of turns.

4.3 Accessibility: Accessibility indicates the extent to which others can access the intended space. Accessibility is a global component of design that directly affects the pedestrian experience. One of the concepts related to accessibility is wayfinding for evacuation when users within space are uncertain about their destination, which makes them intersect with others (Natapov *et al.*, 2022). The accessibility of the building can be good if the ordinary occupants and prospective visitors do not have difficulty reaching their destinations, can participate in the expected activities and can use the facilities required for this purpose (Van Der Voordt & Van Wegen, 2007). When evaluating within-space path walkability, various path lengths must be distinguished: the path from the door (an initial point) to all all-other objects (an endpoint).

4.4 Density: Space density refers to the space available for each occupant and the relative relationship between the occupant and the space within a certain distance from the target employee (Chan, 1999; Fried *et al.*, 2001). In an office space, this term refers, for example, to square meters (ft²) per occupant of the office. According to Kockelman (1997) density is one of three key dimensions that pedestrians' travel within space is influenced by the built environment (e.g., accessibility to counters) along with design and diversity (Cervero & Kockelman, 1997). Denser users would be expected to have shorter travel times than dispersed ones (Hanlon *et al.*, 2012). In this study, space density is measured by the space available for users within a certain distance from the target point.

5. Case study

The research was based on the selection of three samples of local office buildings in Iraq, these buildings represent public government buildings that provide basic services to the community in multiple sectors such as tax services, retirement and real estate housing. Where the users in these buildings usually suffer from severe overcrowding and density for reasons related to the obsolescence of these buildings and the bureaucracy in the management of work, in addition to the spatial layout of the denser spaces within these buildings. Shared transaction spaces represent the denser and more used spaces in the building where most of the visitor's transactions are carried out. The spatial layout of these spaces is in the form of multiple topologies (Linear, opposite linear, U shape and L shape). (See Tables 2, 3, 4).

6. Research Methodology

The research methodology adopted in this study relied on field visits, visual surveys, and quantitative analysis using space syntax analysis, to evaluate walkability in multi-topological shared transactional spaces and determine all of the distance, simplicity, accessibility and space density as indicators in the characteristics of the spatial layout of selected office samples in Iraq. The space syntax approach provides data collection for analyzing and evaluating walkability in shared transactional spaces. The data was processed using DepthmapX v.10. software, for three different types of syntactic maps (Axial map analysis (AMA), Angular segment analysis (ASA), and Visibility Graph

Analysis (VGA)). These analytical maps provide measurement indicators (Betweenness, and Closeness) by AMA (Normalised Angular Choice, and Integration) by ASA, (Integration) by VGA. These syntactic maps are used to evaluate variables related to the walkability of shared spaces, including transactional areas such as (Distance, Simplicity, Accessibility, and Density). Fig. 1. shows the research methodology in a flow chart.

Table 2. U-shape transaction spaces (General Commission of Taxes/Rusafa Branch) (Authors)

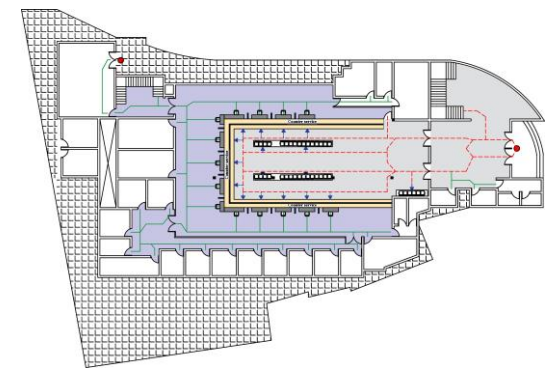
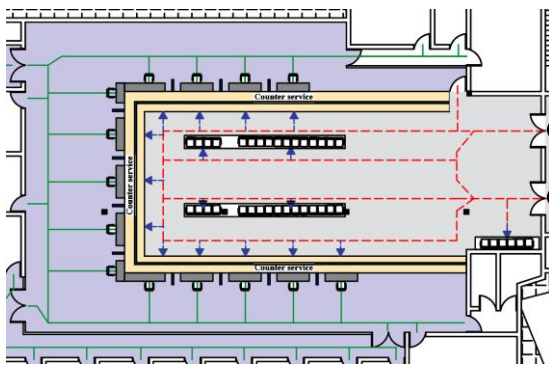
 	
