How Do Universities React with Cities: the Case Study of Wuhan, China

(Interpretation of the "Univercity" and its spatial Policy in the Case of Wuhan)

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Abstract
Cities and universities have been reacting with each other in a complex conflicting way not only in urban morphology but also in economic, social and culture networks. This paper takes Wuhan for an example to explore the relations between universities and cities not only because Wuhan is famous for college education and has the most graduates all over the world，but also because Wuhan has been positioned as the national innovation center by making it as a "univercity". Comparison studies on the historic evolvements how universities react with cities are made between the western countries and China. In this way, efforts are made to interpret the meaning of the "university" in aspects of absorbing talents, promoting industries and developing cities. Then the index system of the "univercity" towards the three dimensions mentioned above has been established. Last but not least, the spatial strategies of making a "univercity" have been given accordingly.

1. Introduction

As major spaces to produce local knowledge, universities have become important public facilities to promote regional innovations, so as to make the cities more competitive globally. For examples, cities like Santa Clara, Boston, Cambridge and Oxford have become key nodes of the global innovation network due to their interaction with local universities with top rankings in the world. As the global innovation resources shifting to Asia, Shanghai, Beijing and other cities have put forward urban strategies of making global innovation centers so as to improve their roles in the innovation network worldwide by developing knowledge-based districts such as Yangpu Areas and Zhongguan Village.

As an important educational and technological base in China, Wuhan has long been attempting to transfer its own strength into regional innovation competitiveness. In 2016, To Make it as a "Univercity" has been put forward as one of the ten strategies of Wuhan innovation, which can be illustrated to make universities integrated with the city as a national technological and industrial innovation center. Among all the administrative divisions in Wuhan, Hongshan district has been listed as the core of the "univercity" with the densest resources of key universities, national labs and undergraduates[1] (see Figure 1). However, the district has been confronted with series of problems such as low contribution of universities to industries and isolation between universities with cities leading to traffic jams and facility shortages. Based on this, how do universities react with cities has long been bothering Wuhan especially Hongshan district. This paper attempts to analyze the histories of the interactions between universities and cities, illustrate the meaning of "univercity" and propose exploratory strategies on physical environment.
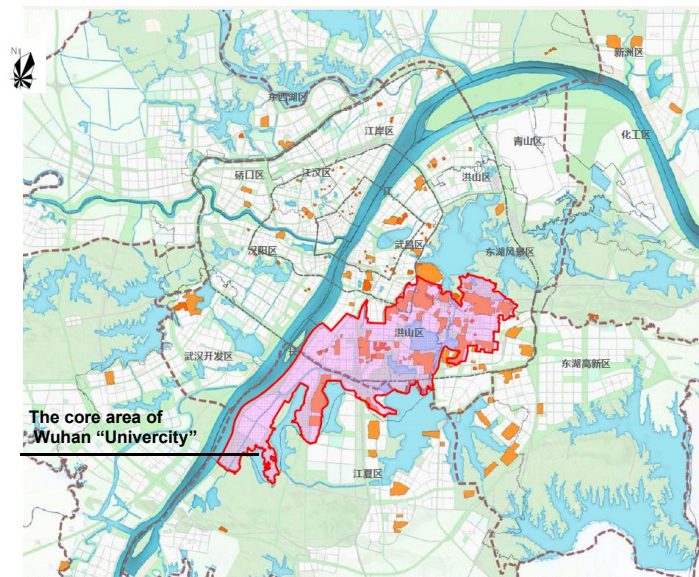
Figure 1: Range of the Core Area of Wuhan "Univercity"

2. The Interaction between Universities with Cities in Historical Perspectives

As the products of western modern civilization, universities can be rooted from the word universus with the meaning of universal, whole, world and universe, which determines that the reactions between universities and cities in China and abroad quite different.

2.1 Experiences in Western Countries
The histories of the reaction between universities and cities in western countries can be divided into the following three stages.

The first stage from the 12th century to the 18th century can be characterized as comparative isolation under the influences of religions. At the beginning of the 12th century, universities have come into being as a new kind of high education facilities especially for government staffs, reverends, noblemen and other elites. Influenced by the Christians, university campuses were almost integrated with churches, which were located besides small towns as enclosures, like the King College of Cambridge University.

Then it was the stage of open public facilities in the ideas of equality and freedom from the 18th century to the 20th century. After the first Industrial revolution, the new emerging business has led to large demands for scientific professionals. As the raise of expenses on high education, universities have expanded themselves for technicians. Greatly influenced by the famous Germany education revolutionist Wilhelm Von Humboldt who advocated the combination of education and research, scientific research has become the responsibility of universities for the first time. As a result, universities which used to be isolated with cities have become open to people especially in the aspects of public facilities. For example, Cambridge University in Britain has torn down the old monasteries and colleges, and instead built a conference center, a library and a museum open to the public. Massachusetts Institute of Technology has set up an opera, a hospital, a gymnasium, parking lots as well as some research centers around the campus.

From the 20th century till Now, it was the third stage characterized as the integration of universities and industries driven by regional innovation. After the third technology revolution, innovation has become the major driven force promoting regional economic developments. With the improving role of scientific research to urban productiveness, the research functions have gradually reached out of campuses and penetrated into the neighboring research institutions. For example, there were more than 8000 technique companies surrounding

Stanford University, Santa Clara University and San Jose University, which has formed a ring of research centers, communities and retail stores (see Figure 2). Under the influences of productivity revolutions and freedom ideologies, the universities in the western countries has transformed from isolated blocks to open neighborhoods sharing public facilities and research institutions, which has not only improved the service efficiency, economic powers and regional innovation competitiveness.

Figure2: Function Analysis of Stanford University and its surrounding areas

2.2 Experiences in China

The histories of the interaction between universities and cities in China can be divided into the following four stages.

