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Research Project

Megacities: Comparative analysis of urban macrosystems.

Unraveling Chinese urban population. A discussion on the six largest settlements.

Igor CERSOSIMO



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Megacities: Comparative analysis of urban macrosystems

Unraveling Chinese urban population. A discussion on the six largest settlements

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Research Project *Megacities: Comparative analysis of urban macrosystems*

By 2020, there will be an estimated 38 megacities on this planet, with a combined population of approximately 685 million people. Compared to 2010, this constitutes an addition of 12 urban agglomeration with populations over 10 million, and a 50% increase in the total population of such megacities. The majority of the world's current and future megacities are in developing regions of the world, particularly in Asia. The development challenges that these megacities face in an era of climate change are immense.

In spite of their huge populations, the multi-jurisdictional governance structures of megacities have thwarted comparative study and understanding of these urban regions. The resource flows into megacities, and the wastes produced, likely have environmental impacts on a planetary scale. Unlike nations, however, the quantification of resource and waste flows associated with these massive urban regions is rarely undertaken. Lack of such data on the world's megacities may significantly hamper policy development; therefore, research seeking to understand the sustainable development of megacities is critical.

The research project has two main objectives, to be addressed in two phases:

1. Conduct urban metabolism (UM) studies of 10 to 15 of the world's current megacities, collecting data on a small number of UM parameters, specifically energy (all sources), water, materials and waste flows. From such data it will be possible to identify a set of general biophysical characteristics that are independent of the specific urban system, and that can be used to compare megacities (one example of a biophysical characteristic is population density, which is known to impact among others, transportation energy use). In conducting the UM studies, particular focus will be given to the role of utilities (electricity, natural gas, water, etc.), and how they can affect the urban metabolism.
2. Conduct more detailed analysis of the UM of 3–5 megacities, including extension to appropriate socio-economic sustainability indicators. For these more detailed UM studies, the research can then develop scenarios of sustainable urban evolution, as well as outlining a more general roadmap to sustainable urban development. In this second phase, the objective is to extend the analysis beyond the biophysical UM to include measures of quality of life and other social indicators. The scenarios will then assess the future role of utilities in megacities looking, for example, at how integrated infrastructure solutions, electric mobility and energy efficiency can impact the UM and quality of life in megacities.

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Abstract

The data on Chinese urban cities are notoriously affected by a series of statistical problems. These problems are the result of the repeated changes to statistical procedures over time and of the difficulties arising from a complex administrative system. This article discusses the real urban population of the six largest urban settlements in China, using the most recent census data and comparing them with statistical definitions established in scientific literature and with information deduced from satellite images. The article also uses the history of cities and recent information on their climate and economic structure to draw short profiles to guide and support further scientific investigations.

Keywords: *urban metabolism, megacity, energy, statistics*

Jel Codes: *Q4, L94, L95, L98*

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Introduction

In 2011, for the first time in the country's long history, more than half of China's population was residing in urban areas. This is the result of a stunning growth of the urban population, unprecedented in the history of mankind. China hosts nowadays some of the largest cities in the world and the growth of the urban population, together with some of these cities, still continues at a steady rate.

Urbanization in China started around 3600 years ago. According to some studies, the country was in fact one of the first areas in the world to experience the development of urban settlements (Murowchick and Cohen, 2001; Wheatley, 1971). However, during the long course of the imperial period, Chinese urban population remained very small, both in absolute and in relative terms. In 1949 China's urban population was only 57 million, around 10% of the total. It is only with the foundation of People's Republic of China that the urban population started growing, to accommodate the needs of the industrial and economic development.

More precisely, after a period of extremely fast growth, in the first years of the republican era, the urban population stopped growing and stagnated for almost two decades, because of political factors and economic instability. After Mao's death, Deng Xiaoping took the power and started a series of economic reforms, opening the country to foreign capital and market economy (with Chinese characteristics), stimulating the final phase of the urbanization process that still continues today. Since 1979, the urban population of China grew from 163 million (17.4% of the total) to almost 700 million in 2012 (data of the National Bureau of Statistics of China – NBSC).

Despite this result, Chinese leaders still consider China under-urbanized when compared to the group of developed countries. Several references to a new series of policies to promote urbanization have been made over the last years and the topic is always very present in the political debate.

During the 18th Communist Party congress, in November 2012, President Hu Jintao noticed how the urbanization process continued steadily during his mandate. Nonetheless, he mentioned urbanization as one of the goals for the future development of the country.

The choice of words in the presidential speech reflected a change of perspective in the political plans for urbanization. The urbanization process was in fact referred to as 城镇化 (chéngzhènhuà), instead of the usual 城市化 (chéngshìhuà). While both terms can be correctly translated as "urbanization", the traditional one contains the word 城市 (chéngshì), which typically indicates big cities, and the new one 城镇 (chéngzhèn) that is used for small/medium size cities³.