Ground Floor Plan. (Source: Authors based on engineering department of General Tax Authority in Baghdad)	
Location:	The western sector of Rusafa in Baghdad, Iraq
Area:	1273 m ²
Path pattern:	Composite pattern
Initial point:	2 Doors
Endpoint:	1 Door/ 14 counters/ 5 sets of chairs

Table 3. Linear and opposite linear shape transaction spaces (The National Pension Agency) (Authors)

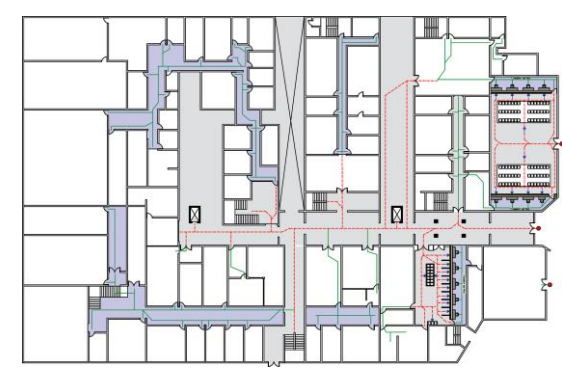
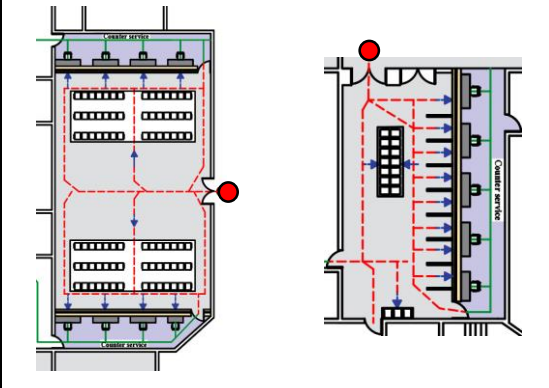
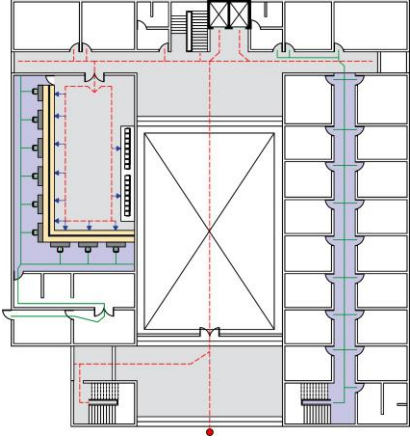
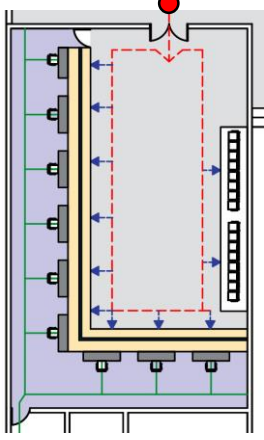
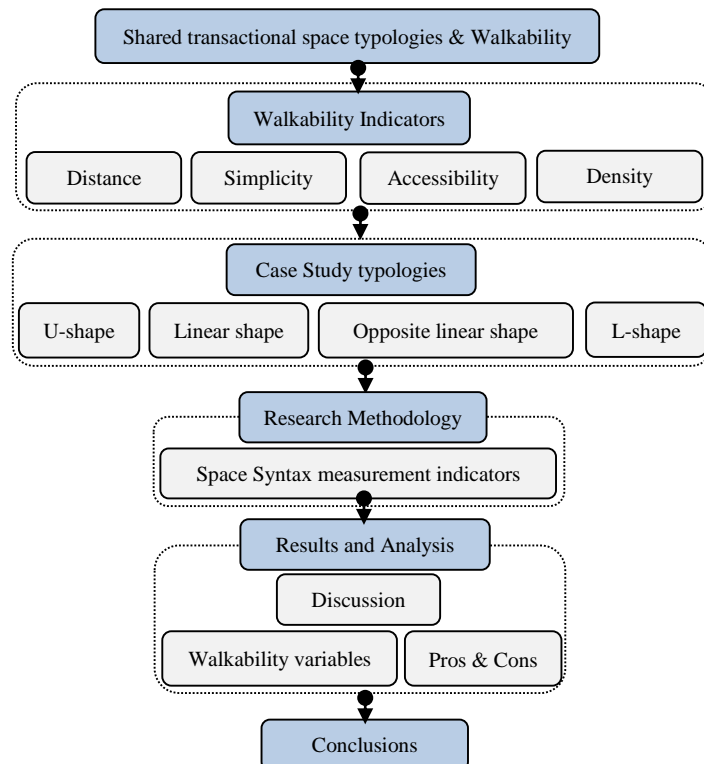
 	