The first stage can be characterized as enclosure academies in the ideas of elitism education, which was from the 9th Century to the 19th Century. The oldest universities originated from the academies especially for the gentries, scholars and government staffs in the feudal society. Influenced by the naturism of Taoism and Confucianism, the universities were mostly located in the forest on the outskirts such as Changsha Yuelu Academy. Then to improve the convenience of administration, universities were mostly located in the cities such as Beijing Jingtai Academy. There were one or multiple courtyards in the academies with the functions of teaching, studying and resting.

From the early 19th century to 1949 was the second stage of open campuses under the influences of western education. As the revolutionary change in the traditional education driven by the Westernization Movement, the academies were gradually transferred into schools influenced by the western education thoughts. Later on, campuses become more open to cities, which can be considered as the early forms of the "univercity" in China.

It was the third stage from 1949 to 1978 under the influences of western education, which can be characterized as self-contained compounds. From the foundation of the People's Republic of China to the Reform and Open-up, universities were mostly located on the outskirts which were usually planned as the educational areas in the city master plans. There were multiple defined and connected functional areas such as education, research, libraries

and living quarters, which composed the unique self-contained compounds. On one hand, the state encouraged universities to share their gymnasiums and auditoriums with the public. On the other hand, factories and warehouses were built in the campuses to make use of every bit of space, which has led to the disorder of land use. As a result, the self-contained compound model has set back the integration of universities and cities in China.

From 1978 till now was the fourth stage of function overflows under the influences of high education revolutionary movements. After the Reform and Open-up, the high education revolutionary movements have not only inspired the commercialization of research but also promoted the overflows of adjunctive functions to cities. Based on the self-contained compound model, some functions including caterings and retails were gradually shifting outside of campuses where assembled innovative research institutes spontaneously in correspondence to the famous disciplines. After 1998, continuous expansion of universities have led to the popularization of high education with low input and fast speeds. Local governments began to set up new colleges or expand existing universities which also demonstrated different kinds of spatial features. For example, some were located in new towns with abundant land resources as university towns like the Guangzhou University Town or as featured industrial parks like the Hangzhou Eastlake Creative Valley. Some were located in the main cities, like the central Intellectual Area around Shanghai Tongji University and Fudan University with multiple functions of business, retails, leisure and entertainments.

Greatly influenced by western education thoughts, the interactions between universities and cities have transformed from isolation, gradual openness to sharing services and contributing to industries. However, the traditional academies and self-contained compound models have exerted deep influences which demonstrated themselves as fences to keep isolations both physically and mentally. Taking the core area of the "univercity" in Wuhan as an example, most universities were located along the mountains and lakes like compounds or as clusters. Although the expansion of universities in the 1980s have promoted their interaction with research companies, isolation has been still clear both in the functions and forms. On one hand, there was a lack of commercialization of research leading to the massive demands but limited supply of innovation spaces outside campuses. On the other hand, enclosure campuses have not only led to the failure of sharing public services, roads and open spaces with the public, but also resulted into the big city diseases such as traffic jams and service shortages.

3. Interpretation of the "Univercity"

From the historical experiences how universities reacted with cities, the "univercity" should be illustrated as a sustainable mechanism of talents, industries and cities, which operates by transforming the education resources into industry competitiveness and sharing the service facilities with the public. To interpret the idea of "univercity" more concisely, an index system can be established from the dimensions of talents, industries and cites(see Table 1). Based on the *Guidelines of Developing Innovative Cities*[2] issued by the Ministry of Science and Technology and the National Development and Reform Commission, nine categories were made out of the basic index base by learning from the advanced areas and following principles of easy to compare and implement. For every category, two to five indexes were set up to demonstrate the features, goals and processes of making the "univercity". By the method of type research and comparative studies, quantitative analysis has been made for every index also learned from the references.

Table 1
Key Indexes of the "Univercity"

Dimensions	Categories	Indexes	Types		
			Features -related	Goals -related	Processes -related
Talents	Input on Education Expenses	Percentage of Technology Input to Public Finance(%)	√		√
		Percentage of R&D Expenditure to GDP（%）	√		√
		Percentage of Basic Research to R&D Expenditure(%)	√		√
		Number of Labs with Nobel Prizes	√	√	√
	key disciplinary &interdisciplinary platforms	Number of World-famous Leading Universities	√	√	
		Number of World-famous Leading Disciplines	√	√	
		Number of National Key Technological Facilities	√	√	
		Number of Research Platforms between Universities	√	√	√
	Personnel Recruitment	Percentage of Graduates to Local Employments(%)	√	√	
		Number of High-level Talents		√	
Industries	R&D Expenditure	Percentage of Enterprise Input to University Research Expenses (%)	√		√
		Number of Key Disciplines Transformed to Industries	√	√	
	Innovation Facility Platform	Number of Innovation Facility Platforms	√		√
		Contribution rate of technology to economy increase(%)	√	√	√
	High-tech enterprises	Number Percentage of High-tech Enterprises to Enterprises(%)	√	√	
		Revenue Percentage of High-tech Enterprises to Enterprises(%)	√	√	
Cities	Urban Quality	Number of Projects for National Garden City	√	√	
		Coverage of Metro Station with a Radius of 500m to Universities (%)	√		√
		Number of Talent Apartments Per Year	√		√
		Number of International Schools	√		√
	Open Campuses	Sharing Rate of Facilities (%)	√	√	√
		Number of Landscape Projects Funded by Governments	√		√
		Network Density(km/km²)	√	√	
	Urban Regeneration	Percentage of Land used for Innovation (%)	√	√	√
		Percentage of Revenues for R&D (%)	√		√
		Areas of Key Facilities or Labs（m²）		√	√
		Rewards for New-built Research Facilities			√
		Rewards for New-built Talent Apartments			√

3.1 The Dimension of Talents

Universities were essentially the cradle of talents output to cities. On one hand, the basic interpretation of the "univercity" is to cultivate and raise leading talents especially by nurturing

key disciplines of universities and promoting interdisciplinary construction and international corporations , so as to improve the strengths of city human resources. As a result, more talents will be attracted into the city once the competitiveness has been improved. Therefore, the indexes in the dimension of talents include input on education expenses, key disciplinary and interdisciplinary platforms as well as personnel recruitment. For example, key indexes like world-famous leading universities, world-famous leading disciplines and national key technological facilities were chosen for the sub-category of key disciplinary and interdisciplinary platforms. In a goal-oriented way, these indexes can not only represent the overall features in the domain, but also focus on both the qualities and quantities.