³ The full version of Hu Jintao's report is available at http://www.xj.xinhuanet.com/2012-11/19/c_113722546.htm

Former President Hu also mentioned the intention to promote scientific planning of urban structure and dimension, to foster the industrial development of small and medium size cities (城镇 – chéngzhèn) and to improve their capability of providing services to attract larger share of the population.

The new generation of leaders confirmed Hu Jintao's plans. The new premier, Li Ke-qiang, has been particularly keen in announcing urbanization plans and is sometimes considered to be the one who framed the new vision for urban development. According to Premier Li, urbanization is an inevitable trend, fundamental for the economic growth and the development of the country, capable of fostering consumption and investments and creating new job opportunities. In an article recently published on Financial Times⁴, Li explains that China's urbanization rate, just above 50%, is still low compared to more developed countries, where the average rate is around 80%. Following common development laws, he expects 100 million people to be absorbed into urban areas in the next ten years.

In March 2014, media announced the new long term plan for urban development, containing the details of Premier Li's vision and the policies for the next future. The document contains some reforms to support urbanization, improve cities sustainability (reducing the consumption of energy and resources) and social equity (in particular by extending the rights of migrant population)⁵.

⁴ Financial Times, September 8th 2013: "China will stay the course on sustainable growth".

<http://www.ft.com/cms/s/0/03377ccc-16e0-11e3-9ec2-00144feabdc0.html>

⁵ http://news.xinhuanet.com/english/china/2014-03/17/c_133192830.htm

1 The dimension of China's urban population – Statistical issues

The correct dimension of Chinese urban population, for the whole country as much as for single cities, has always been an enigma (Orleans and Burnham, 1984). The reasons include the complex administrative division of the country and the modification of statistical practices over time, often changed to accommodate political needs more than to provide high quality information.

The issue has received thorough attention from scientific literature (see for instance Chan, 2007; Kamal-Chaoui et al., 2009; Zhou and Ma, 2005). These studies point out how the statistical definitions of urban population and of city have been changed repeatedly over time; furthermore, they notice the impact of the complex administrative system on the urban population totals.

Some of the existing inconsistencies, however, have a direct impact on the analysis of large Chinese urban settlements. Besides the obvious importance of the correct population accounting for the calculation of all per-capita values, the total population is often a decisive criterion for including or excluding cities in a certain group or study. For instance, letting aside other social and economic considerations, cities are defined as “megacities” when the total population is above the 10 million threshold and even this simple criterion can lead to drastically different results when incorrectly applied to Chinese urban settlements. As a matter of fact, the number of Chinese megacities itself can change, from a minimum of four to a maximum of eight, depending on the way urban population is calculated. A first major complication for calculating the exact urban population of Chinese cities emerges from the administrative division of the territory and the way statistical data are aggregated according to this division. The system is extremely complex and

includes several exceptions and various types of special administrative or autonomous areas. For the purposes of a research focused on (mega) cities, the most important elements of the division are (source NBSC):

1. The country is divided into provinces, autonomous regions and municipalities (Beijing, Shanghai, Chongqing and Tianjin) directly under the central government;
2. Provinces and autonomous regions are divided into prefectures, counties, and cities;
3. Prefectures are divided into counties and cities;
4. Municipalities and large cities are divided into districts and counties.

It is already evident how cities appear at every level of this administrative division. The situation is further complicated by the fact that all cities are referred to as *shì* (市, which, in fact, means city) both in common language and in the statistical publications, no matter the level in which they appear. The four municipalities are indicated as *shì* (市) as well.

Additionally, it is often the case that the whole prefecture/county, surrounding the city, falls under the administrative control of the city itself, and the level of the city is upgraded to prefecture-level or county-level. In these cases, both the real urban settlement and the whole prefecture/county are indicated as *shì* (市) and they both share the same name, even if the larger territory typically includes other urban settlements and counties with different names.

An example can help clarifying this issue. The province of Shandong contains several prefectures and cities. One of these is the prefecture-level city of Jinan. Jinan *shì* (济宁市 – literally “city of Jinan”) is an urban settlement *per se*, but the same name Jinan *shì* is used in official statistical publications to indi-

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cate the whole prefecture under Jining jurisdiction, making it easy (and very common) to misread the data. The real city of Jining has a population of 1.2 million, while the whole prefecture counts 8 million people. The whole prefecture, in fact, contains 3 county-level cities and 7 counties. One of the county-level cities, Yanzhou, is a city of 600,000 people. Notably, Yanzhou is indicated as *shì* (市), as much as the whole county under its jurisdiction which contains large rural areas and even other smaller towns. As a matter of fact, then, Yanzhou replicates the same type of data aggregation of Jining, at a lower administrative level.