Ground Floor Plan. (Source: Authors based on the engineering department of the Public Retirement Authority in Baghdad)	
Location:	Karkh side of Baghdad, Iraq
Area:	5780 m ²
Path pattern:	Radial pattern Linear pattern
Initial point:	1 Door 1 Door
Endpoint:	2 Doors/8 counters/12 sets of chairs/1 Door/5 counters/3 sets of chairs

Table 4. L-shape transaction spaces (Tax Department / Babylon Branch) (Authors)

	
Ground Floor Plan. (Source: Authors based on Engineering department of the Tax Authority in Babylon)	
Location:	Babil, south of Baghdad, Iraq
Area:	1752 m2
Path pattern:	Linear pattern
Initial point:	1 Door
Endpoint:	1 Door/ 9 counters/ 2 sets of chairs

**Figure 1.** Methodology Flow Chart (Authors)

6.1. Syntactic maps and measurement indicators

Space syntax, as an architectural theory in both urban planning and design, presented by Hillier and Hanson (1984), suggests that built environment have a social dimension and societies have spatial logic, which was adopted to explore social relations tacit in the architectural setting, this process requires an understanding of physical topologies between design elements (Hillier, 1984). Space syntax studies focus on how spatial arrangements influence patterns of social behaviour and question if built space contains a social logic (Shpuza, 2006). In offices, Space syntax has been used to describe office spatial structures that relate to patterns of space use, including movement, encounter, and interaction between different groups. Space Syntax theory examines relationships between spatial layout and social, economic and cognitive factors (Charalambous & Mavridou, 2012). Space syntax theory reflects human movement and decision-making when walking (McCormack *et al.*, 2021).

Space Syntax approaches privilege the topological properties of space over its geography because people manage to behave (e.g., move) in ways that are based on topology by understanding the differences between different typologies and users ability to walk (Ostwald, 2011; Saraoui *et al.*, 2022). Table 5 shows maps and indicators used for measuring study variables.

The most recent architectural studies primarily used the space syntax methodology, with two aspects—the layout of public buildings from a social perspective (user preference) to evaluate walkability (Fu *et al.*, 2021), and studies focusing on explaining users' social activities and their behaviours, such as movement and flow—from the spatial configuration perspective (Saraoui *et al.*, 2022).

Table 5. Maps and indicators to measuring variables. (Authors)

Maps	Measurement Indicators	Variables
Axial Map analysis (AMA)	Closeness, or Integration	Distance
	Betweenness, or Choice	
	Normalised Angular Choice	
Angular segment analysis (ASA)	Integration	Simplicity
Axial Map analysis (AMA)		
Angular segment analysis (ASA)	Integration	Accessibility
Axial Map analysis (AMA)	Integration	Density
Visibility graph analysis (VGA)	Integration	

6.1.1. Axial Map analysis (AMA):

The indicators of the Axial Map analysis method are calculated using the following:

Closeness, or Integration: One of the fundamental syntactic measurements of mathematical closeness is integration. Integration measures how closely connected each segment is to every other segment at certain distances. Integration represents the “to-movement” potential of space (Mustafa & Azeez, 2022). Integration describes how easy is it to get to a destination segment from all other segments (Hillier & Iida, 2005; Hillier & Stonor, 2010). A high result when calculating integration implies that space has the greatest possibility for movement and accessibility between objects, whereas a low value indicates the opposite.

Betweenness, or choice: The choice is a syntactic measure of mathematical Betweenness, which measures how much movement is likely you to pass through as space

on routes between all other pairs of segments, using different types of distance. Choice represents a space's "through-movement" potential (Hillier & Iida, 2005).

The two measures (Closeness, and Betweenness) correspond to the two basic elements in any trip: selecting a destination from an initial point (Integration), and choosing a route, that is the spaces to pass through, between origin and destination (Choice) (Hillier *et al.*, 2012).