Taking the core area of Wuhan "Univercity" as an example, the goal of two world-famous leading universities with twenty first leading disciplines has been proposed based on the resources of current universities and disciplines. According to *the Mid-and-long Term Plan of National Key Technological Facilities(2012-2030)[3]*, there will be about fifty facilities nationwide. Based on this, Wuhan "Univercity" has been proposed to establish two national key technological facilities according to the current situations and comparisons with other cities.

3.2 The Dimension of Industries
As an important way to transform the educational resources into urban innovation competitiveness, fostering industries is the foundation of the "univercity". On one hand, key disciplines should be focused on boosting the process of incubation so as to play the leading role in regional innovation network. On the other hand, cooperation between universities and enterprises should be promoted based on the dominant industries, so as to exert backward forces from demands to supplies and improve the effectiveness of commercialization and appliance of research. Therefore, the indexes in the dimension of industries focus on the whole process of innovation and include spending R&D expenditures, building innovation facility platforms and nurturing high-tech enterprises. As an important part of cultivating innovation, building innovation facility platforms can by evaluated by methods of goal-oriented quantification, which can be indexed as the number of public service platforms and contribution rate of technology to economy increases.

As the most potentially innovative area in Wuhan, the core area of Wuhan "Univercity" has been proposed to meet the demands of leading universities and institutes by paying attention to building the platform of innovation facilities so as to keep up with the international levels. According to the *Thirteenth Five Years' Plan of National Technology Innovation[4],* the contribution rate of technology progresses to economy increases has reached an average level of 55.3% in 2015 and proposed to achieve the goal of 60% in 2020. Learning from experiences of other cities home and abroad, the goal of the core area of Wuhan "Univercity" has been set as 70%.

3.3 The Dimension of Cities
If the aspect of industries is only the economic dimension of the "univercity", the aspect of cities can be considered as a comprehensive dimension. On one hand, sharing all kinds of public facilities of universities with cities so as to promote the overflow of adjunctive functions, make most use of the facilities and improve urban living qualities. On the other hand, featured service functions can be set specially surrounding campuses not only to meet the diverse needs of college students and teachers but also improve the efficiency of urban public service facilities. Accordingly, the aspect of cities can be indexed including both improving urban qualities and promoting university openness. Not only the number of international schools which can be comparable to other areas has been listed, but also the sharing rate of college facilities and road network densities which can be used to evaluate the achievement of goals have been included. Besides, the subcategory of urban regeneration has also been proposed to add especially for the built areas surrounding colleges, which does not only focus on controlling indexes like the land use percentages for

innovations in urban regenerations and also include improving indexes like FAR bonuses on new built incubators.

As the model of the Wuhan "Univercity", the core area has been proposed to focus on the improvement of urban qualities so as to increase the attraction for talents. Learning from the references that there are from 2.3 to 3.3 international schools per billion persons in Beijing, Shanghai and Guangzhou, it has been estimated that there should be at least 3 international schools in the core area according to the population. Besides, as the current road network density is less than 2.5 km/km^2 due to the "compound" model of universities, the goal has been set as 5.5km/km^2 after opening campuses based on the national standards and implementation difficulties.

4. Spatial Strategies to React Universities with Cities

No matter the concepts of university towns and university parks proposed by Chinese scholars long ago or the "univercity" are essentially to react or integrate universities with cities. For the spatial elements, there are studies about university educational units and urban expansion units (Duan and Lu,2003), also discussion about the educational districts, adjunctive function districts and creative function districts(Wang, Chen, Yu, Feng and Zheng, 2016). Based on the theories of regional innovation systems[5], the physical spaces of the "univercity" should include universities to output innovating subjects, incubators to provide spaces for innovation activities and all kinds of facilities to cultivate innovation environments(see Figure 3).To achieve the goals in dimensions of talents, industries and cities, three connections should be made between universities, industries and cities.
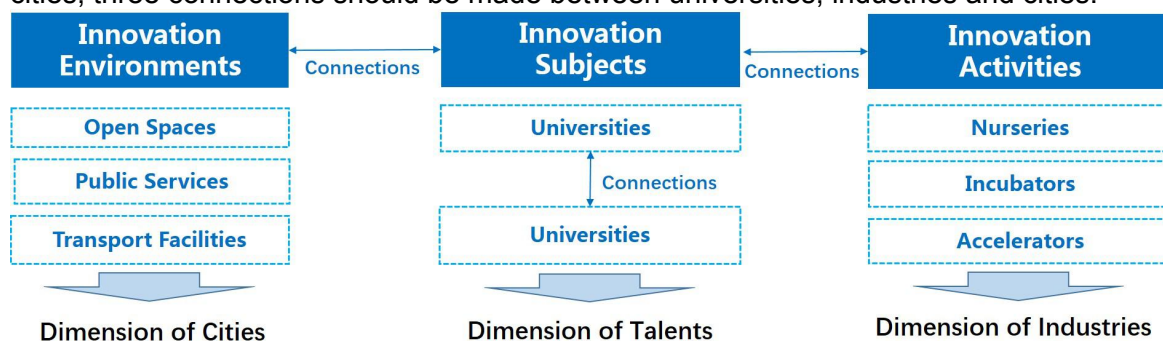

Innovation Environments		**Innovation Subjects**		**Innovation Activities**
	Connections		Connections	
Open Spaces		Universities		Nurseries
Public Services		Connections		Incubators
Transport Facilities		Universities		Accelerators
Dimension of Cities		Dimension of Talents		Dimension of Industries

Figure3:Analysis of the Spatial Elements of the "univercity"