Focusing on the largest cities of the country, they all include urban districts, but most of them include also counties or other cities:

- the municipality of Beijing includes 2 counties;
- the municipality of Shanghai includes 1 county;
- the municipality of Chongqing includes 17 counties, plus four autonomous counties;
- the municipality of Tianjin includes 3 counties;

- guangzhou includes 2 smaller cities;
- shenzhen, Wuhan and Dongguan do not include any county and are composed only of actual urban districts (Dongguan, in particular, by a single district).

It should be noted, though, that urban districts are sometimes similar to counties and can contain, far away from the urban core, rural areas and villages. As a result, the statistics for the population of a typical Chinese city normally include a share of urban population which is living in different urban settlements and even a part of population which is not urban (both in terms of living environment and of lifestyle). The disaggregation of data is left to readers and is frequently not straightforward.

Figure 1 offers a graphical representation of the complex territorial division of a Chinese city and shows how some urban settlements can appear far away from the real urban core, while still belonging to the same statistical aggregate.

FIGURE 1 – Administrative division of a Chinese city and urban statistical areas



Source: Chan, 2007

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A second major problem is that two ways of measuring the urban population are commonly used in China. One is based on the actual number of people living in a place for a certain period of time (*de facto* population), the other one is based on the information on the residence contained in the official residence certificate, called *hukou*, which every Chinese has since birth (*de jure* population). The *hukou* binds people's residence to their birthplace and can be modified only in limited cases. The statistical effect is that the population measured using the *hukou* ignores the large number of migrant workers that live in big cities without an official residence (Chan, 2007; Zhu, 2007). As shown in Table 1, the difference can be extremely significant.

Finally, the definitions of city and of urban population have been repeatedly modified over the last decades (every census so far used different definitions).

Limiting the analysis to the last available data, it should be noted that recent surveys significantly improve the quality of data and of statistical practices. It is now usually possible to deduce the population of the core urban center, at least for the most important cities. Nonetheless, the aggregation remains misleading and incorrect information is frequently used. The following Table 1 reconstructs the *de facto* urban population living in the city districts (as in Chan, 2007) of the main Chinese cities in 2010, using data from the last national census of the population carried out by the National Bureau of Statistics of China. The table also includes the population calculated using different criteria, as reference. The column in red contains the data that better represent the real dimension of the city, while the other columns refer to the *hukou* registrations or include separate urban/rural areas controlled by the main city.

TABLE 1 – Data of the 2010 national census (NSBC), personal elaboration of the author based on the indications of Chan (2007). The second part of this article will give further details on the 6 largest cities and argue that, in some cases, even this stricter definition of urban population can be referred to a settlement larger than the actual urban core and, therefore, potentially inadequate.

| | Whole Region | | | City Districts Only | | | Urban Pop. in City Districts to Region Total Pop. Ratio |
|-----------|------------------|------------------|------------------|---------------------|-------------------|------------------|---|
| | Total Population | Urban Population | Hukou Population | Total Population | Urban Population | Hukou Population | |
| Shanghai | 23,019,196 | 20,555,098 | 14,185,160 | 22,315,474 | 20,217,748 | 13,493,127 | 88% |
| Beijing | 19,612,368 | 16,858,692 | 12,554,049 | 18,827,262 | 16,446,857 | 11,845,658 | 84% |
| Chongqing | 28,846,170 | 15,295,803 | 33,149,845 | 15,693,490 | 10,778,685 | 15,612,594 | 37% |
| Shenzhen | 10,358,381 | 10,358,381 | 2,510,145 | 10,358,381 | 10,358,381 | 2,510,145 | 100% |
| Guangzhou | 12,701,948 | 10,641,408 | 8,077,303 | 11,071,424 | 9,702,144 | 6,670,098 | 76% |
| Tianjin | 12,938,693 | 10,277,893 | 9,919,579 | 11,090,783 | 9,562,255 | 8,156,160 | 74% |
| Wuhan | 9,785,388 | 7,541,527 | 8,383,650 | 9,785,388 | 7,541,527 | 8,383,650 | 77% |
| Dongguan | 8,220,207 | 7,271,322 | 1,854,215 | 8,220,207 | 7,271,322 | 1,854,215 | 88% |
| Chengdu | 14,047,625 | 9,237,015 | 11,426,983 | 7,415,590 | 6,316,922 | 5,156,886 | 45% |
| Nanjing | 8,003,744 | 6,238,186 | 6,364,200 | 7,165,292 | 5,827,888 | 5,516,185 | 73% |
| Shenyang | 8,106,171 | 6,247,700 | 7,183,908 | 6,255,921 | 5,718,232 | 5,173,739 | 71% |
| Xian | 8,467,838 | 5,842,704 | 7,732,794 | 6,501,190 | 5,206,253 | 5,573,914 | 61% |
| Harbin | 10,635,971 | 6,501,848 | 9,964,761 | 5,878,939 | 4,933,054 | 4,770,538 | 46% |

Source: Own elaboration

According to this re-calculation of the population, four cities are above the 10 million threshold and two more cities are just below.