Integration: The axial Map analysis is one of the fundamental components of space syntax (Turner, 2007), can be defined as the smallest number of axial lines that are associated and crossed to cover the entire designated area, and the measure of how fine axial lines are crossed can be measured by connectivity and integration (Jacoby, 2006). Integration, a global measure of accessibility, is quantified using the mean axial integration of the axial map and the mean segment integration of a segment map. For this study, integration measurement was used to measure the integrated spaces inside shared transaction spaces, Higher mean integration values indicate greater overall accessibility, and lower values indicate lower overall accessibility of the map. It describes the amount of ease one may experience to move within an area (Rashid, 2017). Axial Map analysis is based on the topological distance between an initial point and an endpoint (a destination), which refers to the number of turns required to reach an endpoint (Sharmin *et al.*, 2020).

6.1.2. Angular segment analysis (ASA):

The indicators of the Angular segment analysis method are calculated using the following:

Choice (Normalised Angular Choice - NACH): The choice is used to measure the flow rate in a given space. Space allows several choices from a large number of shortest connectivity paths that intersect that space (Shahbazi *et al.*, 2018). The choice is calculated by counting the numeral times each street segment falls on the shortest path between all pairs of segments within a 'radius' of a selected distance. The path of the least angular deviation through the system is the 'shortest path' (Hillier *et al.*, 2012; Rashid, 2017).

Integration: The axial and angular segment analysis is recently the most used space syntax technique (Turner, 2007; Omer *et al.*, 2017). It is essentially an extension of the axial analysis (Leccese *et al.*, 2019). The angular segment analysis breaks axial lines into segments and then records the sum of the angles turned from the starting segment to any other segment within the map are recorded and used (Dalton, 2001; Turner, 2001). Unlike the axial Map analysis method, the segment method is based on angular, metric and topological distances. As opposed to the axial map analysis, where the number of turns from an initial point to an endpoint is treated as the cost of a journey, in the Angular segment analysis, the angular sum from an initial point to an endpoint is treated as the "cost" of a journey through the graph (Oliveira & Fontgalland, 2021; Rashid, 2017).

6.1.3. Visibility Graph Analysis (VGA) (Integration):

The correlation between behavior and spatial structure, especially the relationship between the degree of integration and the number of occupants of a particular space, has led to the development of recent interest in spatial cognition among space syntax researchers (Bafna, 2003). Visibility graphs analyse one of the space syntax techniques which means the extent to which any point in a spatial layout is visible from other points. When points are not directly visible, graph measures of a matrix of points can be

calculated to test the number of intervening points needed for one point to see any others (Jake, 2001). Where a high integration value indicates a high-density space and vice versa.

6.2. *Spatial Topology Indicators*

The research adopted the measures of the syntax approach to evaluate the spatial characteristics of walkability, which are affected by the design variables of shared transaction spaces in local office buildings with different topologies identified by the research. The research specified three ratings: poor, normal, and excellent (Table 6).

Table 6. Three different Scales of all indicators. (Authors)

Scale	Distance	Simplicity	Accessibility	Density
Poor	The lower average value (0–250).	The lower average value (5.5–6.5).	The lower average (6–8).	The lower average value (0–22).
Normal	The median average value (250–450).	The median average value (6.5–7.5).	The median average value (8–10).	The median average value (22–42).
Excellent	The higher average value (450–650).	The higher average value (7.5–8.5).	The higher average value (10–12).	The higher average value (42–62).

7. Results and Analysis

To evaluate walkability related to spatial layout variables, including (distance, simplicity, accessibility, and density), which benefit both space design and the usage of space. Space syntax methodology provided data processing using three different syntactic maps (Axial Map analysis AMA, Angular segment analysis ASA, and Visibility graph analysis VGA). The analytical maps measurement indicators (Closeness or Integration, Betweenness or choice, Normalised Angular Choice in AMA - Integration in both AMA and ASA – Integration in VGA). All spatial variables will be analysed and discussed in every sample to evaluate walkability between users, in local office buildings, especially in shared transaction spaces. The colour range indicates the readings; Red, orange and yellow colours indicate high readings, while blue and dark blue colours indicate low readings. The graphs have been used to compare different models to design shared transaction spaces for all samples in terms of distance, simplicity, accessibility and space density, to draw important conclusions that can be used in the research field. The analysis process was performed as follows:

