# Appendix

A.1 Theoretical Framework

City competitiveness is a city's capacity of constantly attracting, controlling and transforming resources, occupying and controlling the market, creating more value in a more efficient and faster manner, obtaining economic rent, thus continuously providing benefits for their residents by virtue of the external economic advantages and internal organizational efficiency developed based on its own elements and environment in the process of competition and development. Therefore, urban competitiveness is the city's ability of creating value currently and in the future. The current size, speed and efficiency of the city's value creation is the short-term reflection of its capacity, i.e., the output of urban competitiveness, which is urban economic competitiveness. The urban competitiveness is based on the elements and environment. The agglomeration of economic entities such as talents and enterprises constitutes the absolute advantage, comparative advantage and competitive advantage of the industrial system. The process of competing with other cities' industries and enterprises in obtaining the economic rent is the explanatory variable of urban competitiveness. The city's elements and environmental conditions determine the sustainability and long-term performance of the city's capacity which is the input of urban competitiveness, i.e., the sustainable competitiveness. Thus, we can construct the urban competitiveness model as follows: the sustainable competitiveness determines the urban economic competitiveness via the explanatory variable of economic competitiveness; in turn, the urban economic competitiveness affects the sustainable competitiveness via the explanatory variable of economic competitiveness.

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│              Urban value: economic competitiveness                │
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        ⇓                                                    ⇑
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│      Urban industrial quality: economic competitiveness explainable │
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        ⇓                                                    ⇑
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│     Urban elements and environment: sustainable competitiveness    │
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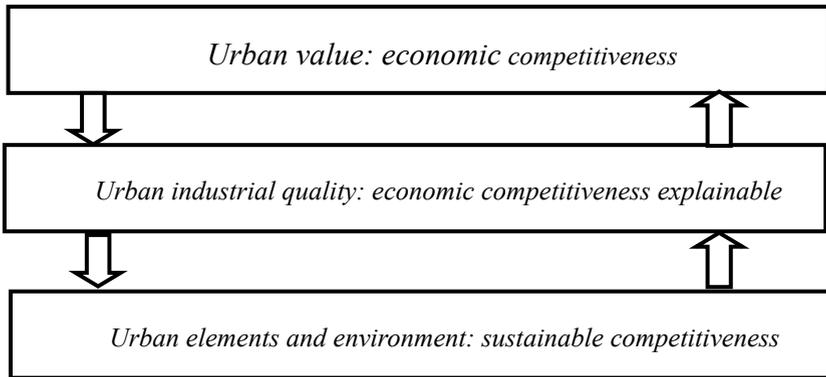
i. Economic competitiveness and its explanatory variable

Economic competitiveness is essentially the city's ability to create value and obtain economic rent. The capacity level is reflected by the city's competitive results in the current period, which is the output, current and short-term reflection of urban competitiveness. Economic competitiveness is mainly manifested as the comprehensive long-term growth of urban economy and the comprehensive economic efficiency, which are measured by the average increment of GDP for 5 consecutive years and the GDP per square kilometer of land. The urban economic competitiveness model is as follows:

$$\mathbf{EC = F(LI, EE)}$$

EC is the economic competitiveness. LI, comprehensive long-term increase: The ability, potentiality and sustainability of a city's attraction, occupation, competition, control of resources and market value creation are determined by the long-term growth of GDP. The average annual increment of GDP in 5 consecutive years is used as an indicator measuring the comprehensive long-term growth. EE, the comprehensive economic efficiency: The GDP per square kilometer land modified by per capita GDP is used as an indicator to measure the comprehensive economic efficiency. The GDP per square kilometer land reflects the city's capacity of wealth creation per unit space, and efficiency in obtaining economic rent and economic benefit as well as utilizing the land which is an important resource. The per capita GDP reflects the urban development level.

The process is that, the urban industrial system is turned into economic competitiveness, and in turn, the urban economic competitiveness affects the sustainable competitiveness through explanatory variables of economic competitiveness. The urban industrial system is the sum of industries, and the industry is the sum of enterprise entities. The economic activities of enterprises are ultimately carried out through labor and creation, so people and enterprises are the behavioral subjects in urban industrial system. Based on the above theoretical analysis, this paper constructs the following explanatory model of economic competitiveness:

