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MORPHOLOGICAL TRANSFORMATION OF HISTORICAL CENTRES IN TIANJIN

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Abstract

Many historical centres in China are considered to have been left behind by rapid urban growth. The decline of these historical centres has been studied as a social and economic issue, whereas the role of space is generally or simply ignored. Few studies on urban morphology have linked spatial elements to street-level socio-economic variations to explore the shifting relationship between urban form and function. By adopting space syntax methodologies to investigate the shifting relationships between spatial configuration and land use patterns in urban transformation, this paper examines the underlying spatial reason for the changing roles of historical centres in the inner city and colonial areas in Tianjin. This goal is accomplished by studying the morphological evolution of the historical centres in question. In this study, the colonial cores in Tianjin that functions well in modern grid maintain integration at pedestrian level, closeness to the traffic arteries and sense of neighbourhood in terms of the spatial structure than the inner city. The results indicate that shifts in various types of land use correspond to spatial changes in varying degrees, which reflects the changing roles of historical centres in history, and suggest that the interaction between urban form and function is complicated and continuous rather than linear and instant. The overall results also indicate that understanding these relationships is a key to historical conservation and renewal in old cities.

Keywords: *Spatial Configuration, Land Use Patterns, Urban Transformation, Historical Centres, Spatial Centrality*

Theme: *Historical Evolution of Built Form*

1. Introduction

Over the past two decades, historical centres throughout China have drawn increasing attention from researchers and the government. As a distinctive form of the urban landscape that emerged during different historical periods, historical centres have faced tremendous pressure as a result of rapid Chinese urbanization, particularly the economic reforms of the 1980s. Research on the subject has been undertaken, which covers a variety of aspects that range from its meanings, connotations, classifications, and generative mechanisms to redevelopment modes and ideas.

Chinese urban planning largely considers historical centres a socio-economic problem that results from the dichotomy of form and function (Wang, 1994; Wang & Wang, 1997; Ruan & Sun, 2001; Ruan & Gu, 2004). City governments have typically viewed historical centres as a dilemma: on one hand, they maintain a degree of historical interest; on the other hand, they appear problematic in their functional applicability to modern city centres. Thus, local governments often completely eliminate the majority of historical centres. However, inspired by Jacobs's idea (1961), more recent studies have shown the positive aspects of these traditional neighbourhoods and argue that they are beneficial to inhabitants and in a wider urban context. For example, historical centres substantially increase the income of residents through profitable housing rental businesses and provide various small mixed-use spaces, thereby maintaining vitality and smoothly integrating with cities (Xia & Lu, 2007). Therefore, the most pressing matter that concerns historical regeneration is activating the functions of the forms present in historical centres in the context of rapid urbanization to prevent constructive destruction (Ruan 2003; Yuan 2010). Introducing interaction between the spatial factors and patterns of land use could enrich the current discourse and provide a basis for linking spatial and socioeconomic factors.

The common means of regenerating these centres in China is to transform them into tourist destinations or preserve them as museums. However, the following questions arise: do the historic centres have the potential to support mixed land use patterns? What are the underlying forces that promote or impede the development of historical centres in the context of the whole city? In this study, through an analysis of land use patterns and their relationship with spatial configuration in Tianjin, the shifting social and economic roles of historical centres are investigated. The guiding questions are as follows:

1) To what extent can the morphological transformation of historical centres in Tianjin be reflected by its spatial configuration?

2) Are the land use patterns of historical centres influenced by spatial structure in a centrality process?

3) Can the roles of historical centres within the wider city be described by the interaction between spatial configuration and land use patterns?

As one of the economic centres, the earliest modern city and the largest colonial district in China, Tianjin has experienced extremely rapid growth throughout the 20th century. With this dramatic social and economic transformation, the urban structure of the entire city also underwent extreme changes. Such developments have resulted in a changing context where historical centres gained and then lost their vitality. Based on the transformation of the spatial morphology of Tianjin and from the perspective of space syntax, this study argues that the syntactical representation of Tianjin could shed light on the shifting roles of historical centres aiming to improve the current understanding of the underlying spatial reason for the changing roles of historical centres in Tianjin.

2. Background

As the gathering space of urban life throughout history, historical centres function as the key parts of old cities. Hence, the conservation and regeneration of historical centres are vital measures for maintaining their sustainable vitality and preventing decline. The decay of historical centres originates from the decline of the urban vitality of these hubs. However, the detailed reasons vary with the context. This issue has drawn considerable academic attention from all over the world over the past few decades, although most of these studies have focused on the social and economic dimensions, with little attention given to the effect of space on the issues in question.

In China, a country that has exhibited rapid urban growth over the last 30 years, the decay of historical centres has posed serious challenges to the urbanization of old cities. Unlike some Western cities, the decline of historical centres in China resulted from rapid urbanization in historical hubs and not from counter-urbanization. For a long time, most scholars in China attributed the decay of historical centres to the inability of the physical form of historical centres to meet the requirement of modern centres (Ruan & Sun, 2001; Qiu, 2006). Therefore, related studies preferred to focus mainly on social and economic dimensions, with only a small number of studies involving historical morphology addressing the spatial aspects of the issue. Undermining the effects of space has resulted not only in a lack of active historic regeneration and urban conservation, but also in deliberate destruction in China. Thus, the effects of spatial configuration on the social and economic decline of historical centres should be given more attention.

Over the past two decades, the urban morphology of historical centres has been studied from architectural and geographical perspectives. All these studies vary in scale, from individual building architecture to block, street, area, and even regional scales. Due to the development of GIS, recent studies have explored the prototypes of urban forms and growth (Batty, 2001; Jiang, 2009). But most of these studies have not narrowed the gap between urban form and function. The introduction of space syntax theories and methodologies offers a new perspective for linking formal and functional aspects of society.

As indicators of the actual uses of urban space and the planning tools used to organize these activities, land use distribution reflects social and economic activities that occur in the physical urban environment. In the field of urban morphology, Hillier's theories on 'movement economy' (Hillier, 1996), 'centrality as a process' (Hillier, 1999), and 'pervasive centrality' (Hillier, 2009) constitute the systematic foundation for the study of the interaction between land use patterns and spatial configuration. In this model, by influencing natural movement, spatial configuration further interacts with land use patterns. Based on this interaction, a number of studies have explored the relationship between urban configuration and land use distribution. Such studies include Karimi's comparative study between old English and Iranian cities (1998) throughout history, Dai's study (2004) on transformational form and function in Suzhou, Zhang's study (2005) on the Clerkenwell area of Greater London, Oritiz-Chao's research (2008) about the frequency distribution of land use patterns in Mexico City, Vaughan's study (2009) on suburban centres, and Feng's study (2012) on the evolution of Macau. All these studies are pertinent to the present study.

3. Methodology

This study is a comparison of case studies based on a correlation analysis that applies space syntax theories and normalised segmental analysis – a spatial accessibility measurement of by the segmental angle and metric distance in the urban grid. The historical centres in Tianjin over four key time nodes of modern urbanization are selected as the case studies. In this research we have followed the following four basic research stages:

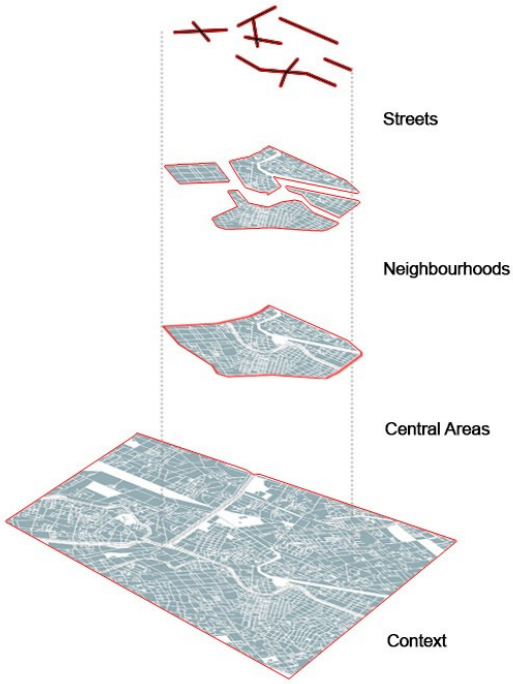

Figure 1: Research Levels.