4.1 Connecting universities with universities to make use of inner spaces
As the cradle to nurture innovative talents, universities as well as research institutes are in the upper stream of innovation chains, which supply the platform for building disciplines, undertaking research and promoting international academic cooperation. Therefore, adequate spaces should be provided by optimizing inner spaces of campuses to make close connections between universities. For example, residents for teachers and staff, dormitories, cafeterias as well as other logistic service spaces can gradually evacuate their functions out of campuses with the socialization reform of university, so as to provide spaces for key technology facilities and research platforms between universities. With the renovations of classroom, schoolhouses and warehouses, research functions could be added on. Meanwhile, the intensities and densities are encouraged to be improved when educational lands are transformed into key technological facilities so as to promote the intensive utilization of land use(see Figure 4).
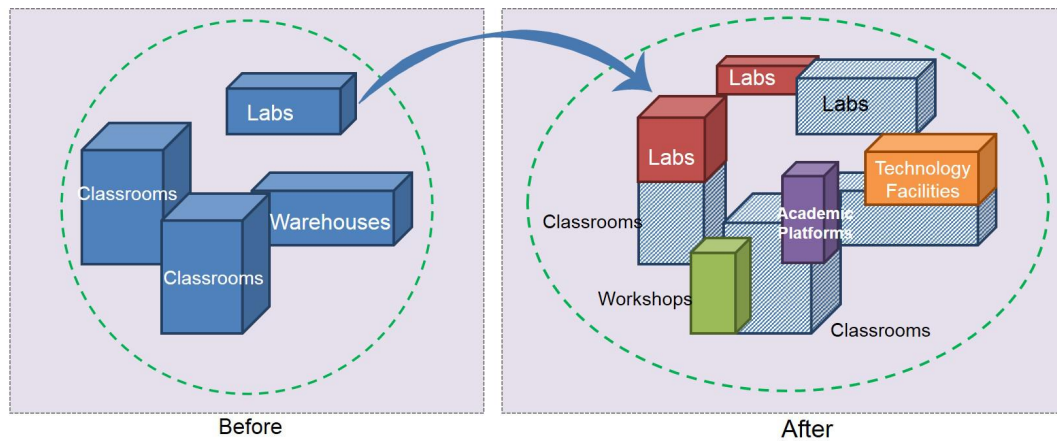
Figure4: Function Analysis of University Inner Spaces

To solve the problems of lacking platforms for key technological facilities such as laboratories, and research platforms in the core area of Wuhan "Univercity", it has been proposed to reconstruct the logistic service facilities with inefficient land use, which can be remade as national key technological facilities and academic platforms between universities. Besides, encouragement has also been proposed to make FAR rewards ranging from 1.1 to 1.2 so as to promote the reconstruction of inner spaces(see Figure 5).
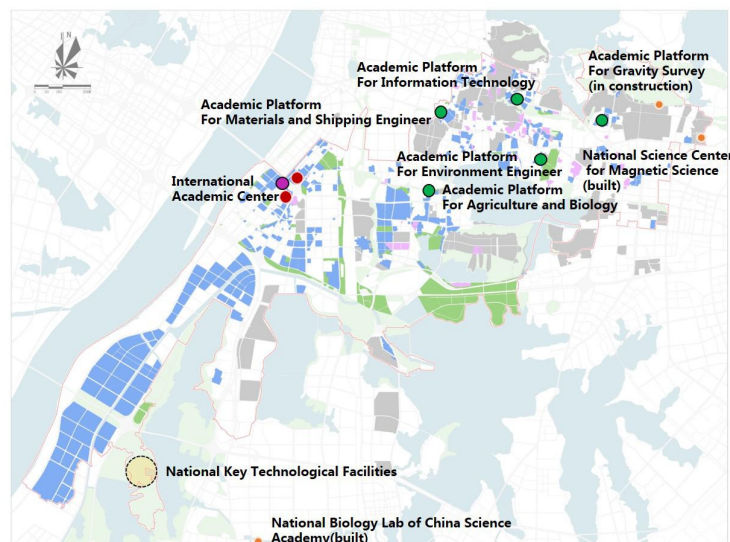
Figure5: Layouts of the Research Facilities in the Core Area of Wuhan "Univercity"

4.2 Connecting Universities with Industries to Set up the Whole Chain of Innovation

As the major physical spaces for innovation activities, incubators will play the determinant role of transforming educational resources into urban innovation competitiveness. Based on the key disciplines of universities and dominant industries of cities, corresponding innovation spaces will need to be provided to complete the whole chain of innovation.

Learning form experiences of innovation spaces home and abroad, it has been proposed that the whole chain of innovation including nurseries, incubators and accelerators needs to be built. On one hand, innovation nurseries especially for new-born start-ups are suggested to be located surrounding old residential areas, commercial facilities and offices, to which it will take 10 to 30 minutes from universities(see Figure 6). One the other hand, incubators for growing start-ups would be better to be located on the lands planned as industries and business with easy access. Accelerators for grown-up start-ups will be suggested to be located in industrial parks with abundant lands. Especially the scales and locations of