$$EEC = F(FE, TI, IS, HR, LD, CC, SE, IN, LE, GC)$$

EEC is the explanatory variable result of economic competitiveness. FE, financial services: A city or area's capability and efficiency of mobilizing storage, absorbing and allocating capital is an important decisive variable for a new global city. TI, technology innovation: Technology innovation is an inexhaustible and ultimate motive force of the sustainable development of urban economy and society, and the basic decisive variable of new global city. IS, industrial system: The industrial quality and modernization of a city. HR, human resources: Human resources are the main body of wealth and value creation in a city. LD, local demand: It is the local market demand. CC, commercial cost: The time and cost and so forth required in the setting up, operation, trading activities, taxes paying, contracts closing and executing of an enterprise pursuant to policies and regulations. SE, system environment: The institutional rules and environment. IN, infrastructure: The status of local infrastructure. LE, living environment: Local living environment and safety situation. GC, global connection: It is the position and visibility of urban subjects in the global industrial system.
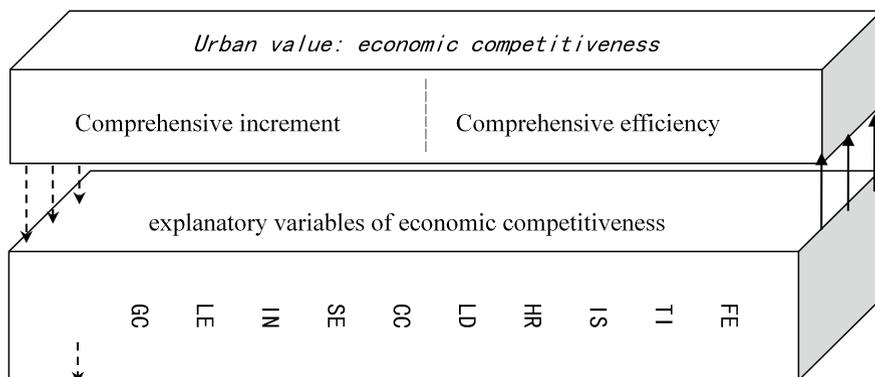

ii. Sustainable competitiveness

Urban sustainable competitiveness is essentially the conditions of a city's elements and environment. As the decisive factors in the process of urban development, the situation of a city's elements and environment has a decisive impact on the current and future development of the city. Thereby, urban sustainable competitiveness is the input, sustainable and long-term city competitiveness. According to the definition, economic competitiveness emphasizes the output while sustainable competitiveness emphasizes the input. Human capital, as the basic variable input in the city production, is a basic indicator measuring the sustainable competitiveness of the city, so we should use human capital density and increment to measure the sustainable competitiveness. Subject to the availability of international urban human capital data and the timeliness of the project, this report does not adopt human capital as a measure of sustainable competitiveness, but continues to

use explanatory variables of sustainable competitiveness for analysis. In the future, it is considered to make further analysis based on the size and increment of urban high-income population.

Based on previous studies, this paper builds a model of urban sustainable competitiveness with 8 explanatory variables:

$$SC = F(HRP, EV, TI, SI, EQ, CE, IN, GC)$$

SC is urban sustainable competitiveness. HRP, human capital potential: Different from human resources, the human capital potential represents the future situation of the city's human capital. EV, economic vitality: Economic vitality is the level and speed of local economic development, and it is an important manifestation of urban sustainable development capacity. TI, technology innovation: Technology innovation is an inexhaustible and ultimate motive force of the sustainable development of urban economy and society. SI, social inclusion: It reflects the city's social mobilization and integration capabilities. EQ, environmental quality: It is the result of the combined impact of local natural environment and social and economic development, reflecting the capacity and level of local sustainable development. BE, Business environment: Local institutions and policies have important influence on urban competitiveness and its supply of elements. IN, infrastructure: The condition of local infrastructure is the material base of urban sustainable development. GC, global connection: It is the position and visibility of a city in the global industrial system and reflects the city's status in the global urban system.
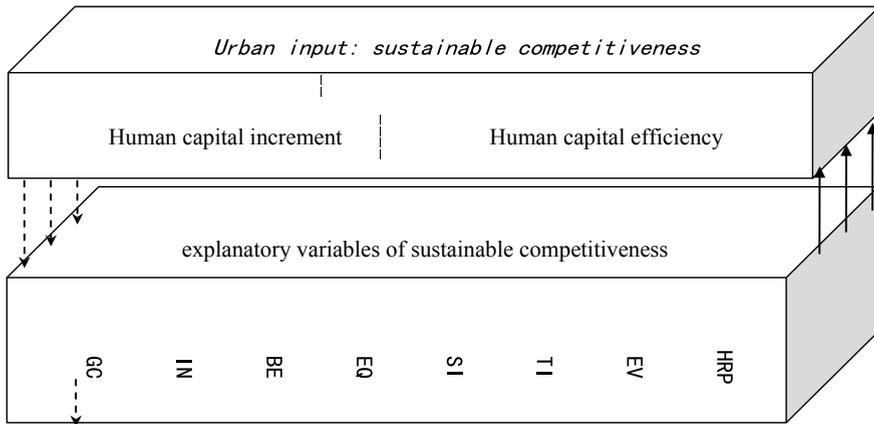
The above model takes the subject's quality as the center, internal and external links as the main line, the counterparty's institutions as the baisis and the subject's supply and demand as the content, and integrates multidimensional factors affecting the competitiveness: the subject and the environment, supply and demand, stock and increment, short term and long term, static and dynamic, software and hardware, internal and external.