The first step is about the definition of study areas in a multi-scale and contextual way. Four urban levels are studied in this research, including the whole city as the context, the central area, the neighbourhoods, and the historical centres, which are the most variant streets (Figure 1). The central areas are used to investigate how the historical centres combine into a relatively integrated area and are affected by the broad contextual structure. Within these central areas, the relationships among historical centres are examined by analysing how centrality shifts from one to another. With the spatial transformation of the whole city, the definitions of the central areas have likewise shifted. Thus, finding a universal method by which to clearly define the boundaries of changing central areas is difficult. However, by collecting fragmental resources, such as *Planning Log of Tianjin City* (1993, 2004), *Master Plan of Tianjin* (2009, 2011), and *Tianjin Business Atlas* (1990), to lock the locations of vibrant streets at various time periods, the central areas where the main commercial streets are densely concentrated are marked by circles on the GIS platform.

The second stage involves spatial analysis of the central areas of the historical centres of Tianjin throughout history based on syntactic models built according to the historical review and previous records. Four syntactic models are established based on historical maps from 1845, 1936, 1984, and 2012. These models illustrate the spatial transformation of Tianjin over a continuous timeline of nearly 150 years. The shifting syntactic centrality is captured through syntactic analysis of the spatial configurations to find spatial clues of the morphological changes.

The third step concerns the shifting land use patterns of historical centres. The relationship between land use distribution and spatial configuration is analysed. Land use patterns are explored to reflect advanced functional morphologies. In this manner, the significance of space in distributing land use is investigated to represent the relatively explicit interaction process between form and function in the evolution of Tianjin.

The final stage involves exploring the changing roles of historical centres by comparing the stability of various land use patterns in urban transformation. The relative locations of vibrant urban elements and land use in the scatter grams and the visualized interfaces were recorded. Thus the functional changes underwent by historical centres are revealed from a spatial perspective to find spatial clues of the changing roles of these historical centres.

4. FORMAL DESCRIPTION OF HISTORIC CENTRES IN TIANJIN

4.1 Brief historical review

Figure 2: Tianjin City in 1899 (from the United States Library of Congress's Geography & Map Division under the digital ID g7824t.ct002306)

Rapid urban growth has caused Tianjin to experience extreme spatial transformation over the past 150 years. As one of the most significant cities in the modern history of urbanization in China, Tianjin has a history that can be traced back to the 14th century. When Tianjin was opened to foreign nations as a colonial city, Tianjin experienced the earliest modernization and urban transformation in China in 1860 (Figure 2). Over nearly 150 years, urban growth in the area accelerated, and the physical development of Tianjin was accompanied by four urban extensions and large renewals that resulted from foreign occupation (1860), the development of new China (1949), the open policy (1979) and the new century (2000). In this process, different areas were situated near each other, thereby contributing to the patchwork-like forms of Tianjin, which is a typical example of rapid urban growth. Thus, in this study, we select four typical stages of Tianjin's history to represent its evolution: 1846, 1936, 1984, and 2012 (Figure 3).

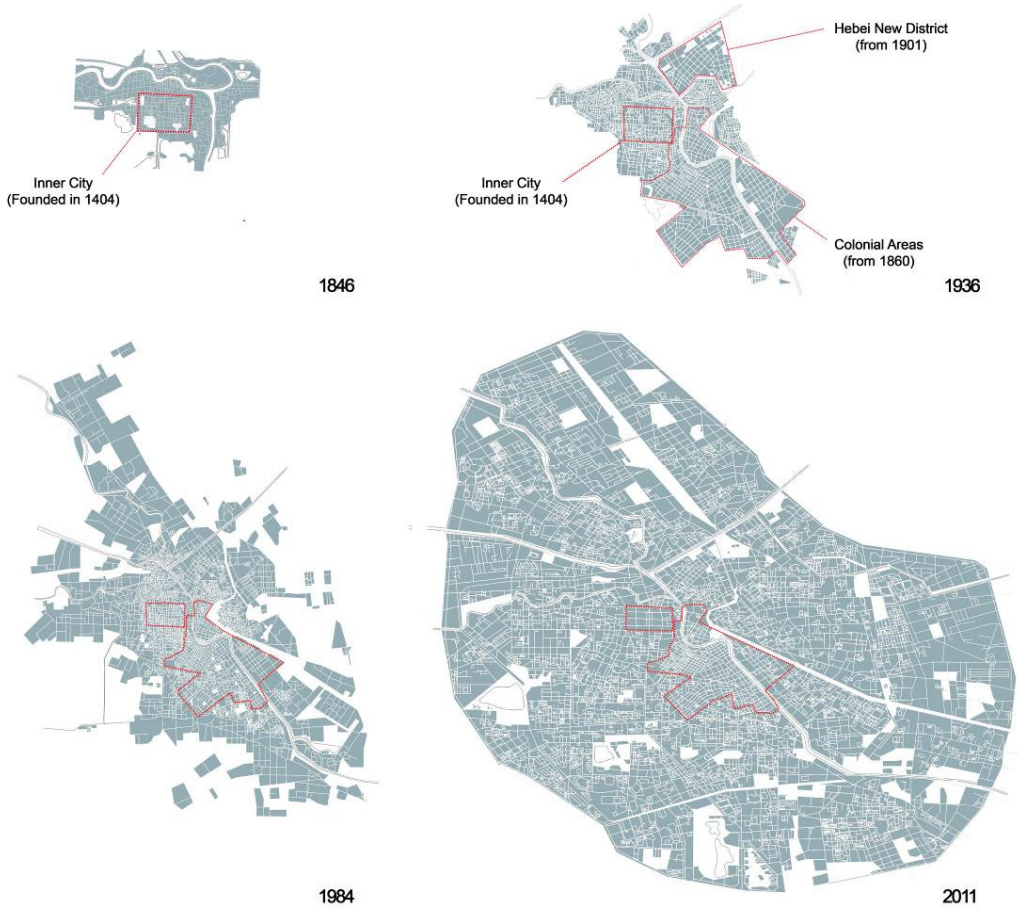

Figure 3: Transformation of Block Structures of Tianjin from 1846 to 2011 (Source of the base map from Historical Maps Collection of Tianjin, 1999).

In its earliest history, Tianjin was called “Zhigu,” which means "Straight Port.” Since the opening of the Grand Canal during the Sui Dynasty, Tianjin was transformed into a trading centre. In 1404, a fort known as “Tianjin Wei”—the fort of Tianjin—was established beside the organic town. Since then until 1860, Tianjin experienced a long process of self-organization, although the fort seemed to follow traditional Chinese planning theories.

After the Second Opium War ended in 1860, Tianjin was opened up as a treaty port to foreigners, with nine countries establishing concession areas in the city. The foreigners destroyed the existing city walls and established their territories in a certain place along the river. By 1907, after the colonial period, the colonial area had been 3.07 times than the size of the inner city in 1860 (*Planning Log of Tianjin City*, 1993), achieving one of the earliest and largest-scale transformations in the urban history of Tianjin.

In the 20th century, Tianjin experienced a period of relatively stable growth (the first half) and rapid urbanization (the second half). Figure 1C shows the development of the area between the old centre and the colonial areas. Urban extension occurred along the main roads of the old centre toward the open ground around the city.

Early in the present century, a new round of massive urban growth began. The new areas were divided into larger blocks, and several large neighbourhoods emerged. At present, large-scale development continues, and large-scale renewal has occurred inside the historical centre, where the old inner city was demolished and swiftly replaced by high-rise commercial and residential areas. Thus, only the main roads remain of the old inner city.

Figure 4: Axial Maps showing the Transformation of Street Structure in Tianjin from 1846 to 2011

The network structure and block configuration of Tianjin tell a similar story about the periodic extension of the city boundaries and the spatial transformation (Figure 4). The urban structure is characterized by a mixture of newly attached and old areas. In the 1846 map, the crossing streets of the inner city of Tianjin functioned as the major spines of the whole network, with several hutongs directly linked to the crossing streets. In 1936, the North–South Street extended to the south, with the modern orthogonal grid of the colonial areas patched along the Haihe River; the old cores and their surrounding structures were more intensive than before. In the 1984 map, as the urban centres shifted, the street networks of the new centres correspondingly became intensive. A series of long, straight lines emerged from the centres toward the suburban areas. By 2011, following large-scale urban development, various patchworks had been introduced and rapidly filled the space inside the ring-shaped freeway, thereby creating a layered structure. In the process of attaching the new to the old, the basic spatial structure of the historical centres has been maintained to a large extent even though the evolution of Tianjin appears to be a collage of various grids. Tianjin seems to have developed in a compound manner, where projects indicate signs of planning, yet the whole city still exhibits self-organization.