platforms for innovation activities should be regulated so provide sufficient physical spaces to start-ups(see Figure 7). For the universities with key disciplines of human and social sciences, facilities of culture innovation, creative productions, creative consumption and entertainments should also be established surrounding the current historical districts and open spaces(see Figure 8). Creative industry clusters neighboring universities will be formed so as to provide spaces for the conversion of human and social science to creative industries and also redefine the culture identities of cities.
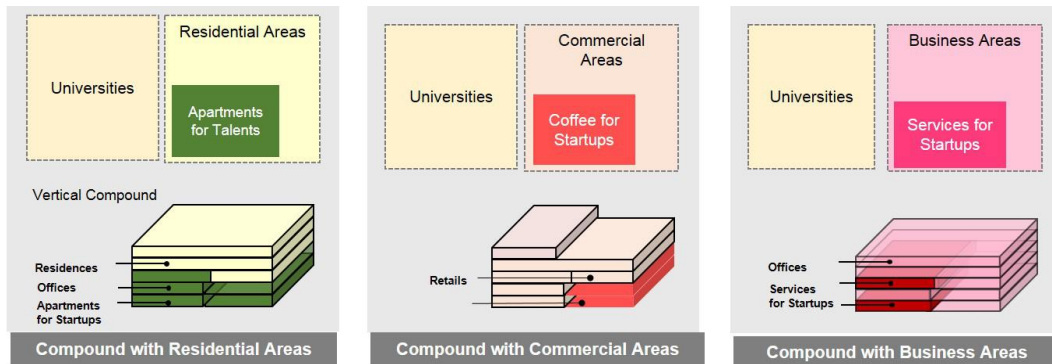
Figure6: Location Analysis of the Nurseries for New-born Start-ups
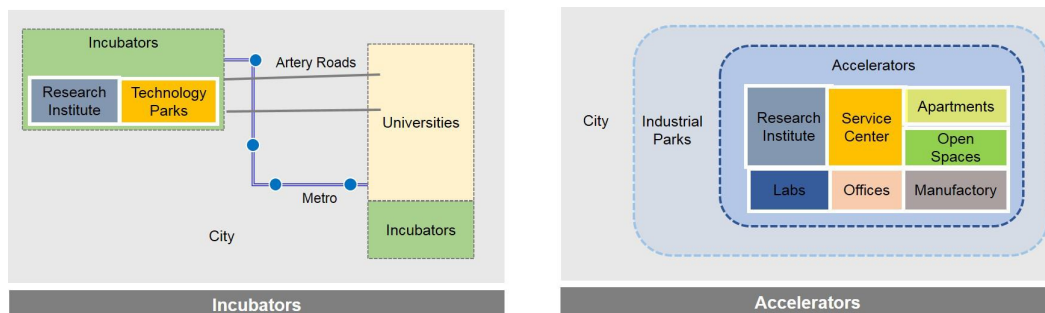
Figure7: Location Analysis of the Incubators and Accelerators
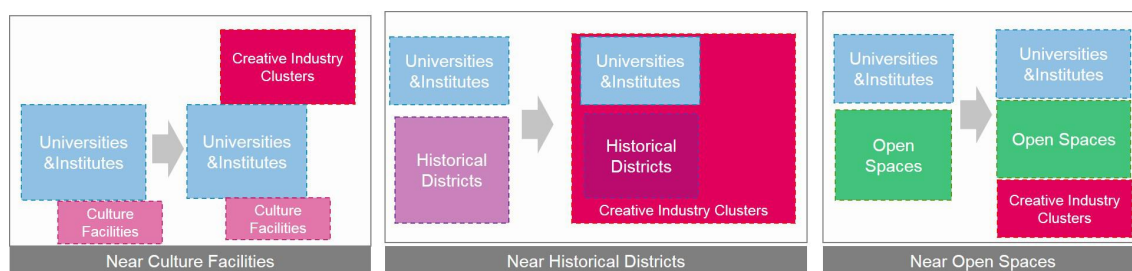
Figure8: Location Analysis of Creative Industry Clusters Surrounding Universities

Aiming at the problems of lacking research commercialization, innovation enterprises, job positions and venture capitals in the core area of Wuhan "Univercity", it has been proposed to layout the innovation spaces along with urban regeneration based on the key disciplines of universities and dominant industries of Wuhan. On one hand, nurseries for new born start-ups have been suggested to locate in old communities and factories neighboring universities. On the other hand, incubators for growing start-ups have been proposed to be located in areas with easy access of public transport. Also, accelerators for grown-up start-ups has been suggested to be locate in industrial parks with abundant land. Based on this, there will be a whole innovation chain from nursery, incubators and accelerators in accordance with the growth of start-ups from the north to the south and the east to the west(see Figure 9). Besides, seven creative industries districts and six innovation service centers has been

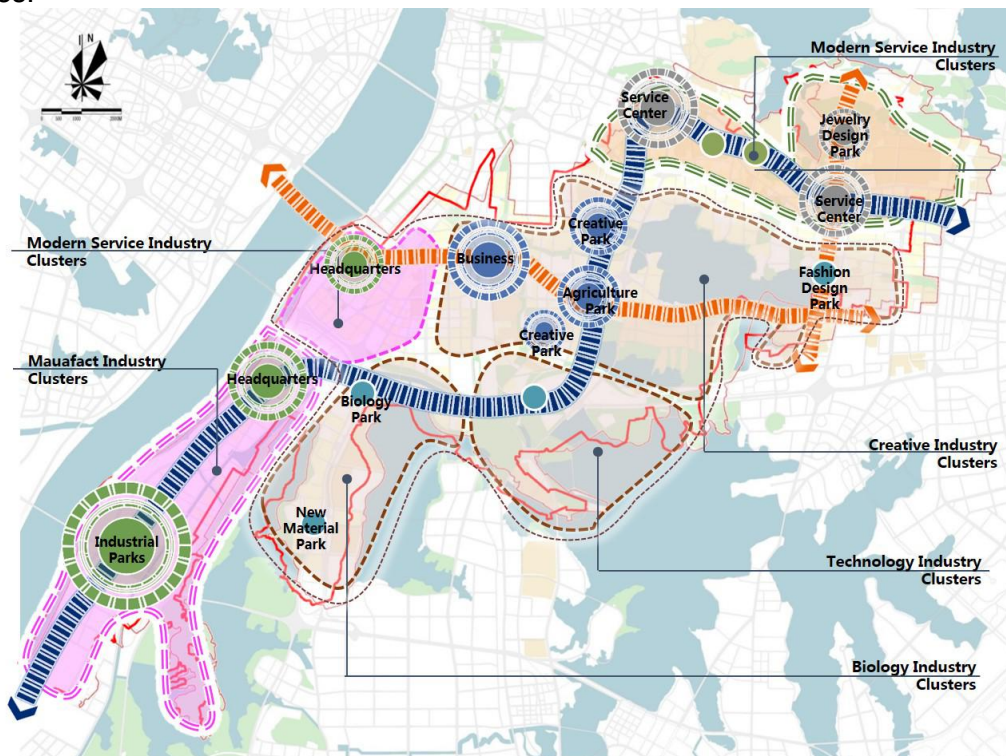proposed to be locate based on the social science and humanity disciplines and dominant industries.