A.2 Indicator System

i. The result-oriental index estimating system of global urban comprehensive economic competitiveness

Sub index	Index name	Data source
Revealed economic competitiveness	1.1 The five-year GDP increment	The Economist EIU database, 2016 base period
	1.2 GDP per square kilometer land	The data of urban area is collected by the research group, and the urban GDP data is from the Economist EIU database and modified by per capita GDP

ii. The result-oriental index estimating system of global urban comprehensive economic competitiveness

Sub index	Index name	Data source and calculation method
1. Financial services	1.1 Bank index	The data is from Forbes 2000 indexes and processed by weighted calculation
	1.2 Bank branch index	The data is from the World Bank WDI database and converted proportionally based on the urban population
	1.3 Index at the exchange	The distribution of global stock exchanges adopts weighted transaction size
2. Technological innovation	2.1 Patent index	The data is from the World Intellectual Property Organization (WIPO), which is the synthesis of the total number of historical patents and the number of patents in the year
	2.2 Paper index	The data is from Web of Science
3. Industry system	3.1 Index of productive services enterprise	The data is from Forbes 2000 indexes and processed by empowerment calculation
	3.2 Technology enterprise index	The data is from Forbes 2000 indexes and processed by empowerment calculation
4. Human capital	4.1 The population of labor force (15–59)	The Economist EIU database
	4.2 The proportion of young people	The proportion of the population aged 20–29 years to the total population, and the data is from the Economist EIU database
	4.3 University index	The data of the ranking of world universities is from Ranking Web of Universities

(continued)

Sub index	Index name	Data source and calculation method
5. Local demand	5.1 Total disposable income	The Economist EIU database
6. Business cost	6.1 Loan interest rate	The data is from the World Bank WDI database
	6.2 The proportion of tax revenue to GDP	The data is from the World Bank WDI database
	6.3 Per capita income/base price of hotel	The data of per capita income is from the Economist EIU database, and the data of basic hotel prices is from web crawler.
7. Institutional cost	7.1 Business facilitation	The data is from the World Bank's annual *Business Environment Report*
	7.2 Economic liberation degree	The economic liberation index released by the Wall Street Journal and The Heritage Foundation
8. Infrastructure	8.1 Convenience of shipping	The shortest earth surface distance from the city to the top 100 global ports
	8.2 Broadband subscriber volume	The data is from the World Bank WDI database and converted proportionally based on the population size
	8.3 The number of air routes and the distance from airports	The data is from the city airport websites, Wikipedia and the International Air Transport Association (IATA) (2016)
9. Living environment	9.1 PM2.5	The data is from WHO and the World Bank
	9.2 Crime rate	The data is from NUMBEO, and some Chinese urban data is the result of the regressive calculation of China's crime rate

iii. The index system of global urban sustainable competitiveness

Sub index	Index name	Data source and calculation method
1. Human capital	1.1 University index	The data is from Ranking Web of Universities, with the calculation method of adopting the ranking of the city's best university
	1.2 The proportion of young people aged 20–29	The Economist EIU database
2. Economic vitality	2.1 Per capita GDP (USD/person)	The Economist EIU database
	2.2 The average annual GDP increment of five years	The Economist EIU database
3. Technological innovation	3.1 Patent index	The data is from the World Intellectual Property Organization (WIPO), which is the synthesis of the total number of historical patents and the number of patents in the year
	3.2 Number of papers published	The data is from Web of Science

(continued)