Except for Shenzhen, where the entire population is actually urban and living inside the city districts, the other cities have a significant part of the population living outside the core urban settlement and often in rural areas. The most extreme case is Chongqing, a municipality large approximately like Austria (82.000 Km²), which is commonly referred to as a 30 million people city (Davidson, 2005), but where the actual urban population is instead far smaller. Even considering only Chongqing's urban population, around one third (5 million people) lives in cities different from the real Chongqing, but belonging to the same administrative entity.

Using this last definition of urban population, the city of Chongqing still has a structure that includes several centers far away (some extremely far) from the original core, while still being considered as urban districts. As a result, even the 10.8 million people population can be considered inappropriate (further details on Chongqing and on the other

main cities will be given later in this paper).

Disaggregated data are now available for the population, and it is therefore possible focusing on the "real" urban settlement. The situation is not equally good for all the data of interest for urban metabolism analysis. Energy and water consumption data, material flows etc. are typically available only as aggregate for the whole administrative division, which implies large shares of non-urban population and vast agricultural areas are included in the analysis. The problem should be properly addressed in order to ensure comparability of results with other cities around the world.

A possible solution could be to re-calculate the real consumption values of the urban core using per-capita values obtained from the original data. The result is not predictable, as rural areas will be characterized by very different consumption patterns. It is critical, anyway, to associate every data to the exact area or population to which it refers to avoid seriously misleading interpretations.

The following section contains brief profiles of the main cities and their characteristics.

2 Shanghai

Despite some statistical inconsistencies (with the case of Chongqing), Shanghai is today the largest city in China by population. It is located on the delta of the Yangze River and so “on top of the sea” (a possible explanation for its name that has exactly that meaning).

The city developed from a fishermen’s village, around 1000 years ago, into an active commercial city. The city was quickly promoted to county seat, but then was maintained to this administrative status even in front of an economic power and importance that had grown far beyond county level.

By the beginning of the 18th century, in fact, the city was already the major trade port of the region, attracting the interest of foreign countries. After the Opium War, British, French and Americans established their concessions in the city (but outside the walled area), where they could trade with local businessmen. The foreign community grew significantly and, despite representing a small part of total population, built an international settlement controlled mostly by British through the Shanghai Municipal Council and finally got control over most of the whole city.

Japanese joined the other foreign communities by the end of the 19th century, after the First Sino-Japanese War, and contributed to the growth of the city by starting its industrial development. The importance of the city as industrial and financial center grew even further and the city got upgraded to municipality (a status that conserves today) in 1927. In the following years, Shanghai suffered the effect of the second Sino-Japanese war. The city was attacked a first time in 1932 and then conquered in 1937, including the international settlement a few years later.

After the foundation of People’s Republic of China,

the city lived 30 years of relative decline. National policies promoted the industrial development of internal regions, less exposed to possible attacks from foreign countries (Mao’s “third front” policy). The policies of that period, moreover, were generally characterized by a negative attitude against big cities, especially of the coastal regions, example of capitalism and consumption (Bernstein, 1977). Even during the first years of the Deng Xiaoping leadership, when national policies started to openly favor coastal regions, the city suffered the lag of opening reforms when compared to southern cities like Guangzhou and the emerging Shenzhen.

The final push to the city’s growth came at the end of the 80’s with a series of reforms that reduced local taxation and promoted investment in the city’s economy. The city started a rapid growth that led it to become an international industrial, commercial, and financial center of primary importance.

Shanghai is today one of the richest cities in China, with a per capita GDP in 2010 of 76000 RMB (9300 Euro at September 2013 exchange rate). The economy is strongly service oriented (around 60% of the local GDP), while industry generates 39% of the GDP and primary industry is marginal (below 1%), but still employs around 370,000 workers.

Climate

Shanghai is characterized by a subtropical climate, humid and influenced by Asian monsoon. Autumn is relatively dry while the rest of the year is humid with frequent precipitations. Summer is generally hot while winters are chilly and occasionally cold.