4.2 Evolution of urban centres in the context

Figure 5: Transformation of Commercial Centres of Tianjin from 1846 to 2011

Figure 6: Transformation of Block Size of Street Structure in Tianjin from 1846 to 2011

By collecting fragmental resources, such as *Planning Log of Tianjin City* (1993, 2004), *Master Plan of Tianjin* (2009, 2011), and *Tianjin Business Atlas* (1990), to lock the locations of vibrant streets during different periods, the central areas where the main commercial streets are densely concentrated are marked by circles on the GIS platform. Since the 15th century, neighbourhoods near the north intersection of the Haihe River were developed into a trading centre. After the fort of Tianjin was built to the south of the organic town, the main crossing streets were linked to the previous town centre, thereby creating a continuous centre between the inner and outer cities (Figure 6a). Since the development of foreign concessions along the Haihe River, the global urban centre shifted toward the southeast, as did modern business areas such as the Japanese and Italian colonial areas (Jianguo Road and Heping Road, respectively). Despite this, the traditional commercial centres still functioned well (Figure 6b). As the key waterway transport area, Tianjin emerged as a belt-shaped city in the early 20th century along the river. However, for political reasons, the new centres in the colonial areas were relatively isolated from the traditional Chinese centres, although the locations of the new centres had good potential to link to the old centres. By the 1980s, more centres emerged around the previous central areas, which indicates that urban development began to break away from the rivers and developed circularly. Within the old area, the traditional centres shifted from the inner city to the colonial areas. The new modern centres in the old colonial areas were linked to the old cores (Figure 6c), thereby creating a new, bigger centre. Over the next 30 years, Tianjin experienced extremely rapid urban extension. Based on the Master Plan of Tianjin (2011 version), the number of observed centres grew at an increasing rate (Figure 6d). More new centres emerged in the downtown area where the old centres were interrelated, and a larger centre was being shaped. In addition, although new large-scale projects were built in the past 30 years, a recognizable bottom–up process could still be observed, given that the surveyed centres normally emerged within a larger area rather than inside designed projects.

Thus, the commercial centres of Tianjin reflected urban development over the past 150 years as well as detailed shifts in centrality. The linear shift of the global centres toward the southeast extended across the river and was distributed to the newly developing areas around the city. It is verified by the patterns of block size following a principles that a higher concentration of small urban blocks in the commercial centres of Tianjin.

4.3 Evolution of urban centres in central areas

The spatial definitions of the central areas during various times are difficult to explain because of the evolution of urban centres. One relatively reliable method is to capture the geometric core of the aggregation of urban centres according to the density of the historical centres (Figure 7). Within these circled areas, the existing historical centres and the vital neighbourhoods are presented in the context of the whole city.

With the evolution of the whole context, the transformation that occurred inside the central areas also exhibit intensified centrality with the exception of modern urban regeneration in the inner city in 2011. More streets emerged and played a role in commercial development from 1846 to 2011. Furthermore, consistent with the increasing urban growth, the shapes of the clusters of centres changed from a relatively linear pattern to a convex one. Simultaneously, the block size became smaller and denser in the centres, but the renewal happened in the inner city broke this rule. In 2011, the rebuilt inner city broadened the blocks and turned them to the modern grids. Moreover, compared with the transformation of the urban context, the shapes of the central area more closely represent the whole structure of the city, which suggests a two-fold relationship between urban centres and the structure of the city as a whole, specifically that the centres affect urban growth. On the contrary, urban growth also affects the transformation of the centres.

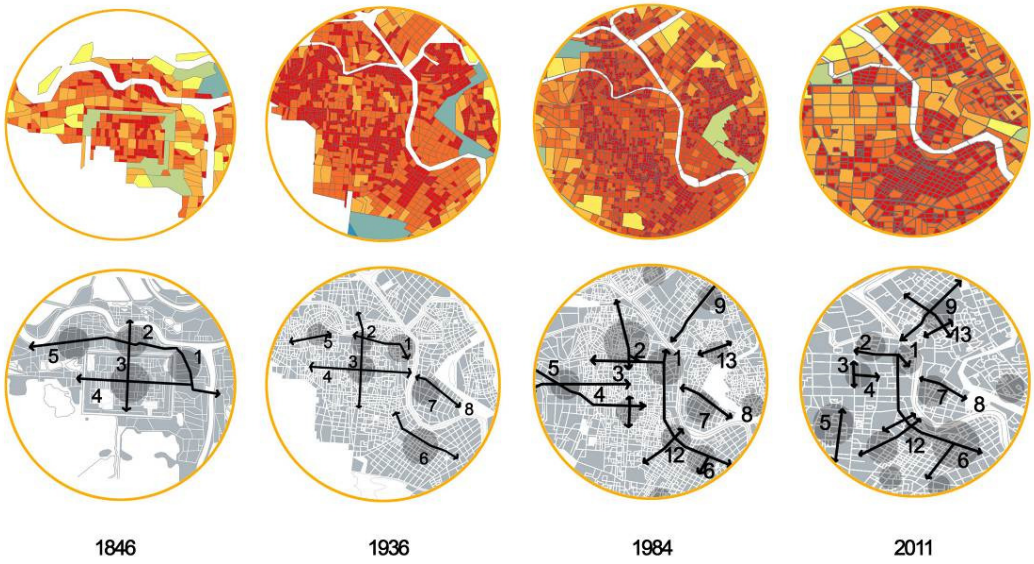

Figure 7: Evolution of Central Areas where Historical Centres are Located from 1846 to 2011 (upper row: block sizes in central areas; lower row: main commercial centres in central areas)

5. SPATIAL ANALYSIS OF HISTORICAL CENTRES IN TIANJIN

The above visual inspection reveals the tendency of centrality to occur in the central area of Tianjin. To examine how the historical centres have evolved spatially, the following sections compare the shapes and locations of the integration cores chronologically. The central areas that are historical centres at various times are studied within the context at hand. This comparison focuses on normalised segmental integration and choice analysis on a global scale for the embedded system. The historical centres in the central area undergo normalised segmental analysis at all radii to explore the relationships among historical centres.

5.1 Centrality process in the context

Based on the historical maps, we transform the street system to an axial map that is a geometric model in space syntax theory (Figure 3). The street network of Tianjin gradually evolved from an organic pattern to a modern grid. Marked intensification of the grid occurred and contributed to rapid urban growth.

The urban development of Tianjin is syntactically investigated by performing segmental analysis on various scales. In this manner, we analyse the spatial characteristics of the urban structure globally and locally during different periods to gain a better understanding of the development of the urban structure of Tianjin.

Figure 8 shows that patterns of global choice have picked up the reported centres. In the central area, historical centres are located in relatively strategic places throughout the city, whereas the new centres and centres in peripheral areas are located by the side of routes with high choice values. The number of integrated routes increases rapidly as urban development progresses, thereby shaping a series of spoke-like routes that originate from the central areas to the urban periphery. The convex integration core emerges near the traditional Chinese centre and develops stably into a cluster of centres. Hence, the compact and inter-accessible configuration was shaped in previous periods.