7.1. *General Commission of Taxes/Rusafa Branch (First sample) analysis*

According to the values obtained from the analysis of (AMA, and ASA) in the analysis of space syntax to measuring the distance variable, the first sample (U-Shape type) obtained the excellent integration value of (11.024) and this means a high potential for space to a destination to-movement and therefore high accessibility through any point to all other points. At the same time, a normal value was recorded for both choice and normalised Angular Choice (657.983, and 4.75238), respectively. This indicates a medium weight for how likely a line is to be chosen from one point to another, while a high angular choice value indicates the shortest path that intersects a particular space (Fig. 2., 4.). As for the simplicity variable measured in (AMA, and ASA), and the accessibility variable measured in (AMA) the integration value measured in both maps was (11.024,

and 4.68225) respectively. The high integration value in (ASA) indicates the highest number of turns within space because the way the seats are distributed and the paths extending from the initial point to all other points are the reason for a large number of turns that the user must go through. The excellent integration value in (AMA) refers to a high value of accessibility compared to other samples, attributed to the large area and shape of space and the lack of many seats, which may hinder movement within this space. As for the value of integration measured by (VGA), with a normal weight (of 20.9309), due to the presence of obstacles that decrease the field of vision for users, this means a medium spatial density (Fig. 3.). High accessibility and short paths within this type of spatial configuration topology do not lead to high walkability because it is constrained by high spatial density and low simplicity. As it is shown in (Table 7).

Table 7. General results from syntactic maps. (Authors)

Transaction spaces typology				U-shape	Linear	Opposite linear	L-shape
Space Syntax Maps	AMA	Closeness	Avg.	11.024	8.32773	10.8881	7.26042
	AMA	Betweenness		657.983	281.937	1882.05	141
	ASA	Angular Choice		4.75238	4.6859	5.35376	4.41846
	AMA	Integration	Avg.	11.024	8.32773	10.8881	7.26042
	ASA	Integration		4.68225	4.43894	2.29047	4.47288
	AMA	Integration	Avg.	11.024	8.32773	10.8881	7.26042
	VGA	Integration	Avg.	20.9309	24.0853	15.9183	60.0814
Red value: excellent rating,				Blue value: poor rating,		Black value: normal rating	

7.2. The National Pension Agency (Second sample) analysis

As for the second sample with (linear and opposite linear) topologies for measuring the distance variable, the integration value measured by (AMA) was an excellent value for the opposite linear type (10.8881), and a normal value for the linear type (8.32773). This means a high possibility of movement and access to all directions for the opposite linear type. The opposite linear type got the excellent choice value with an amount (of 1882.05), while the linear type got the lowest value (281.937). The values of the normalised angular choice were excellent for the opposite linear type by (5.35376), which means short-length paths. Concerning the simplicity variable measured by (AMA, and ASA), the integration values of linear shape type were with the lowest value (8.32773, and 4.43894) and opposite linear shape type with a medium weight (10.8881, and 2.29047), respectively. This indicates normal accessibility as well as a normal simplicity of the linear type compared to high accessibility and simplicity of the opposite linear type, and the reason for this is because of the many deflections of the linear type, which reduce the simplicity of space and the possibility of users' movement within it, in addition to the location of the furniture and its arrangement near the counters. Density variable measured by (VGA) The integration value was the lowest in the opposite linear type (15.9183), this indicates a high spatial density, and a medium value of the linear type (24.0853) with moderate density to a certain extent (Fig. 3). The opposite linear type with excellent values of accessibility, simplicity, and shortest paths scores high walkability within this type of spatial configuration topology. Shown in (Table 7, Fig. 2, 4).