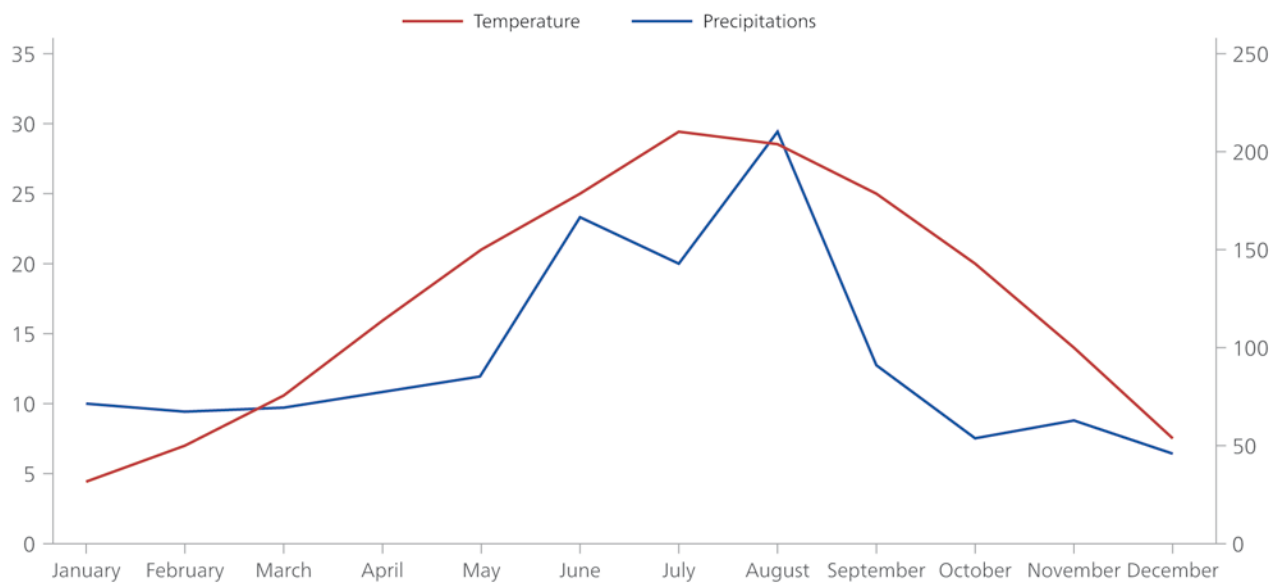
Notably, despite rather cold winter temperatures, Shanghai administratively belongs to the south of

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China and has to respect the national regulation according to which no central heating is provided to buildings in the south of the country (as it is considered an unnecessary waste of energy). Most people

provide with personal home appliances (warm air conditioning systems, electrical stoves and blankets...) with obvious impact on electricity consumption.

FIGURE 2 – Shanghai's temperature (Celsius degrees) and precipitations (mm). Monthly average data for the period 2000-2011.



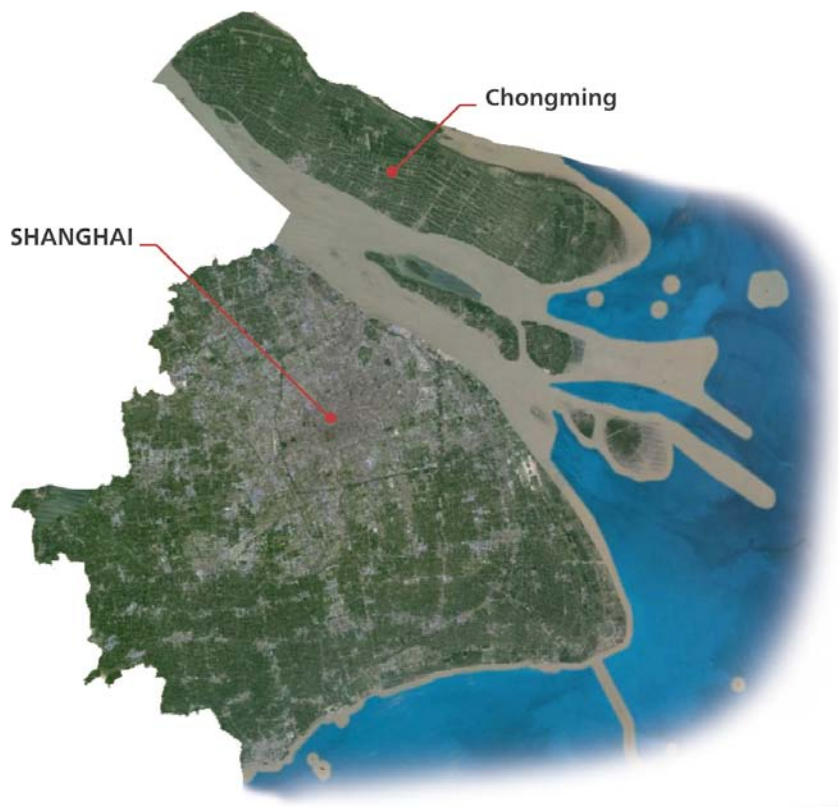
Source: Personal elaboration of the author on NBSC data

Data availability and aggregation

The municipality includes a significant share of rural population (even inside the city districts) and a county, which population is predominantly rural. The only county is Chongming, a large island located north of the urban core with a population of around

700,000, 48% of which urban. Central districts of the city are completely urbanized, while the peri-urban area alternates rural agricultural zones to larger settlements. The map, however, does not show clearly visible discontinuities in the built-up area.

FIGURE 3 – Satellite view of the whole municipality of Shanghai.