Sub index	Index name	Data source and calculation method
4. Social inclusion	4.1 Crime rate	The data is from NUMBEO, and some Chinese urban data is the proportional conversion result
	4.2 Gini coefficient	The data is from the Economist EIU database, which is calculated
5. Environmental quality	5.1 Per capita CO_2 emission	The data is from the World Bank WDI database and converted proportionally based on the urban population
	5.2 PM2.5	The data is from WHO and the World Bank
6. Business environment	6.1 Business environment index	The data is from the World Bank's annual *Business Environment Report*
	6.2 Economic liberation degree	The economic liberation index released by the Wall Street Journal and The Heritage Foundation
7. Infrastructure	7.1 Convenience of shipping	The shortest earth surface distance from the city to the top 100 global ports
	7.2 Broadband subscriber volume	The data is from the World Bank WDI database and converted proportionally based on the urban population
	7.3 The number of air routes	The data is from the city airport websites, Wikipedia and the International Air Transport Association (IATA) (2016)
8. Global connection	8.1 The connection degree of transnational corporations	The data is from Forbes 2000 companies, and the calculation method is in *WORLD CITY NETWORK*
	8.2 Global visibility	The number of searches of the city in GOOGLE is obtained through web crawler

A.3 Sample Selection and Stratification

i. **Definition of city**

A city is usually a residential area with a high degree of urbanization. However, there are different definitions and scopes for city in different countries. The "city" in the report refers to the aggregation region with the central city as the core which radiates to the surrounding area. It is clear from this definition that the cities herein are cities in the sense of metropolis rather than administration. It should be noted that, in the research process, for some cities, only statistics at the administrative

level are available (such as most sample cities in China). We have made special notes for the related cities, but the other cities are ones in the sense of metropolis.

ii. **City samples**

Secondly, we should select cities for urban competitiveness assessment. The universality and typicality of the samples are related to the accuracy and value of the research conclusions. This report, according to the *World Urbanization Prospects* released by Department of Economic and Social Affairs of the United Nations in 2015, selects global cities with the population above 500,000 as samples, and based on China's urban situation, a total of 1035 sample cities around the world have been selected. From the view of spatial distribution, the 1035 cities are from 136 countries or regions of 6 continents, specifically, including 585 Asian cities, 130 European cities, 135 North American cities, 103 African cities, 75 South American cities, and 7 Oceanian cities. The 1035 cities basically represent the status of cities in different regions and at different levels. For the specific 1035 sample cities, see Chapter One. It is noteworthy that, GDP per square kilometer is adopted in measuring economic competitiveness, the selection criteria of which are more stringent, and due to its availability and accuracy, only 1007 cities are selected for the economic competitiveness model and ranking.

iii. **Sample stratification**

Global city, also known as the world-class city, refers to the city that directly affects global affairs at the social, economic, cultural or political levels and is the center of global economic system or the organizational node of global urban network. These nodes of different grades, capacities and connection degrees are aggregated into a multi-polarization and multi-level global urban network system. The existing researches generally classify the world cities through a single indicator from the perspective of urban function and value system. However, it is not comprehensive to analyze global cities through a single indicator, instead, we should proceed from the dimensions of population, space, network, etc. to identify the accurate position of a city in the global urban network. According to study, the competitiveness consists of such four aspects as elements, industries, functions, and value, among which, the value is a more general standard. Therefore, this study proceeds from the perspective of value, based on the revealed comprehensive economic competitiveness index, includes elements of urban agglomeration degree and connection degree, adopts the method of cluster analysis, preliminarily classifies global cities into the four levels of A, B, C and D. Furthermore, the levels of A, B and C are divided into three sections respectively. In total, there are ten sections at four levels. The specific division can be found in global urban comprehensive competitiveness index table in Chapter One.

iv. **Data source**

The study of global urban competitiveness is a research project which requires high quality and quantity of data. The data collection team of the research group has started work from last July, organized the translation of data in English, French,

German, Spanish, Portuguese, Italian, Arabic, Russian, Japanese, Korean, etc., and established the collection team to collect data from official statistical publications, official network, academic researches and other channels. In this process, many foreign scholars and research institutions, as well as students studying abroad have offered great help. After nearly half a year of repeated searches and sorting, a fairly ideal index coverage is achieved. In view of countries' difference in data standards, we first study the statistics projects and standards of the United Nations Statistical Distribution (UNSD), the World Development Indicators of the World Bank, the OECD database and others, in combination with the actual situation of the countries, establish appropriate statistical standards with the strongest comparability and the widest coverage to apply in data collection and data processing, eventually forming a unified database covering 1035 global cities. The index data used in this international urban competitiveness index system mainly has four sources, i.e., the governmental statistical institutes of various countries; international statistical institutes; thematic reports and survey data of international research institutions or companies; big data obtained through web crawlers. For specific data sources and index interpretation, please refer to the GUCP database.