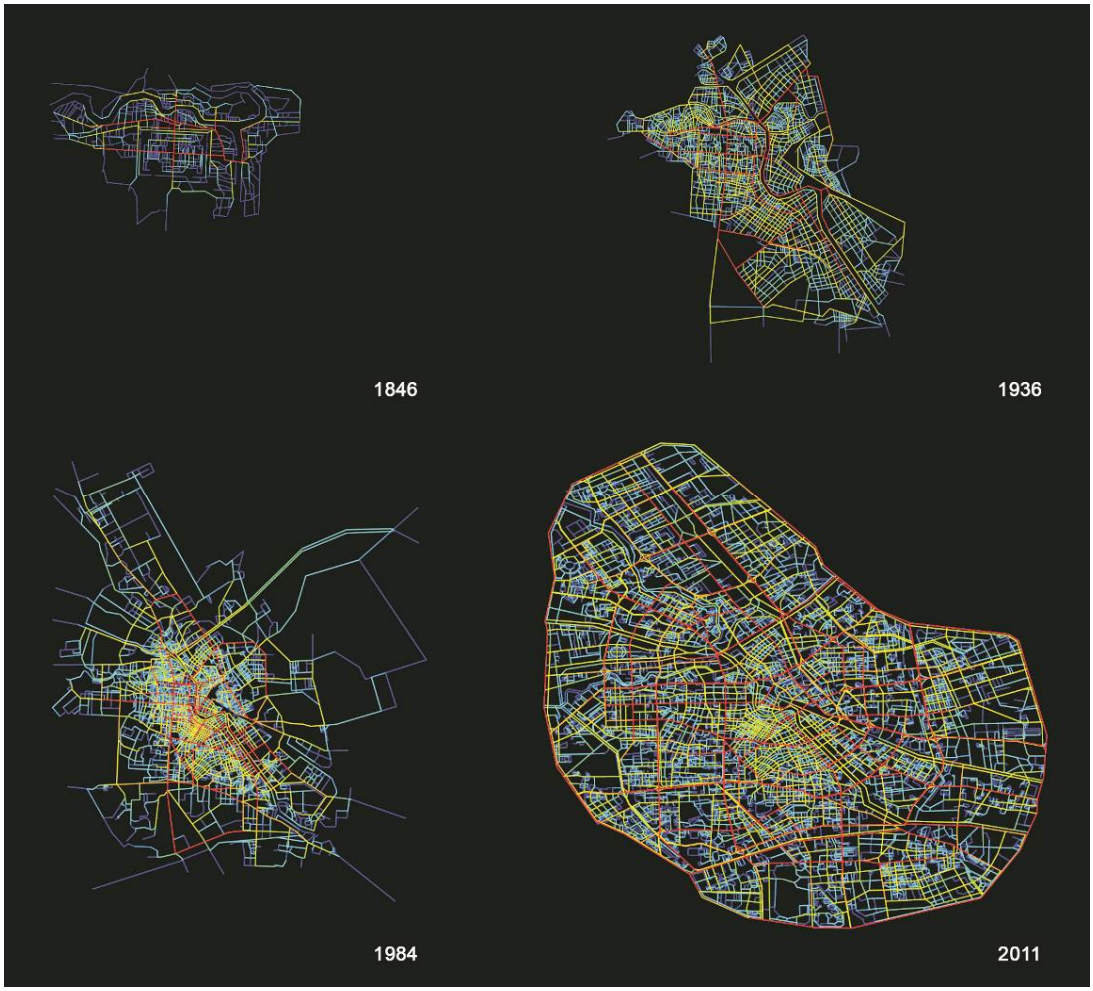

Figure 8: 1.4 Angular Choice Structures of Tianjin from 1846 to 2011 (segmental model-Rn).

By recording the results of the normalised segmental analysis on the syntactic parameters, we can gain a statistical view of morphological changes in the historical centres of Tianjin. Table 1 shows a remarkable rise in syntactic values in urbanization. The foreground network of the urban structure has become more shallow and accessible. However, from 1936 until the present, choice value, connectivity, and segment length decreased, which suggests a more relatively dispersed movement in the background network of Tianjin. This result also suggests that the characteristics of the foreground and background of Tianjin differ from each other in urbanization.

Table 1: Syntactic Perimeters of the Spatial Configuration of Tianjin City from 1846 to 2011 (segmental model).

		1846	**1936**	**1984**	**2011**
General Indices	Mean Connectivity	4.267	4.714	4.250	4.099
	Mean Segment Length	84.728	73.182	96.901	95.050
Foreground	Maximum Normalised Integration	1.662	1.821	1.962	2.174
	Maximum Normalised Choice (Rn)	1.563	1.595	1.602	1.594
Background	Mean Normalised Integration	1.098	1.212	1.271	1.393
	Mean Normalised Choice (Rn)	0.939	0.975	0.921	0.864

On the GIS platform, we calculate the changes in global integration by interpolation method between each two time nodes to represent the shifting direction of the urban structure (Figure 9). The new centres seem to emerge from the edges of the cities. The city also appears to grow and extend toward clusters with a high chance of integration. The developing direction of the urban environment reflects the data from historical sources, which suggests that shifts in centrality are affected by the structural transformation of cities and exert its influence from the outside inward.

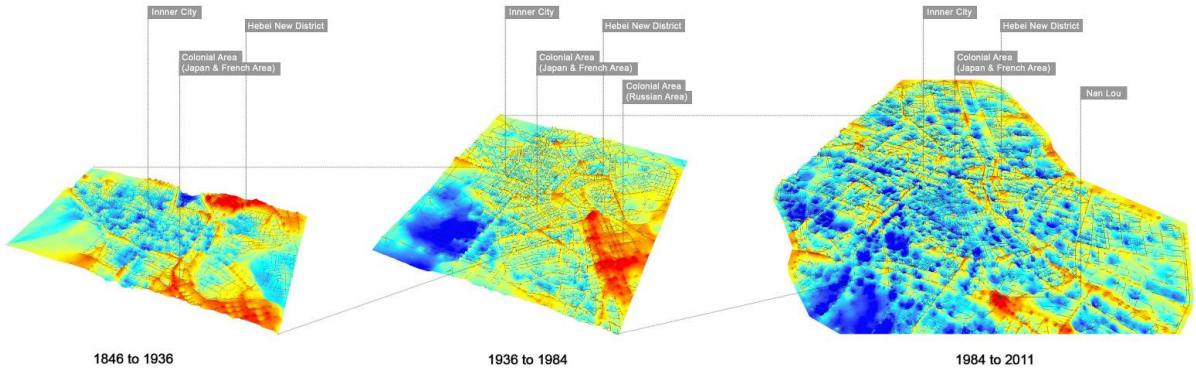

Figure 9: Changes in Global Integration from 1846 to 2011. (based on the segmental map, red indicates increase, yellow indicates no change, and blue indicates decrease)

5.2 Centrality process inside central areas

Compared with the whole structure, the central areas are more accessible and well-connected than the context (Table 2). The whole core areas are effectively integrated in terms of internal development. Apart from the shifting process of urban transformation, this internal development reflects another way in which the centres in the urban central area interact with each other and aims to achieve a more integrated cluster of historical centres, which then recreates the relationship between centres.

Table 2: Syntactic Perimeters of Spatial Configuration of Central Areas from 1846 to 2011 (segmental model)

		1846	**1936**	**1984**	**2011**
General Indices	Mean Connectivity	4.365	4.690	4.382	4.513
	Mean Segment Length	77.657	64.21	57.59	74.533
Foreground	Maximum Normalised Integration	1.662	1.821	1.962	2.174
	Maximum Normalised Choice (Rn)	1.563	1.595	1.602	1.594
Background	Mean Normalised Integration (Rn)	1.155	1.302	1.406	1.592
	Mean Normalised Choice (Rn)	0.967	1.010	0.969	0.984

In the changing context of urban growth, the central areas experience intensification and competition between historical centres during diverse periods; hence, a shifting of centres is represented (Figure 10). On the global level, routes with high choice values are increasingly concentrated on the arterial roads, which suggests that modern cities are highly dependent on mobility. On the local level, the colonial centre emerged with a relatively clear boundary in 2011, and local and global centres have relatively high synergy, which suggests that the spatial intensification between historical centres in the central areas is the outcome of the simultaneous interaction between the local and the global structures. Specifically, when the same threshold is adapted in the segmental analysis, the overall accessibility of roads and streets in central areas of Tianjin are clearly improved. The main roads of the city are

responsible for vehicle travel, thereby becoming the highest integrators in the downtown area. Along with this tendency, the main commercial centres turn out to be the streets with high local integration and choice for walkability as well as proximity to global integrators. For instance, from 1860 to 1936, commercial centres were located in urban corridors. However, since 1984, newly built and widened streets and roads have become major arteries for modern traffic, and the centres have become adjacent to the main roads, which are accessible from the local level.