Source: Personal elaboration of the author of a snapshot from Google Earth software

Information and data on Shanghai are generally just sufficient, in terms of availability, quality and disaggregation. The Local branch of NBSC publishes a statistical yearbook for the city. However, the impact of the large rural population on statistical data is unclear. Moreover, the city of Shanghai has been recently pushing against disaggregating data, to avoid competition among urban districts⁶. The main

effect is that GDP data are only available as aggregate and other indicators are likely to undergo a similar censoring.

There is no specific urban metabolism study on the city available in English. Some partial studies are available on energy and water. In Chinese, no research exists on urban metabolism, while there are a few ones on energy consumption.

⁶ <http://news.sina.com.cn/c/2005-04-07/13335585184s.shtml>

3 Beijing

Beijing's history goes back around 3000 years and during its past the city has always been a major political, cultural and economic center for the whole country. Since 1949, with the foundation of People's Republic of China, the city was declared by Chairman Mao capital of the Republic, a role that the city had played several times in the past. Mao also reinstated the name of the city to Beijing (literally "Capital of the North"), which had been changed repeatedly over history.

The first archeological traces are from the 11th century B.C. and refer to the city state of Ji, located within modern Beijing. The city was an important stop in the north-south trading routes.

Over the first centuries of the imperial era, Beijing was only a prefecture capital, used to control the north of the country, while the national capital was located elsewhere. The city was made national capital for the first time in 352 AD, but soon lost this position.

During the long series of political struggles of the period, Beijing was a peripheral center of secondary relevance, but its importance grew after the invasion by the Mongolian nomadic tribe of Khitan that started the Liao dynasty and made Beijing a secondary capital (with the name Nanjing) in 938. The city experienced about 200 years of economic and population growth, ended by the Jurchens (a Manchurian nomadic tribe) invasion. The same Jurchens later founded the Jin dynasty, that few decades later moved their capital to Beijing (the first time for one of the major dynasties), renaming it Zhongdu. Once again, after a period (60 years) of rapid expansion, Beijing was center of the political turmoil and suffered the invasion and devastations carried on by the Mongolian tribes led by Genghis Khan. Later, in the second half of 13th century, Kublai Khan re-

stored Beijing as capital of the empire (with name Dadu) and founded there the Yuan dynasty.

With the beginning of the Ming dynasty, the capital of the country was moved away again, to modern Nanjing, but Beijing quickly regained its central position with the rise to power of Yongle, third emperor of the Ming dynasty. Emperor Yongle named the city Beijing (for the first time) and started the construction of several of the city's landmarks (the Forbidden City, Tiananmen Square and the Temple of Heaven). The following dynasty, the Qing, confirmed Beijing's status of capital and also maintained most of its urban structure.

The Qing army was defeated during the Second Opium War, in 1860, and foreign powers gained the right to a stable diplomatic presence in the city. The foreign presence and influence in the city grew even more a few decades later, after the unsuccessful Boxer Rebellion.

During the period of wars in the first half of 20th century, after the end of the Imperial era, Beijing lost its role of capital to Nanjing and Chongqing, interrupting a period of rapid growth and modernization, influenced by foreign presence. The city then fell under the attack of Japanese forces, during the Second Sino-Japanese War, but luckily without suffering major destructions.

After the end of the civil war and the foundation of People's Republic of China, Beijing was reassigned its actual name (that had shifted to Beiping in the last period) and its role as national capital. As the capital of the new Republic, the city's development was pushed forward by the central government, even in spite of the comparative advantage and the favorable location of other major cities. A rapid industrial development took place, with the establishment of several factories in the inner part of the city.

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With the beginning of the reform period, Beijing saw the first forms of market economy, including the development of a land market that later pushed the economic development of the city.

Since the establishment of a market economy, Beijing has experienced an extraordinary economic growth, has been growing steadily and underwent a rapid modernization. In 2008, Beijing hosted the summer Olympic Games, an event that helped pushing further economic and infrastructural development.

Beijing's per capita GDP in 2010 was 74000 RMB (9000 Euro at September 2013 exchange rate), a bit lower than Shanghai's one. The city has been constantly deindustrializing over the years and services now generate more than 76% of the local GDP. Industry accounts for most of the remaining part of