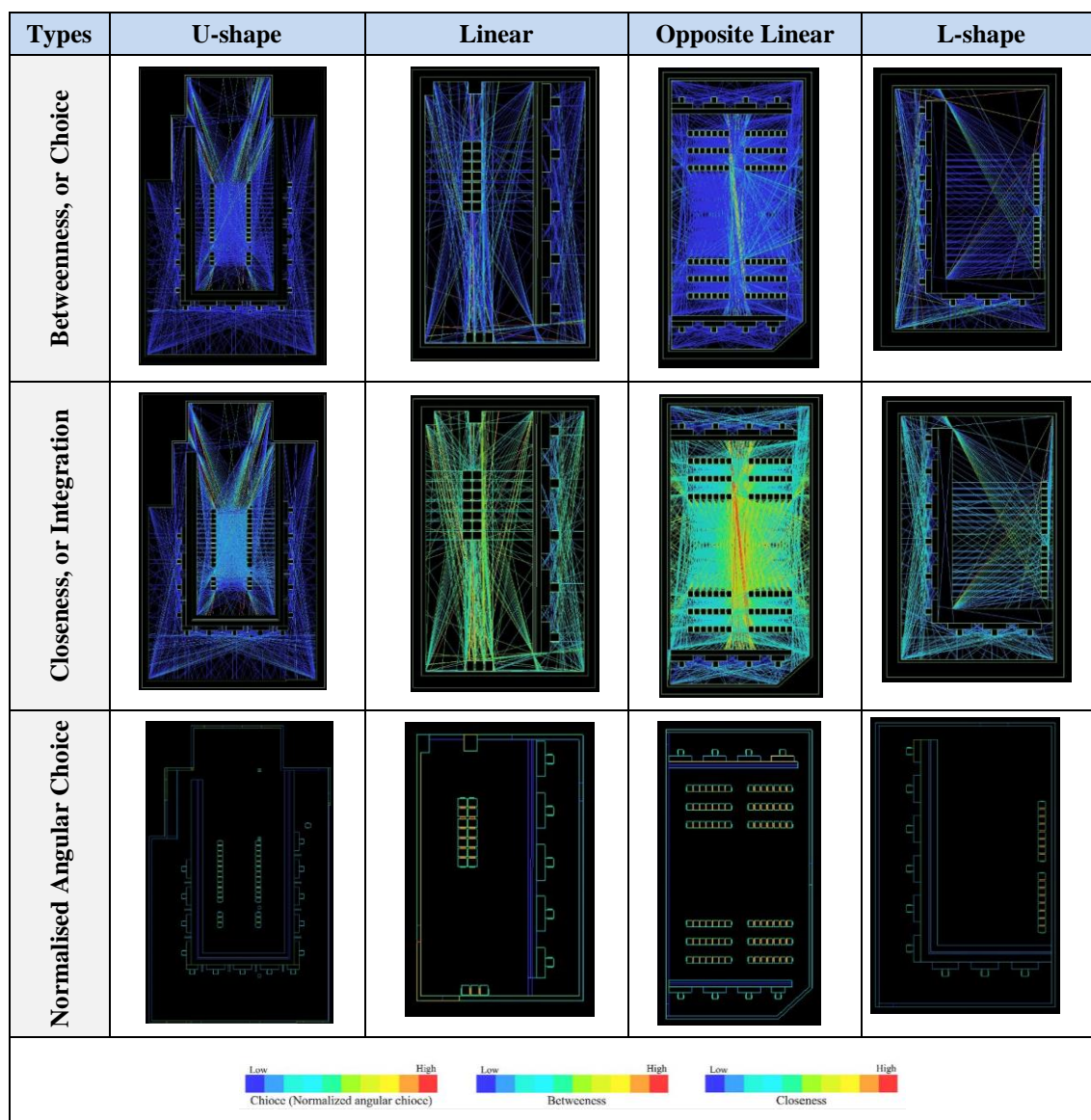


Figure 2. An analysis of four transaction space typologies indicating Distance. (Authors)

7.3. Tax Department / Babylon Branch (Third sample) analysis

In the third sample of (L-Shape type), the distance variable measured by (AMA), the values of integration (7.26042) and choice (141) were recorded with the poorest value, which means the low possibility of movement and access, normalised angular choice value measured by (ASA) recorded value (4.41846), and these records longest paths chosen from initial points to all endpoints (Fig. 2, 4). A poor value of integration indicates weak accessibility within this type of space. The integration measured in (AMA) plus the integration measured in (ASA) which is in the amount of (4.47288), indicates a medium value of simplicity. The integration value measured by (VGA) to determine the space density variable came with the highest value (60.0814), this indicates the low density of space due to the wide range of vision for users and the absence of obstacles blocking this range (Fig. 3) and (Table 7).