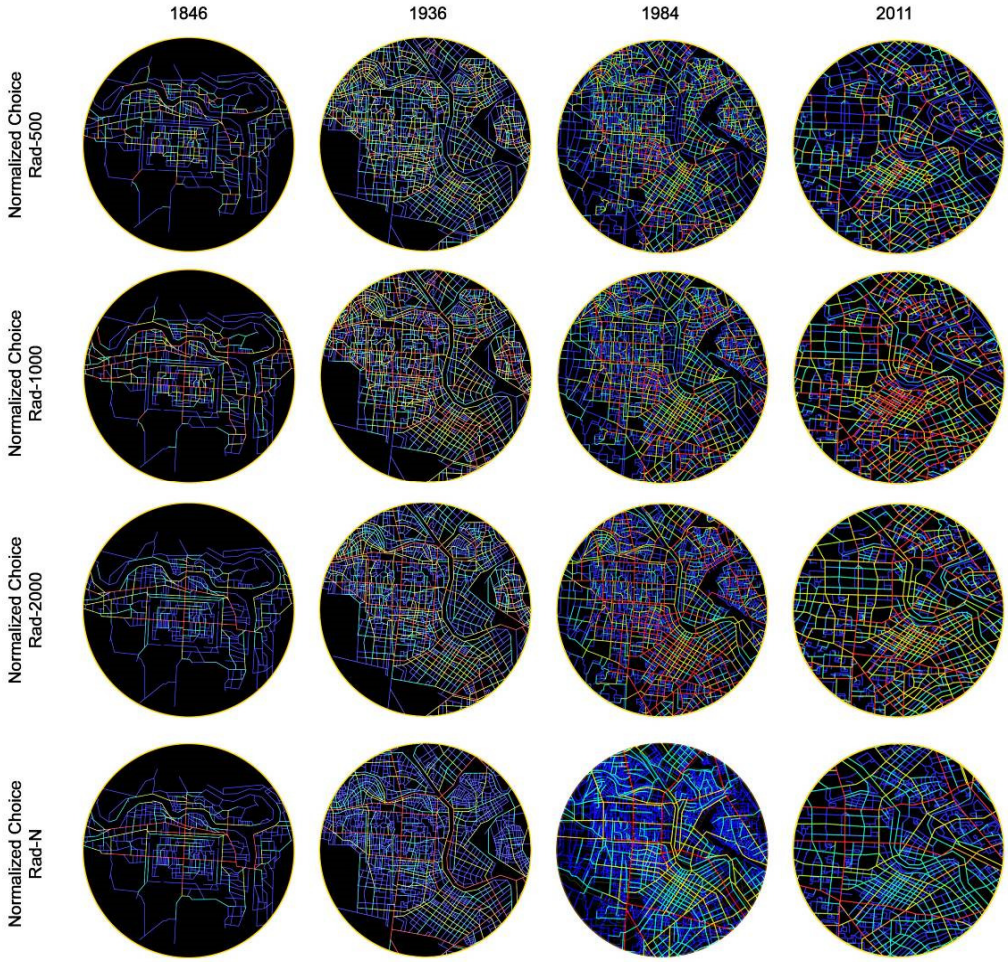

Figure 10: Choice Analysis of Tianjin from 1846 to 2011 (segmental model).

Moreover, since the removal of the walls of the inner city of Tianjin in 1990, the ring roads and the crossing roads caused the centre to form a strong structure that is like a “deformed wheel” (Hillier, 2001) that creates a strong traffic route system at a global level. On a local scale, the colonial area has been a pedestrian centre since 1936 (Figure 11). With the demolition of old communities in the old central area, the centres in colonial areas have shown strong advantage within a low radius. This indicates the tendency of local centrality to migrate from the inner city toward the colonial areas. We then apply the analysis of metric mean depth to investigate how the changing relation between the neighbourhoods is influenced by the morphological evolution of the context.

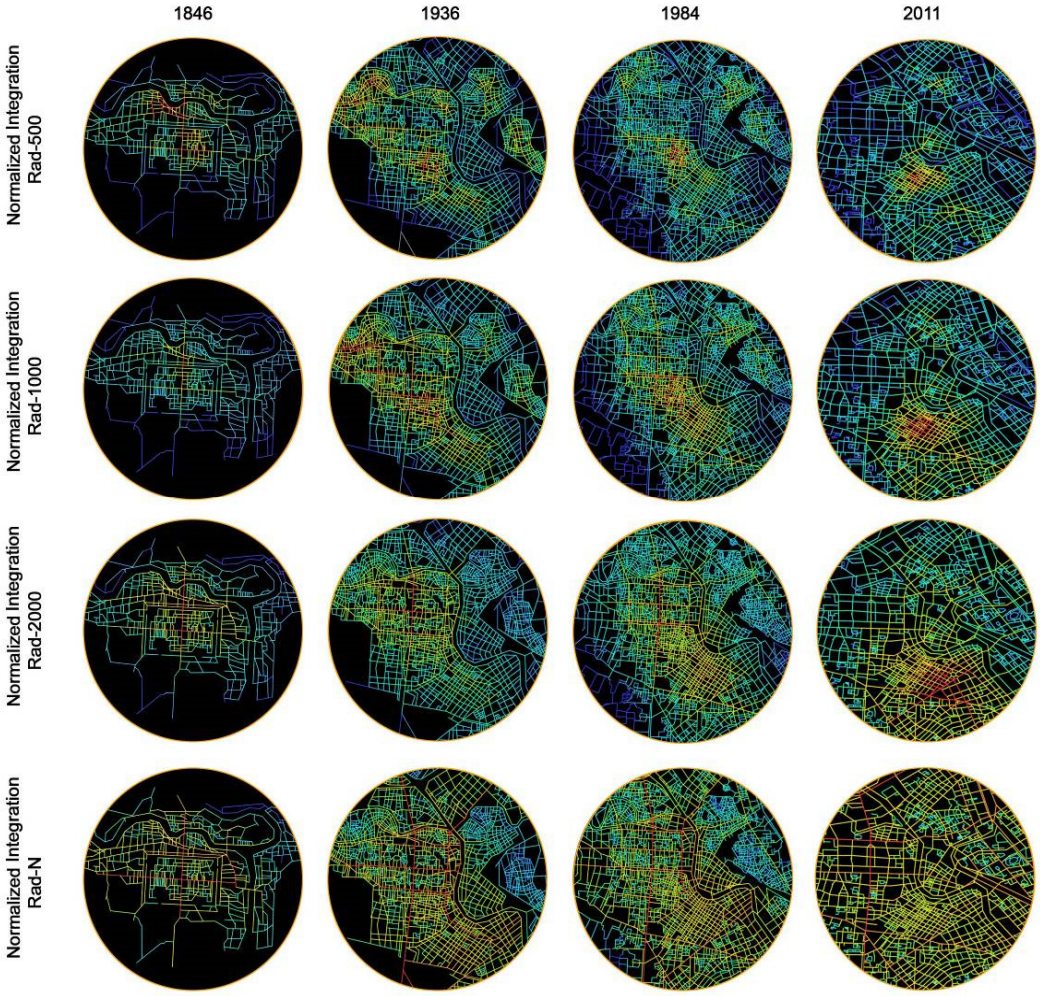

Figure 11: Integration Analysis of Tianjin from 1846 to 2011 (segmental model).

Figure 12 shows the different shapes of neighbourhoods (red patchworks) during different periods, which are all connected by capital routes with high global choice values. Given that the localities captured by the syntactic analysis are relatively self-similar (Park, 2007) and maintain higher intelligibility (Dalton, 2007), the boundaries of the patchworks thus represent the interface between the vicinities and the context. In previous studies, Yang (2007) notes that the boundaries of the neighbourhoods are fuzzy. In the case of Tianjin, the evolution of neighbourhoods in the inner city is dramatic than the ones in colonial areas. In the process of urbanization, the organic patterns are replaced by regular and large modern grids, and the stability of the neighbourhoods in the inner city is then lost in the urban development. By contrast, the neighbourhoods in the colonial areas are preserved and linked to similar patchworks. Furthermore, the captured patchworks represent the difficulty of wayfinding and structural similarity between various parts of the city, which indicates that the neighbours located next to each other will promote each other and will generate more interaccessibility between them. Thus, the colonial areas maintain better sense of neighbours and walkability than the inner city.

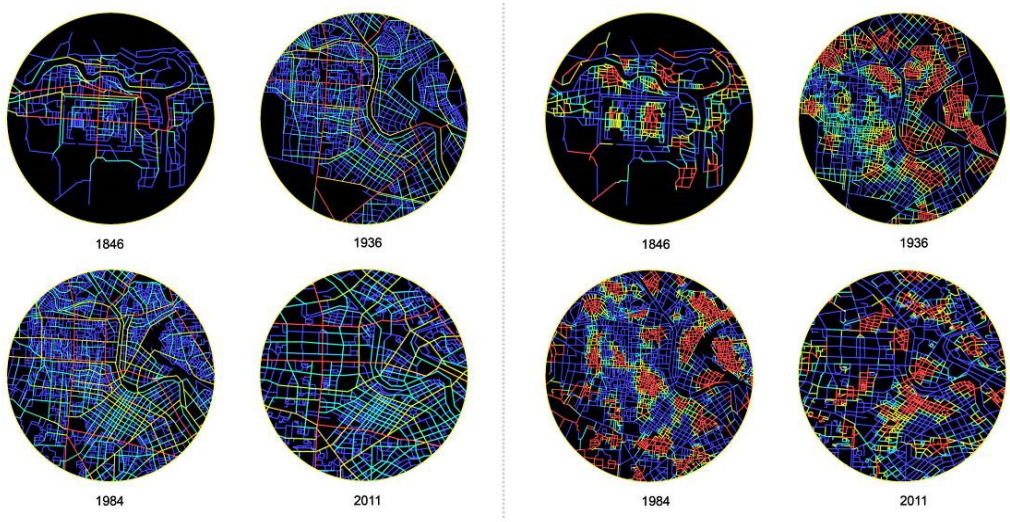

Figure 12: Relationship between Routes (Rad-n) and Neighbourhoods (Rad-800 metric).