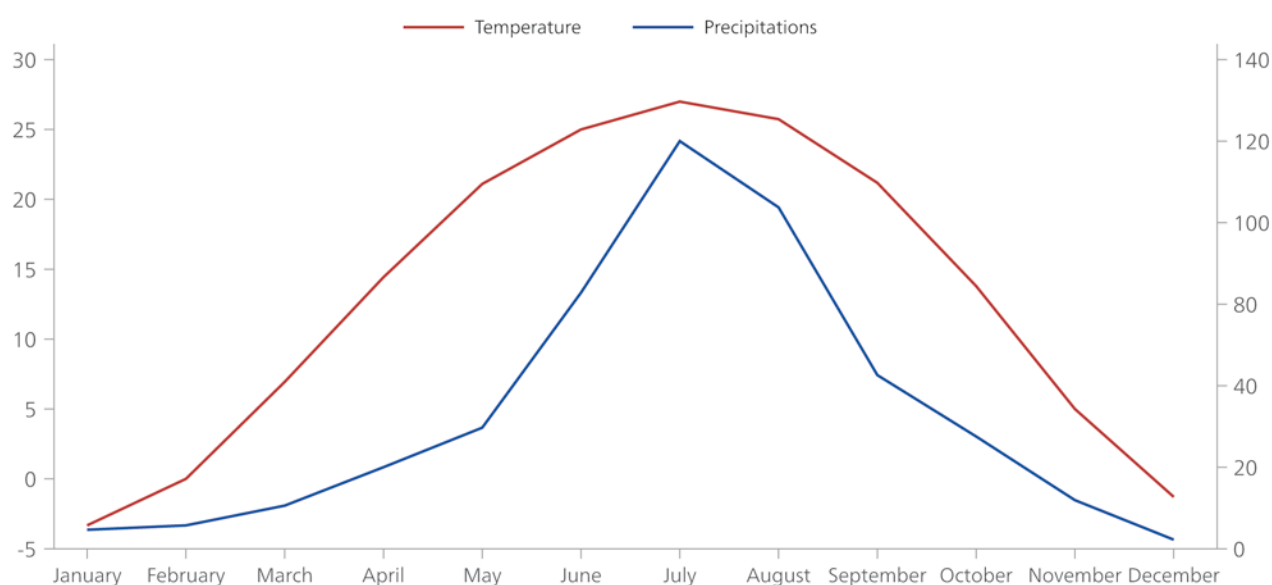
the GDP, while agriculture is below 1%, but employs more than 5% of the working population.

Climate

The city has a generally dry climate, partially influenced by the Asian monsoon. Summers are hot and humid, while the rest of the year can be extremely dry. Winter is typically very cold, with minimum temperatures easily below -15 degrees and strong wind. Spring and autumn are temperate and dry.

During spring, the city is sometimes subject to sandstorms because of the strong winds blowing from the North West desertic areas. As shown in Figure 4, precipitations are very limited and concentrated in summer.

FIGURE 4 – Beijing's temperature (Celsius degrees) and precipitations (mm). Monthly average data for the period 2000-2011.



Source: Personal elaboration of the author on NBSC data

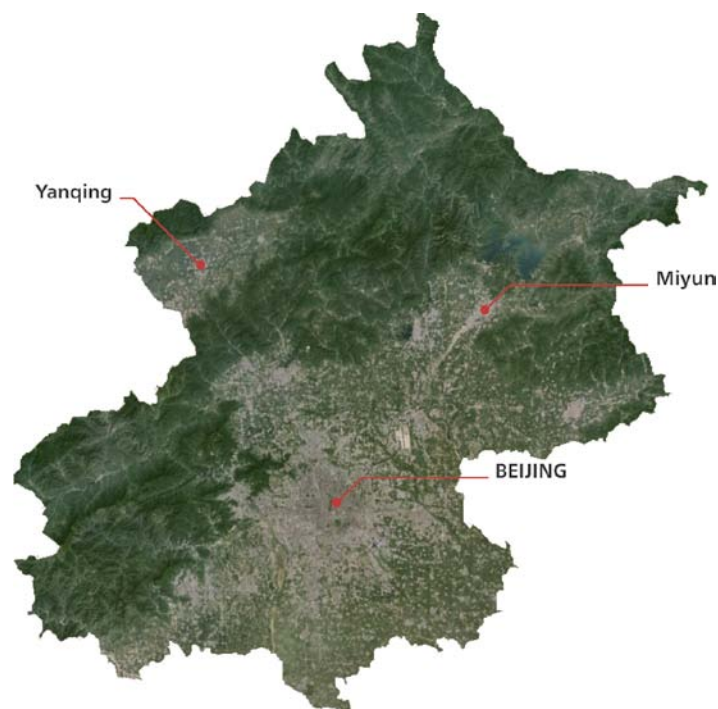
Data availability and aggregation

Like Shanghai, Beijing has the administrative status of municipality under direct control of the government. The administered territory is around 16.500 km² large and includes vast rural areas.

Two counties fall under the jurisdiction of the local

government: Yanqing and Miyun (see Figure 5). The first one is located North West of the center, separated by a clear discontinuity of the built-up area. The second one stands North East, after a rather smooth transition from the central Beijing, and has a special importance for the city, since it hosts its main water reservoir.

FIGURE 5 – Satellite view of the whole municipality of Shanghai.