Figure9: Layout of the Industries in the Core Area of Wuhan "Univercity"

4.3 Connecting Universities with Cities to Share Service Facilities

Connecting universities with cities to promote the sharing of public facilities, open spaces, roads and municipal facilities will not only improve the quality of urban environments but also increase the city competitiveness of innovation and attraction for talents.

4.3.1 Providing the sharing spaces of public services

On one hand, activities centers, libraries and gyms in universities have been encouraged to be gradually open to the public with all kinds of culture activities organized in the weekends or holidays to improve the efficiency of campus facilities. Meanwhile, some of university facilities with large scale, high qualities and good accesses located in the areas with a shortage of public facilities would be suggested to be regulated as urban public facilities with incentive mechanisms of co-management between universities and governments. Taking the core area of Wuhan "Univercity" as an example, it has been proposed that the sharing percentage of service facilities in universities should reach the goal of at least 70% in 2020 and 100% in 2030. Once the facilities have been shared with the public, 60% of the residential areas will be covered with an improvement of service efficiency as large as 8 times(see Figure 10). Besides, three gyms of universities have been chosen to be reconstructed and invested by governments and regulated as the land use of urban sports facilities so as to improve the efficiency of lands.
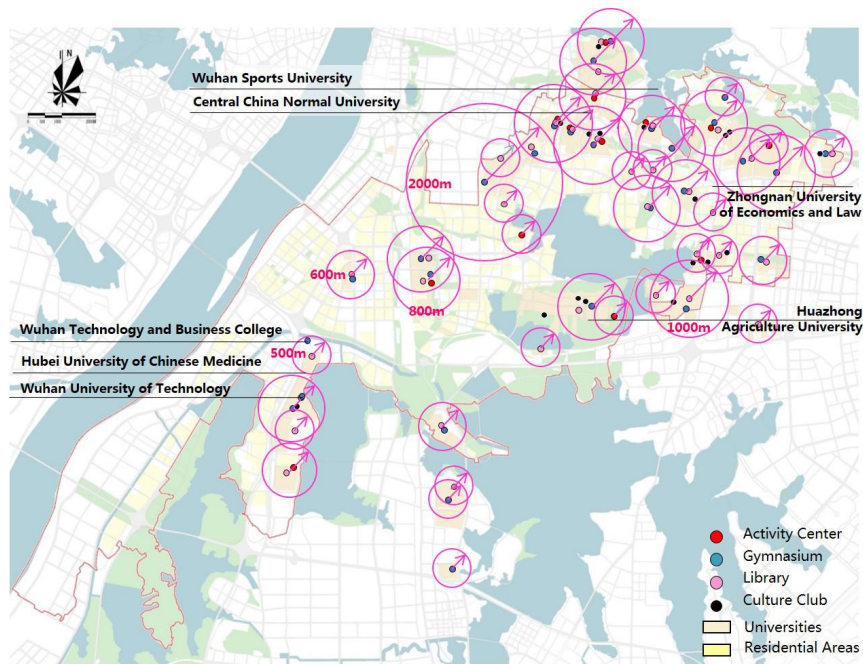
Figure10: Efficiency Analysis of the University Facilities in the Core Area of Wuhan "Univercity"

On the other hand, it has been proposed to focus on the features and provisions of service facilities according to the requirements of innovative talents. To meet the demands of college students, research service facilities which can provide functions including academic communications, talents apartments, retails, leisure, offices, exhibitions and sports have been proposed to be established in the built areas with low efficiency of land use surrounding universities. Not only the current public facilities have been proposed to be upgraded with corresponding incentive mechanism on land use and finance, but also high quality public facilities have been encouraged to supply with larger amounts(see Figure 11).
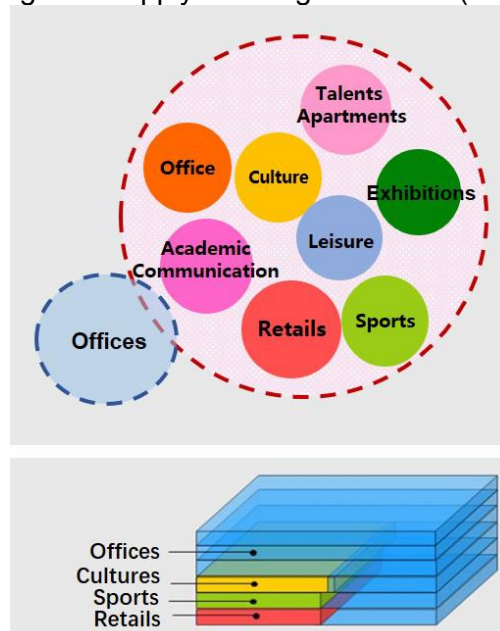
Figure11: Function Analysis of the Research Service Facilities in Universities