The scatter plots of the regression between global syntactic indexes (Figure 13) indicate that the main commercial streets in the centres occupy relatively highly accessible locations in the city. The graphs in Figure 13 further show that the centres in the periphery (sub-centres) are relatively less accessible than the main centres, which is reflected by distribution of integration as well as choice. This result suggests that the advantages of the centres are related to the synergy between choice and integration, which supports Hillier's argument (2012) that integration is similar to cost, and choice is the natural benefit of one segment; thus, a centre will naturally pursue more benefits and less cost. During the period of rapid urban expansion, for instance, from 1846 to 1936 and from 1984 to 2011, peripheral centres emerged in places where integration and choice were relatively high but not as high as in the historical centres, and then reinforced their centralities that resulted from their locations' advantages, as exemplified by the centrality intensification that occurred from 1936 to 1984. By contrast, a number of the historical centres, such as Tianhou Temple and Guyi Street, moved toward the lower positions.

The gain and loss of centrality is therefore related to the global structures in which historical centres are embedded and to the interaction between the centres within the central areas. In this way, the global integration cores of Tianjin have varied in their location, shape, and size over the last 150 years, shifting from the old town toward the colonial areas. In terms of internal spatial structure, the colonial areas seemed to be more integrated than the traditional Chinese urban core. Hence, the shift in spatial configurations can describe the transformation of the urban centres.

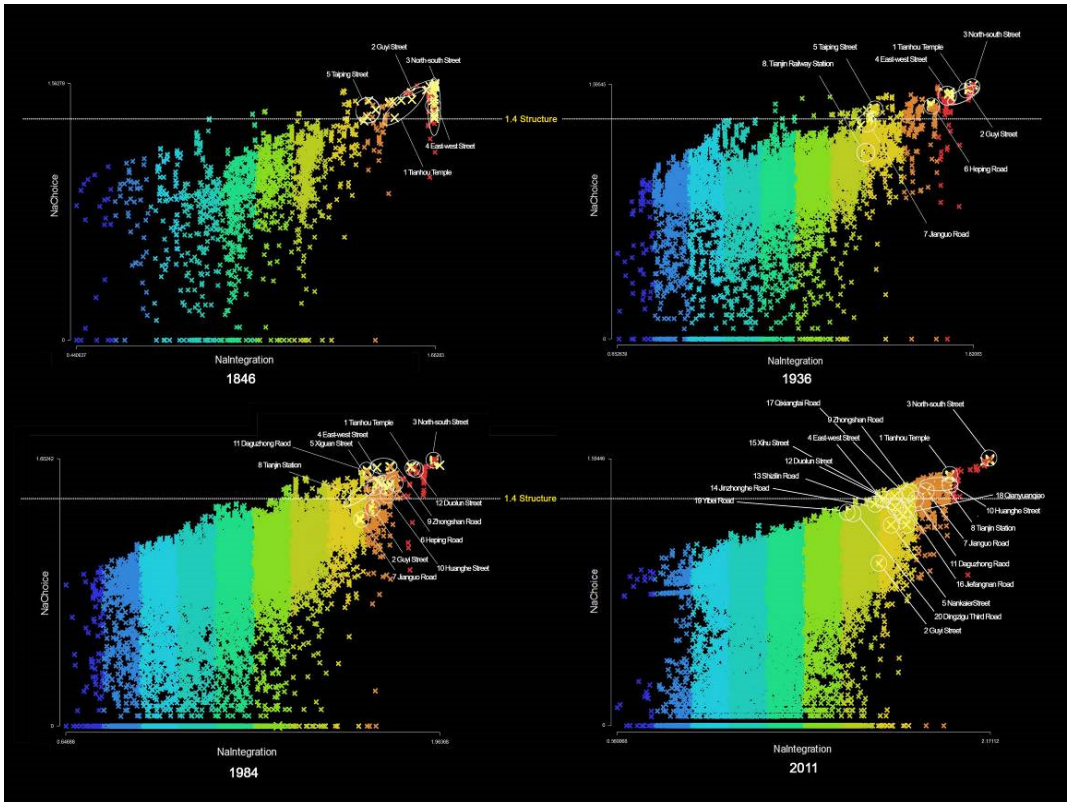

Figure 13: Scatter Plots of the Correlation between Integration (Rn) and Choice (Rn).

6. SOCIOECONOMIC ASPECTS OF CENTRALITY

In the following sections, the plot patterns of commercial land use in 2011 are analysed to investigate the spatial clusters of the subtypes of land use and the extent of the contribution of past spatial transformation to present patterns of land use. All data are obtained from *Chinese Electronic Map* (2011).

6.1 Present spatial clustering of land use patterns

As shown in Figure 14, the spatial aggregation of land use patterns shows the clustering relationship between various land use patterns. The distribution of shops, followed by that of other commercial activity areas including catering areas, banks, and hotels, is clearly correlated to the integration cores in a visual comparison. The shops cluster in the colonial centre, which then establishes this centre as the urban commercial centre for the whole city. Moreover, the patterns of the banks, hotels, and catering places are relatively polycentric. This polycentricity may be related to other functions. For example, the traditional food shopping mall in the south side of the inner city is also a tourist destination, and the streets around the Tianjin Railway Station attract hotels and banks that serve large and small commercial centres.

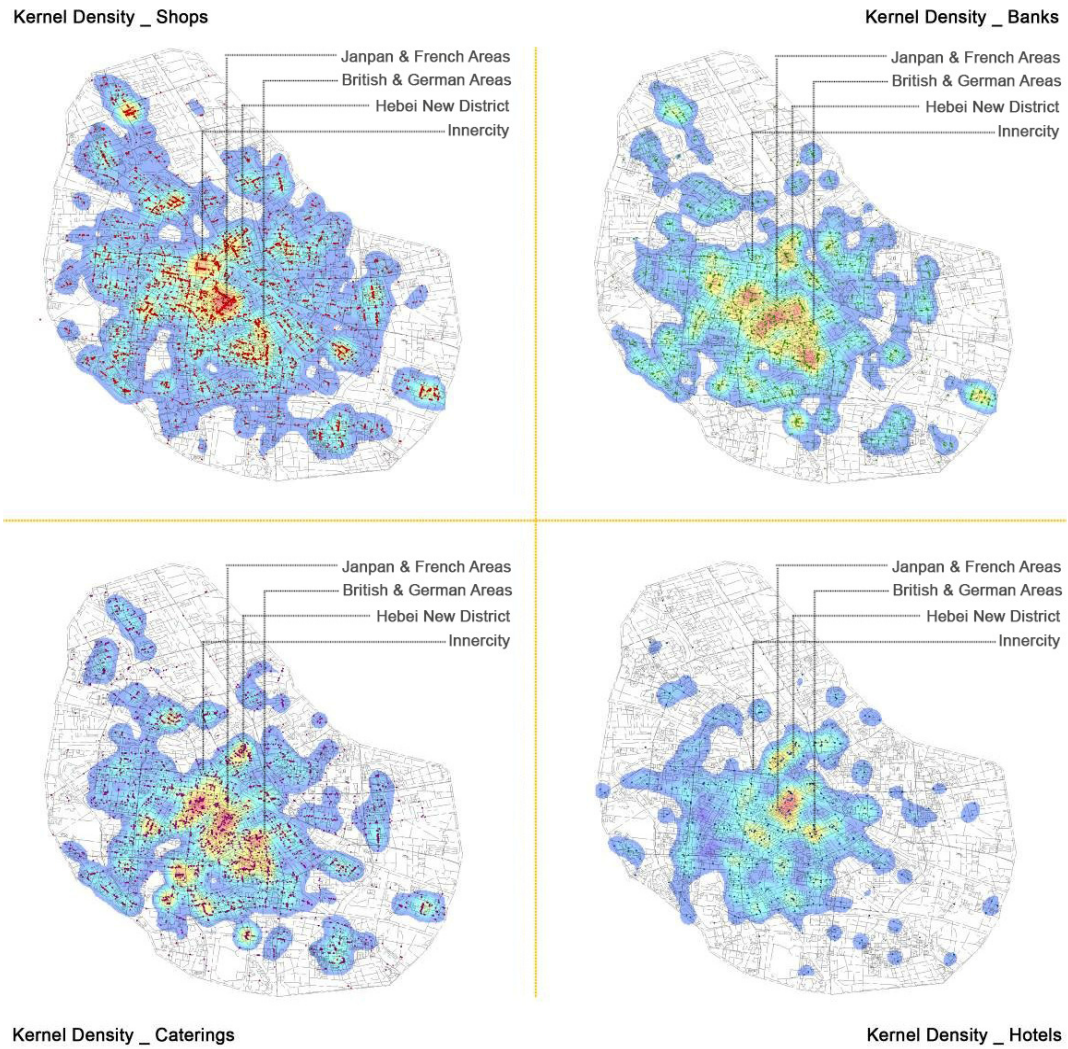

Figure 14: Kernel Density of Commercial Activities in Spatial Structure.