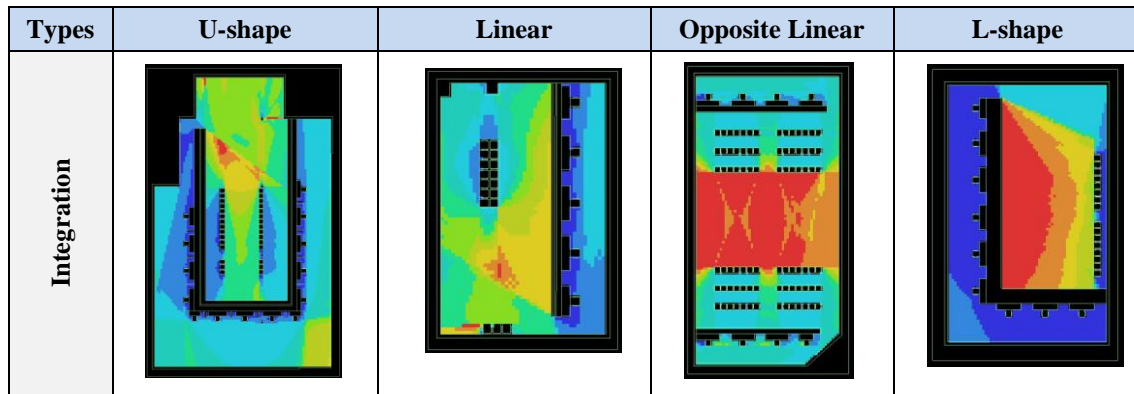


Figure 3. VGA Integration graph of all case studies indicating Density. (Authors)

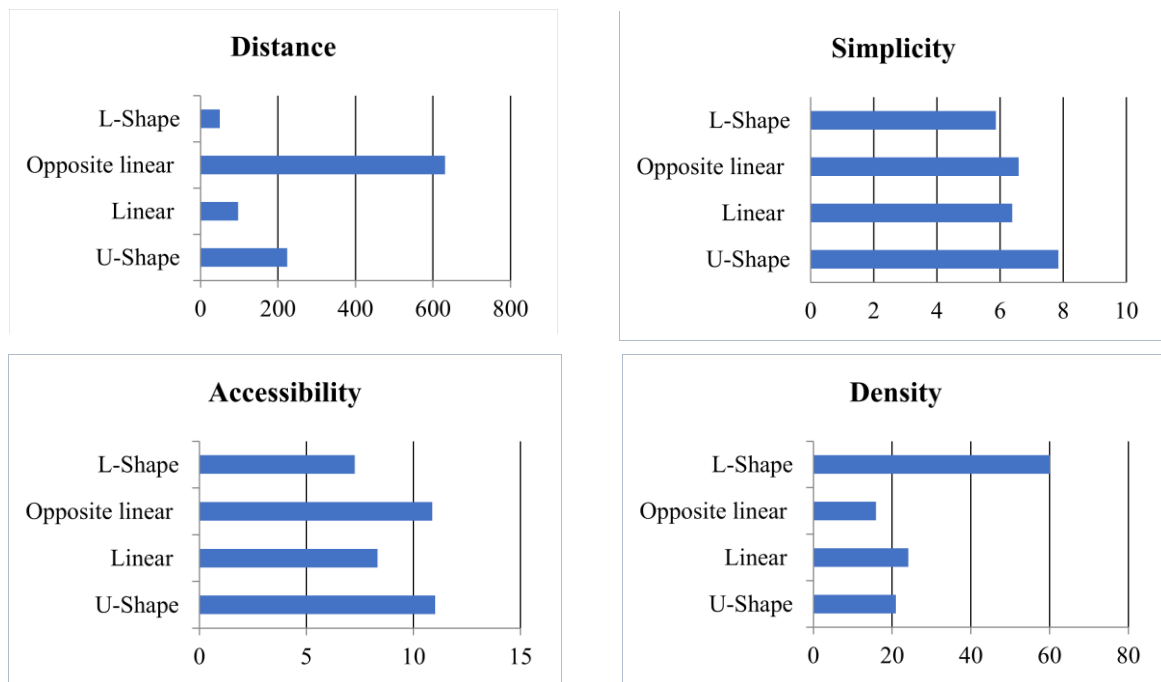


Figure 4. Summary of transactions spaces typology factors results. (Authors)

8. Discussion

The relationship between walkability and topology of the shared transaction spaces in office buildings was explored in this study, along with its role in enhancing the usage and design of space and identifying its pros and cons. Here is a description of the key findings, depending on the analysis, measuring methods, and indicators:

Walkability variables:

For the distance variable, the comparison of syntactic measurements of the (opposite linear type) recorded the highest average distance, and this indicates the shortest paths recorded within this type and thus a higher possibility of walkability, especially since this type provides natural lighting due to the presence of windows overlooking the outside, and thus provides an atmosphere of generosity within the space. In addition to

the existence of loop movement in two different directions linking all parts of the space. In contrast, the (L-shape) type came with the lowest distance values, which attribute to the space size, the location of the initial point and its paths extending to all other points, which are classified as long paths and therefore lower possibility of walkability, although there is a vast intermediate area, people tend to avoid walking within it, and stick to movement along the protected edges of the space for efficient orientation as well as a sense of safety.

As for simplicity and accessibility factors, the (U-Shape type) is the most integrated, and the easiest to access, but it has a higher number of turns and therefore less simplicity value because users prefer paths with fewer turns along the path than short easy distances. Also, many turns lead to oscillatory changes in the direction of users flows and thus intersection of the movement tracked less walkability, as oscillating flows can occur even in the absence of interactions between the users. In contrast, the (L-shape type) is the least integrated and has the greatest number of turns, and therefore the least accessible and simplicity value. The (opposite linear shape) type has a higher integration value, fewer turns, and therefore easier access and higher simplicity among all other cases. Thus, the opposite linear type is the highest in walkability for users.

The (U-shape and opposing linear types) record the lowest integration value assessed using (VGA), which shows denser space in the required area and generates a more crowded environment with more user-to-user movement conflict and a lower level of walkability. While the (L-shape type) has the highest integration value, demonstrating fewer density areas and hence better walkability.

The results of the majority of selected samples in the local reality of office buildings for shared transaction spaces came with negative or weak results for walkability. This is consistent with the research hypothesis that most of the topologies of these spaces' spatial configurations are incompatible with social behaviors, function, spatial organization, and unorganized furniture distribution. The results showed a relative preference for type (opposite linear) as it has short paths, high simplicity and accessibility.

Pros: The opposite linear type as one of the selected samples recorded positive results, shorter distances, high accessibility and simplicity. Thus, the pros of this type of spatial configuration topology can be included:

- The location of the initial point of entry is in the centre of the space, followed by an intermediate space that acts as a central distributor of internal movement on both sides of the space.
- Radial movement pattern contributes to high accessibility to all endpoints.

Cons: The cons of different topologies of spatial configuration were:

- The (U-shape and opposite linear) types and because of the number and arrangement of seating contributed to increasing the space density and difficulty of walking in the area near the counter-service, and thus poor walkability.
- The long paths of the (Linear and L-shape) types negatively affect the walkability of users and their ability to reach all counter-service stations and seating areas.
- The high number of turns in most of the samples is due to the entry point's location and furniture arrangement, and so poor walkability within these spaces.
- The absence of markers and signals within all topologies also leads to psychological stress for users and a weak ability to identify the intended destination, as a logical sequence with clear and accessible signage is needed for efficient navigation and good flow.

9. Conclusions

Depending on the spatial variables, the outputs revealed that there is a difference in the levels of walkability according to the spatial topological patterns. The spatial variables that have been studied mainly focus on the distance travelled through the elected spaces in terms of the shape of the employees' counter-service, the proportion of the empty area represented by the movement paths of the users to the area occupied by their seating places, the simplicity of these spaces in terms of the few turns, the possibility of the users' access to all the endpoints and finally space density and its role in enhancing or undermining the walkability. Priority should be given to the pattern of seating arrangement by clarifying the movement paths between them to ease access to all counter-service stations and reduce the number of turns that the user must pass through. The location of the entry point should also be emphasized as an effective variable in the length of the distance travelled to all other endpoints.

The results of the study concluded that the shared transactions space with an opposite linear shape type, the centric entry point in the middle of the space, radial movement paths and seats with an appropriately organized distribution in promoting walkability.

In conclusion, the topological relationship between spaces and walkability is a relationship of variation according to the variables of walkability and spatial features of spaces. The variables subject to evaluation differ according to the spatial, organizational and administrative environment of the spaces.

As a recommendation for future research, it is important to study other dimensions affecting the users behavior within enclosed spaces of public buildings (technical or human), and within different cultural and normative environments to reach comprehensive results about walkability.

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