For the core area of Wuhan "Univercity" which can be divided into the upgraded district, the supplemented district and the new-built district according to the current public facilities, it has been proposed to build up six research service facilities including talent apartments and communication centers especially in the assembled areas of innovative talents, so as to

solve problems of the failure to meet the demands of talents(see Figure 12). Especially for the urban regeneration aiming at building research service facilities, policies have been proposed to give a reward of 1.1 to1.3 times FAR. Meanwhile, building standards of schools and hospitals have also proposed to be improved so as to establish a high quality living circle of facilities within 15 minutes' walk distance.
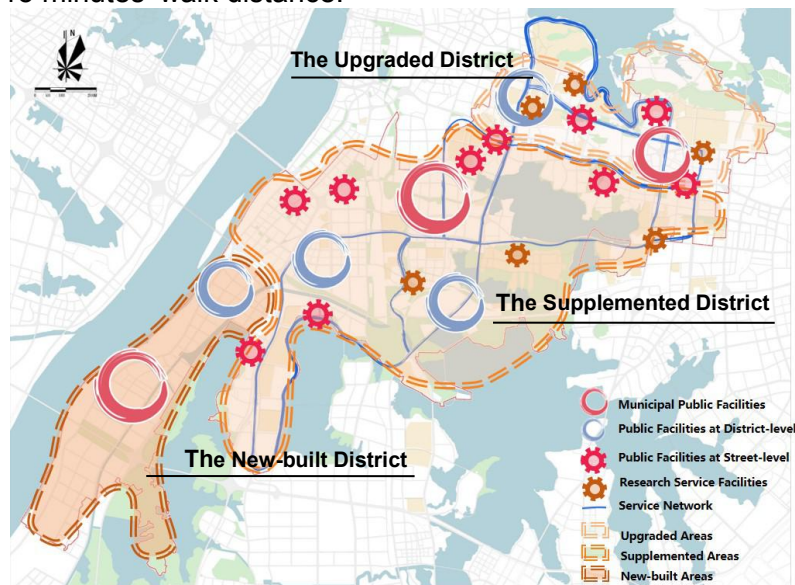

Figure12: Layout of the Public Facilities in the Core Area of Wuhan "Univercity"

4.3.2 Establishing a Green Network System of Transit

The historical spatial model of "Compound" has not only led to the isolation of network system but also urban diseases like failure of implementation. Therefore, campuses should be gradually opened without the influences on teaching and living activities in universities. Driveways should also be opened to the public with the slowing-down design so as to densify the networks and improve the efficiency (see Figure13). Besides, the system of public transport between universities including metros and buses has been proposed to be built to establish a special system of public transport door to door between universities (see Figure14).
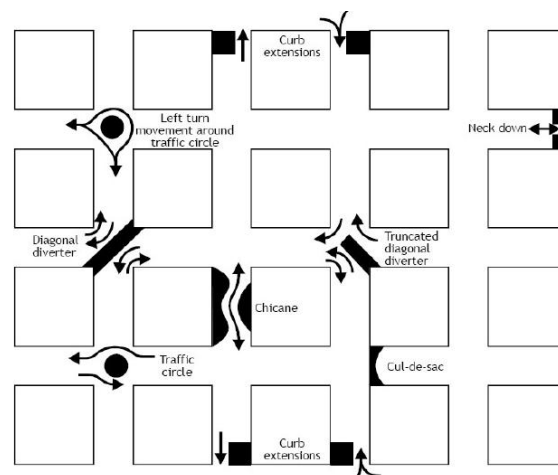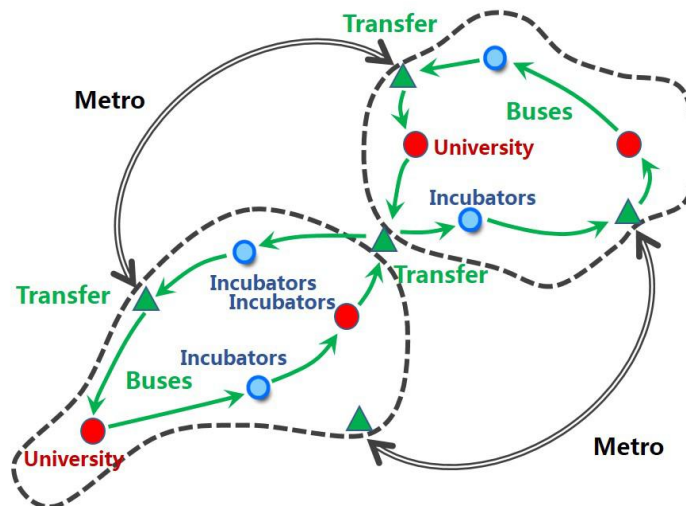

Figure13: Analysis of the Slowing-down Design

Figure14: Analysis of the public transport door to door between universities

Aiming at the problems including low densities of current networks, lack of minor roads and low efficiency of public transport, it has been proposed to add a new ring of metro surrounding the Wuhan "Univercity" and a special line of buses and water buses, so as to cover all the universities in the core area（see Figure 15）.
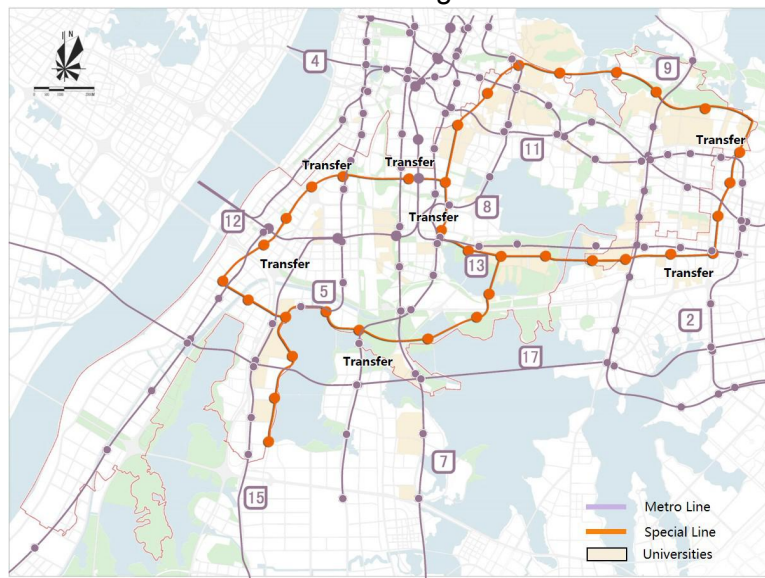

Figure15: Layout of the public transport in the Core Area of Wuhan "Univercity"