We have explained the clustering of functions according to spatial condition. However, the question now is how various types of land use patterns interact with each other. To address this issue, we calculate the spatial correlation between the densities of relevant land use patterns by the spatial statistic tool in GIS (Table 3). These four subtypes of commercial patterns are strongly correlated to each other. The distributions of shops and banks are the most important land use subtypes given that the correlations between the distributions of shops and banks and other land use patterns are approximately 0.8. Even the lowest correlation between hotels and catering is still 0.67. This result suggests that all these commercial sub-functions actively interact in highly accessible places and that the shop is a primary function that attracts other functions.

Table 3: Correlations among Densities of Commercial Activities

	BANK	SHOP	HOTEL	CATERING
BANK	1.000	0.897	0.736	0.807
SHOP	0.897	1.000	0.772	0.829
HOTEL	0.736	0.772	1.000	0.671
CATERING	0.807	0.829	0.671	1.000

6.2 Correlation between space and function

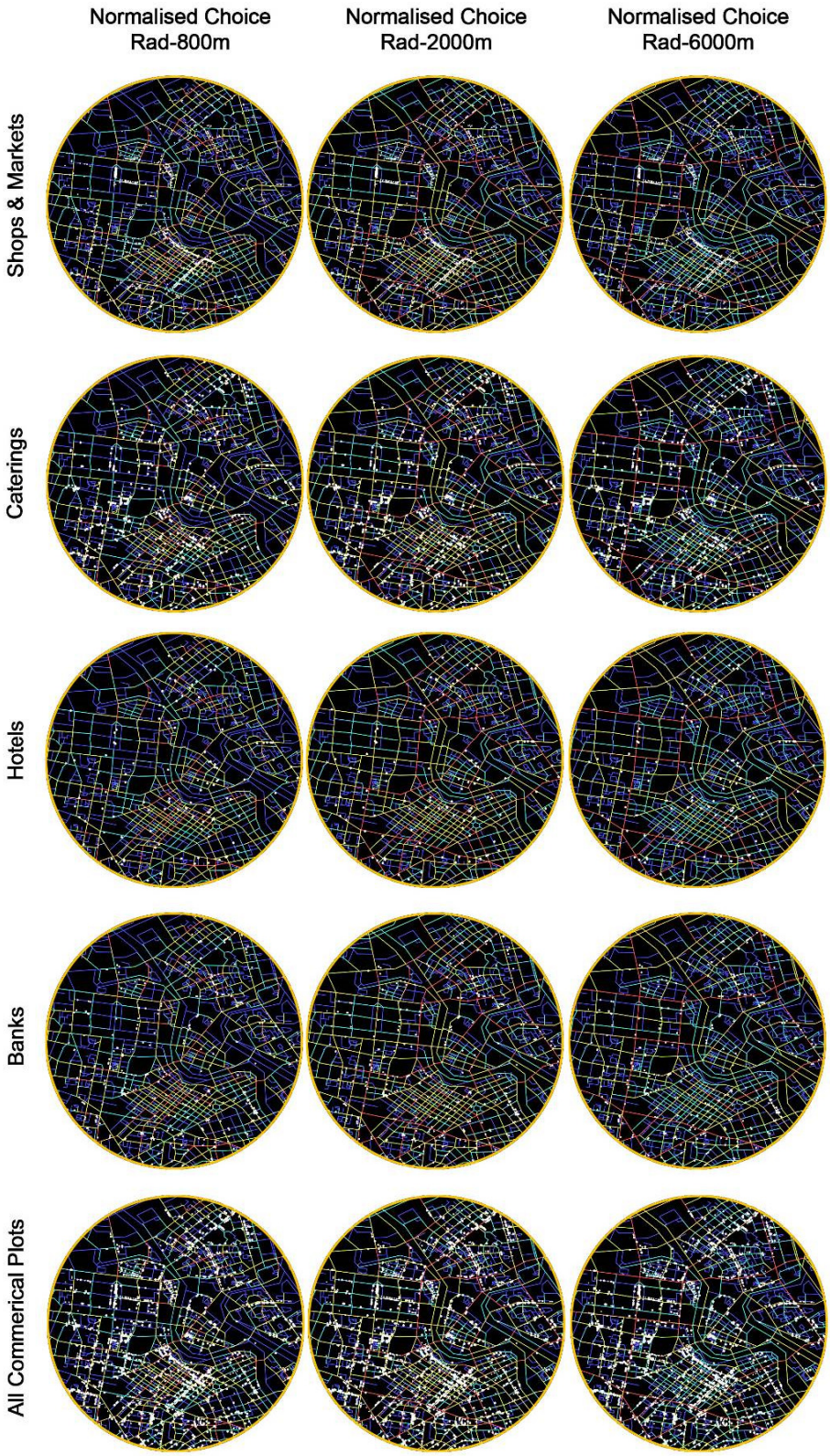

Figure 15: Correlation between Spatial Structure and the Functional Plots (based on segmental map).

A strong correlation exists between syntactic centres and functional plots (Figure 15). Within an 800 m radius, the syntactic integrators match well with the distribution of shops. By contrast, the catering place, hotel, and bank are captured on a relatively larger scale at a radius that ranges from 2000 m to 6000 m. Moreover, these results obey a certain rule; that is, the clusters of shops are picked up precisely at low radius even though the syntactic centres at high radius reflect more plots, which suggests that the syntactic centres at low radius reflect the strongest centres which result from the combination of local and global syntactic strength (Hillier, 2009).

In terms of the mixture of land use patterns, the syntactic centres at low radius are the primary factors that affect interaction among land use patterns. Considering the effects of the distribution of shops, other relatively discrete land use patterns seem to represent a certain regularity and further correlate with syntactic centrality. These results show that the shops are the primary factor that stimulates the other functions. This finding also suggests that spatial configuration affects the mixture of land use.

6.3 Effects of urban elements and land use on spatial patterns

Although a strong spatial correlation exists between land use patterns and spatial structure, a number of functional parts of the city still cannot find good spatial correspondence with syntactic cores (Figure 15). It is interesting to know what kinds of elements will affect the formation of functional clusters without a clear syntactic logic.

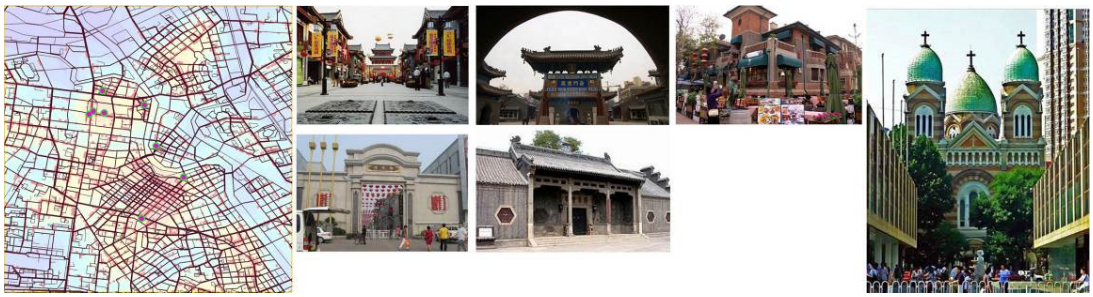

Figure 16: Locations of Historical Urban Elements (Pictures from www.alltrip.cn)

Based on a preliminary survey, we argue that urban elements, particularly historical urban elements, will act as the attractions that will affect land use distribution. As an existing land use, the historical symbols and the citizen memory, a number of historical places will integrate the spatial structures (Figure 16). For example, the inner city tourist shopping streets are organized around the Gulou, the central building of the old Tianjin, and Binjian Street, the most popular shopping street in Tianjin, has numerous historical buildings. At the end of its visual axis is Xikai Church, a symbolic cultural building in Tianjin. This trend indicates that historical elements help in stimulating commercial vitality, and the bridge that connects them is land use patterns. Historically, urban elements act as symbolic carriers of the social and economic life (Kostof, 1991); thus, some urban functions are maintained to some extent. Hence, land use patterns in the inner city of Tianjin changed and provided commercial services for visitors, but not for the local residents. Therefore, historical elements affect street vitality through maintenance of the land use patterns.