Nevertheless, due to subjective and objective restrictions, some exceptional cities are cast aside and some important indicators are adjusted or removed, which has left regret to this research and is hoped to be resolved in the future.

A.4 Calculation Method

i. Standardization method of index data

The dimension of the index data of urban competitiveness is different. First, we should conduct dimensionless processing of all index data. Objective indicators can be divided into single objective index and comprehensive objective index. For the dimensionless processing of single objective index data, this paper mainly adopts four methods: standardization, indexation, thresholding, and percentage ranking.

The standardization formula is: $X_i = \frac{(x_i - \bar{x})}{Q^2}$, X_i is the converted value of x_i, x_i is the original data, $\bar{x}$ is the average value, Q^2 is the square deviation, X_i is the data after standardization.

The indexation formula is: $X_i = \frac{x_i}{x_{0i}}$, X_i is the converted value of x_i, x_i is the original value, x_{0i} is the maximum value, X_i is the index.

The thresholding formula is: $X_i = \frac{(x_i - x_{Min})}{(x_{Max} - x_{Min})}$, X_i is the converted value of x_i, x_i is the original value, x_{Max} the maximum sample value, x_{Min} is the minimum sample value.

The percentage ranking formula is: $X_i = \frac{n_i}{(n_i + N_i)}$, X_i is the converted value of x_i, x_i is the original value, n_i is the number of samples with value smaller than x_i, N_i is the number of samples with value larger than or equal to x_i excluding x_i.

To sum up, the dimensionless processing of original data of objective index is: First quantize each component indicator, then take equal weight method to conclude the comprehensive index value through weighting.

 ii. The method of measuring urban competitiveness

1. Comprehensive economic efficiency

The calculation method of comprehensive economic efficiency (GDP per square kilometer land weighted by per capita GDP) is a nonlinear weighted synthesis method. The so-called nonlinear weighted synthesis method (or multiplicative synthesis) refers to the application of the nonlinear model $g = \prod x_j^{w_j}$ for comprehensive evaluation. In the formula, w_i is the weight coefficient, and $x_i \geq 1$. For nonlinear models, when one indicator value is very small, the final value will be approaching zero. In other words, the evaluation model is sensitive to indicators with small value but unresponsive to indicators with large value. When measuring urban competitiveness with the nonlinear weighted synthesis method, it can reflect the overall index value more comprehensively and scientifically.

2. The calculation methods for economic competitiveness, explanatory variables of economic competitiveness, and sustainable competitiveness

Although the explanatory urban competitiveness index is designed as a grade-two index in the report, in fact, both the original index and the explanatory urban competitiveness index are at grade three. When synthesizing grade-three index into grade-two index and grade-two index into grade-one index, the method of standardization followed by equal weight addition is adopted. The standardization method is as mentioned before. The formula is:

$$z_{il} = \sum_j z_{ilj}$$

Specifically, z_{il} represents the grade-two index and z_{ilj} represents the grade-two index.

$$Z_i = \sum_l z_{il}$$

Specifically, Z_i represents the grade-one index and z_{il} represents the grade-two index.

A.5 Special Explanation

Urban competitiveness is a profound and complicated theme, and different nichetargeting conclusions can be drawn on different research objects through different methods and from different perspectives. The global urban competitiveness assessment system is developed based on the research model of Dr. Ni Pengfei's *Report on China's Urban Competitiveness*, in combination with the latest trend of global city development and multiple factors affecting urban competitiveness as well as the research on national competitiveness and urban competitiveness by other organizations in the world, and integrating urbanization, urban economics, spatial economics and other theories. The analysis framework and main thinking of competitiveness in this book are in line with the ideas in the *Report on China's Urban Competitiveness*, and there are also many references in the setting of index system. However, because of the change in research object, research theme and targeted readers, as well as various subjective and objective restrictions in the process of data collection, some updating and adjustment are made in the book's competitiveness assessment system and measurement methods compared with the *Report on China's Urban Competitiveness*. For academic prudence, the results of the index system and main conclusions in this book is not directly comparable with Report on China's Urban Competitiveness, and we suggest that readers will regard the two as the measure of urban competitiveness from different perspectives and levels.