4.3.3 Establishing a Network of Open Spaces

Open spaces is not only the public domain for people to talk in informal ways but also the physical spaces to represent the image of the "univercity". On one hand, libraries, squares, green areas and sidewalks have been proposed to make full use of as the landscape node to present the natural and cultural image of universities. It has also been suggested that all kinds of college festivals should be planned and touring routes in campuses should be organized so as to promote the communications between universities and cities. On the other hand, pockets parks with scales ranging from 400 to 10000m^2 have also been proposed to be set around communities, universities, research facilities and other innovation spaces so as to provide spaces of informal communication for creative talents. Accordingly, green networks should be built surrounding mountains, lakes and universities so as to establish a system of landscape in and out of campuses and make the open spaces easy to access(see figure16).
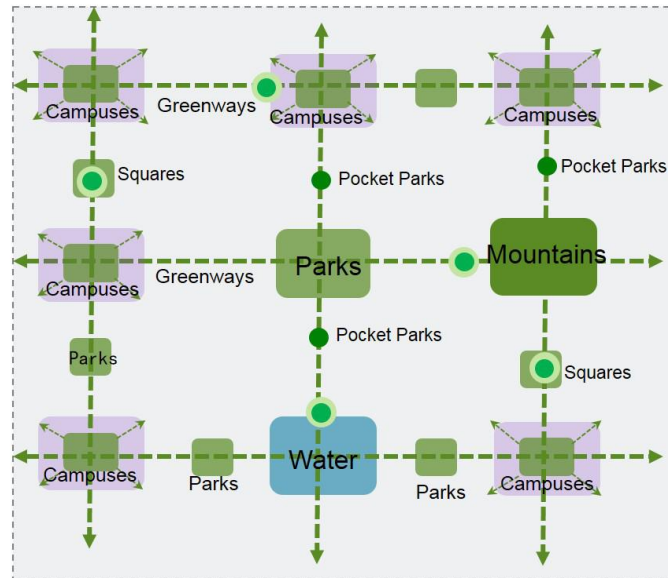
Figure16: Analysis of Open Spaces Network

To make full use of the nature landscape resources of the core area, it has been proposed to connect mountains with cities, link rivers with lakes and build water culture parks surrounding the six lakes, aiming at the problems of isolated landscape, insufficient green areas and obscure image identities(see Figure17). Surrounding universities, there will be loop of innovative culture and six identified areas with three featured touring routes as greenways along with mountains, lakes and universities, which will link the pocket gardens surrounding innovation spaces. Based on this, a network of ecology and culture to integrate cities, universities and nature landscapes will be built so as to rebuild the identities.
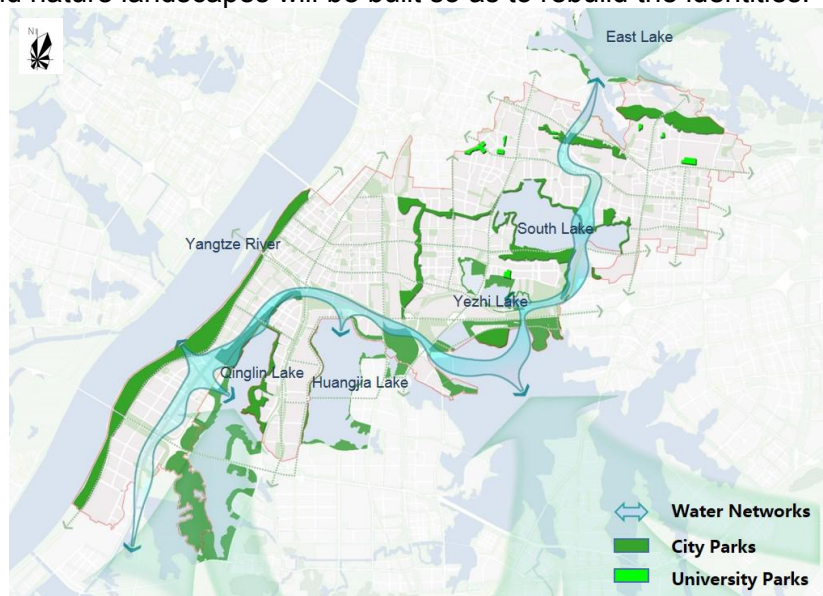

Figure17: Analysis of Open spaces in the Core Area of Wuhan "Univercity"

5. Conclusions

By comparing the historical experiences of universities reacting with cities home and abroad, this paper attempts to interpret the meaning of the "univercity" by both qualitative and quantitative methods, and discuss the spatial strategies by taking the core area of Wuhan "Univercity" as an example, so as to build theoretical and practical foundations for this topic.

One thing to be mentioned is that all the spatial elements of the "univercity" actually overlap each other, which may have been neglected in the discussion in order to analyze their spatial relations and layout requirements as well as define the spatial features. Therefore, it is suggested that a regulation system of indexes should be established especially for the "univercity". In this way, regulations for all the spatial elements of the "univercity" can be implemented in the statutory plans as well as master plans of universities so as to make guidance for environments building in and surrounding campuses. More importantly, the three aspects of the "univercity" do not only need physical spaces but also policies and systems. Therefore, more attention should be paid on the political innovation in the fields of land use, industries, talents, taxation, finance, research commercialization and intellectual property. It has been suggested to make further study on making land use policies and implementation measures as well as encouragement mechanism for sharing university facilities with the public. Influenced by the traditional ideologies, it is a long term process to make universities react with cities , but only the innovation of policy making would open the fences of ideologies.

Acknowledgements

Endnotes

[1]There are 37 universities, 17 national labs and 594 thousand undergraduates which take up 46%, 59% and 50% of the municipality accordingly in the core area of Wuhan "Univercity" scaled at 134.66 km^2.

[2]See:http://www.most.gov.cn/mostinfo/xinxifenlei/fgzc/gfxwj/gfxwj2016/201612/t20161213_129574.htm;

[3]See: http://www.gov.cn/zwgk/2013-03/04/content_2344891.htm;

[4]See: http://www.gov.cn/zhengce/content/2016-08/08/content_5098072.htm ;

[5]According to Philip Nicholas Cooke, the first, second and third spatial elements of innovation cities are universities, incubators and service facilities.

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