Figure 17: Locations of Modern Urban Elements (pictures from www.alltrip.cn)

Other modern large urban elements could also be key factors in this issue, that is, large shopping centres and the public transportation terminals can allocate people in one place and then reshape the local land use pattern (Figure 17). Specifically, the expansion of Tianjin Railway Station greatly contributed to the clustering of hotels in the area. Based on the Master Plan of Tianjin (2005), a central colonial area is defined as a central business district, which induces the aggregation of offices, shopping malls, and banks. As we have previously discussed, such a large-scale urban renewal is bound to affect the urban structure.

Thus, urban elements and historical functions also affect land use patterns and spatial structure. This finding illustrates that the city is the outcome of the balance between form and function. Spatial structures and the land use patterns complement each other and are indispensable. Accordingly, the interaction between these two aspects of the city facilitates social and economic development, which is the key to understanding urban evolution.

6.4 Roles of historical streets

By observing the distribution of the syntactic values of commercial centres throughout the radii, the significant change in the centrality of commercial streets is clearly observed, which to some extent, reflects the characteristics and roles of each historical centre (Figure 18). The roles of the historical centres changed significantly over the past 150 years, depending on the interaction between spatial and function patterns. Since 1936, the colonial centres have gained more centrality at various radii than the inner city particularly on the pedestrian level, which distinguishes their roles. The colonial centres are the urban commercial and business centres. Binjiang Street has increasingly strengthened its advantages at lower radii since 1936. In 2011, Binjiang Street has the most accessible historical centres at a local scale (below 2500 m). Nevertheless, traditional Chinese centres benefit from their spatial characteristics as they still function as centres of tourism even if they have the lowest syntactic value. However, some historical centres are clearly left behind by others, as demonstrated by the following cases. The first case includes the oldest historical centres such as the Guyi Street and Tianhou Temple. These two centres emerged from an organic town that can be traced back to the 14th century. They still function as commercial centres as a result of various traditional buildings that make these streets tourist destinations; this can be proven by the types of goods for sale. The second case involves historical centres, such as Gulou Commercial Street, which are located in the main roads of an old city. These main roads used to serve as crossing streets in the inner city or as a ring road that served as a wall of the inner city. Although the inner city always seems to be the core of the whole city, these streets, unlike the Guyi and Tianhou Temple Streets, are widened to serve as expressways because of modernization, which in turn, reduce the walkability of the streets. As such, Gulou Commercial Street appears as an island in the sea of traffic. Thus, the shifting social and economic characteristics of these centres can be better understood through syntactic parameters that change from the local to the global level.

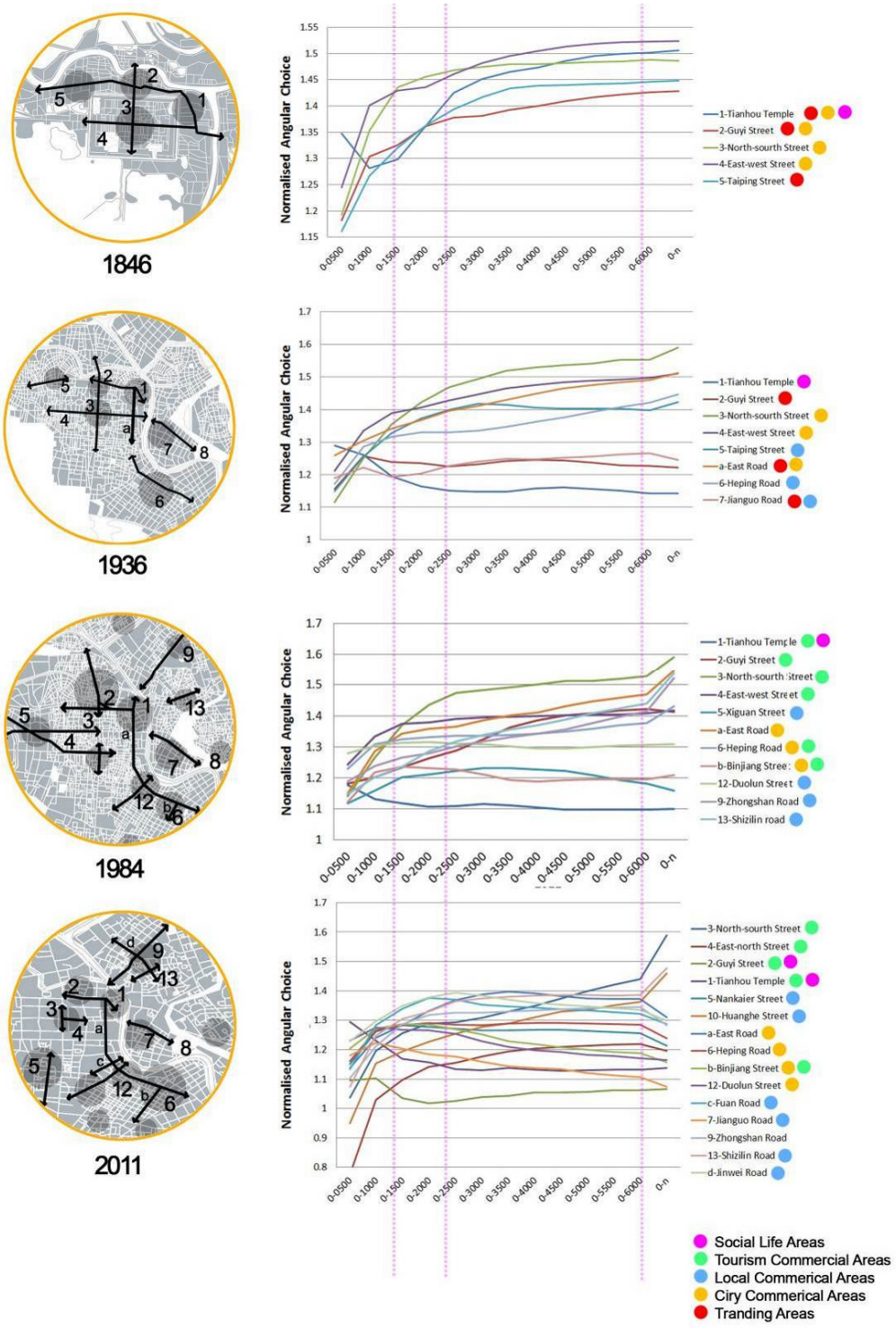

Figure 18: Roles of Historical Centres based on their Syntactic Values at all Radii.

7. Conclusion

The evolution of the whole city as well as competition between new centres and the old cores affect the transformation of historical centres. These external and internal forces mutually affect each other and land use patterns. In the case study of Tianjin City, the colonial areas - the old cores that functions well in modern grid, maintain integration at pedestrian level but closeness to the traffic arteries and sense of neighbourhood in terms of the spatial structure while the inner city of Tianjin functions as the global hub of the whole city without advantage at local level. Land use patterns correlate to spatial structures to varied degrees, which depend on interactions among the land use patterns, thereby forming functional mixtures. By using spatial regression analysis of densities of various types of land use, this paper suggests that the shop is the primary element and the other functions are secondary elements, which are organized by the primary ones. Results of this analysis further show the significant clustering characteristics of these elements. This study likewise illustrates that spatial configuration distributes the land use pattern as well as affects the interaction among land use patterns. On the other hand, land use also affects spatial structure. Historical buildings and land use will maintain their social and economic positions in the whole city. The roles of historical centres are represented through the interaction between space and form. The relationship between land use and spatial structure determines the fate of historical centres.

This study suggests that historical and modern urban elements and land use patterns are the principal urban sources for urban regeneration. Passive conservation such as preserving the historic buildings and quarters as museums, cannot stimulate functional vitality. Regenerations of historical streets, neighbourhoods, and centres should focus on preserving extending and recreating the continuity of the walkable space so that more types of citizens can interact in the historical centres, and, in turn, greater urban diversity will be generated to maintain the liveability of the historical centres.

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