A.6 1007 cities more than 10 competitive explanations variable index and ranking

Detailed data information found in http://www.gucp.org and https://cn.unhabitat.org.

Postscript

"Global Urban Competitiveness Report 2017–2018" by Professor Ni Pengfei (**National Academy of Economic Strategy, CASS**) and Marco Kamiya (UN-HABITAT), dozens of international and domestic well-known universities, authoritative statistical departments, corporate R&D institutions of nearly 100 experts to participate, After more than a year, the theory and investigation, measurement and case studies and other empirical research results. The basic theory, index system, research framework and important conclusions of the Global Urban Competitiveness Report 2017–2018 are mainly made by Dr. Ni Pengfei and Marco Kamiya. Deputy editor Wang Haibo (**National Academy of Economic Strategy**, Chinese Academy of Social Sciences) is responsible for reporting data collection, specific calculation, data collection, coordination and scheduling work.

With regard to urban competitiveness, this report divides it into two parts: economic competitiveness and sustainable competitiveness, and designs the index system respectively. The economic competitiveness of 1007 cities in the world and the sustainable competitiveness of 1035 cities are carried out and measured. This report, based on the relationship between global urban competitiveness and house prices, has written a thematic report named by "house prices, changing the city world". The manuscript of the report is written by the author after the theory of tempering, collecting the data, measuring and drawing the basic conclusion.

The contribution of each chapter is: Chapter 1: Annual ranking of general global urban competitiveness in 2017–2018, The whole group; Chapter 2: Global Urban Competitiveness of the overall report, Pengfei Ni, Marco Kamiya, Li Shen (Graduate School of the CASS), Weijing Gong (CASS) , Haidong Xu (Graduate School of the CASS); Chapter 3: City housing prices and competitiveness: Research Background and Literature Review, Pengfei Ni, Yangzi Zhang (Graduate School of the CASS); Chapter 4: The Relationship between Housing Prices and Urban Competitiveness: A Theoretical Framework, Qingfeng Cao (Tianjin University of Finance and Economics); Chapter 5: Global Urban Real Estate Market Status, Hongyu Guo (China Foreign Affairs University); Chapter 6: Relationship between the Housing Price and Competitiveness :Empirical analysis,

Haidong Xu, HaiboWang; Chapter 7: City story: House Prices and Competitiveness, 7.1 Silicon Valley: Desen Lin (University of Pennsylvania), Andrew Renninger (University of Pennsylvania), Aidan T. Thornton (Ernst & Young U.S., LLP), Susan M. Wachter (University of Pennsylvania), Zhihua Zeng (World Bank), 7.2 Pittsburgh: Peter Karl Kresh (Bucknell University), 7.3 Singapore: Yangzi Zhang (China Everbright Group Postdoctoral Workstation), 7.4 Melbourne: SunSheng Han (University of Melbourne), 7.5 Tokyo: Erbiao Dai (Asian Economic Growth Research Institute, Japan), 7.6 Guangzhou: Jian Qin (Guangzhou Academy of Social Sciences), 7.7 Taipei: Chu-Chia Lin (National Chengchi University), 7.8 Foshan: Geng Xiao (University of Hongkong), Wenzhi LU (Hong Kong University of Science and Technology), 7.9 Madrdi: Paloma Taltavull de La Paz (University of Alicante, Spain), 7.10 Lima: Marco Kamiya, Oswaldo Molina (Universidad del Pacífico, Lima), 7.11 Buenos Aires: Cynthia Goythia (Torcuato Di Tella University); Chapter 8: Economic Foundations for Sustainable Urbanization: The link with Competitiveness, Marco Kamiya, Loeiz Bourdic (UN-Habitat); Chapter 9: Global urban comprehensive economic competitiveness report 2017–2018, Bo Li (Tianjin University of Technology), Xiaonan Liu (Graduate School of the CASS); Chapter 10: Global urban Sustainable Competitiveness report 2017–2018, Yufei Wang (Beijing University of Posts and Telecommunications), Xiaobo Zhou (China Everbright Group Postdoctoral Workstation), Jie Wei (China Northwest University); Appendix: Pengfei Ni, Haibo Wang.

"Global Urban Competitiveness Report 2017–2018" and the study of global urban competitiveness have been reported by consultants and many institutions and individuals with sincere and unselfish support. We express our admiration, respect and thanks for all the support and care of this research unit and person.

Ni Pengfei, Marco Kamiya
October 24, 2017