Source: Personal elaboration of the author of a snapshot from Google Earth software

While there is no doubt about Beijing being a megacity, the statistics of the population still present some aspects worth considering. The official population of the municipality in 2010 was 19.6 million, but the number includes a significative share of rural population, around 2.8 million, most of which living inside the urban districts (2.4 million). The proper urban population of the city, then, amounts to 16.9 million, 84% of the total.

Information and data on Beijing are generally just sufficient, in terms of availability, quality and disaggregation. The Local branch of NBSC publishes a

statistical yearbook for the city. However, local statistical yearbooks do not guarantee a proper disaggregation of the data for all the variables of interest. Water consumption, in particular, seems to be available only as aggregate for the whole municipality. Energy consumption is available for single districts, but still includes non-urban population consumption.

In Chinese, the number of studies on urban metabolism is very limited, while there are more on energy and water consumption.

4 Chongqing

Some historical documents indicate that the city was established and made capital of the Ba Kingdom (with the name of Jiangzhou) around 3000 years ago. Through its history, Chongqing has always been an important political center, for the region and for the whole country. After Opium war, the city became also an important commercial center and started developing a dynamic manufacturing industry, mainly active in textile production.

During the wartime period of the 20th century, the city acted as provisional capital of the country and the economic structure of the city was highly influenced by military factories and heavy industry. The economy was thriving and the city became both the most important manufacturing and financial center of China.

During the early 60's, Chongqing's development was pushed forward by Mao's "third front" policy, which favored industrial development of the internal regions at the expense of coastal areas, more vulnerable to attacks in case of a possible international war. During these years, tens of factories were moved to the area from other cities, including Beijing and Shanghai, and the city saw a rapid economic and urban growth.

Over time, some of the military factories established in the previous decades were turned to civil use, which contributed to restructuring local industry, and maintaining its strength, when the post Maoist reforms started to favor the development of coastal areas.

Two decades after the beginning of the opening reform period, the development of western regions returned to be a priority of the central go-

vernment and Chongqing took advantage from being the political center of the area. In 1997, Chongqing status was raised with the creation of the only municipality under direct control of the government of the inner China, and the city officially took the leading role in the coordination of economic development projects for the region, including the massive project for the construction of the Three Gorges Dam.

Nowadays, Chongqing's industrial system is still dynamic, focused on production for internal consumption more than for export (due to its position) and makes the city one of the most important centers for metal processing, automotive and chemical production.

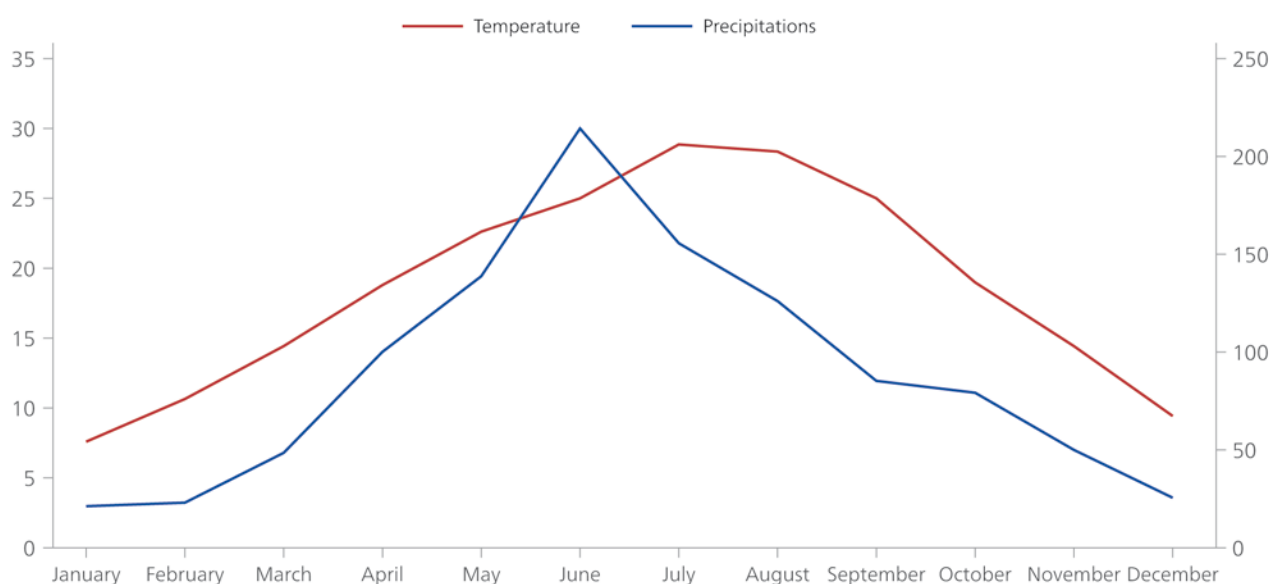
Considering the whole municipality, in 2010 secondary industry generates 55% of local GDP, while services are responsible for 36.5%. The remaining 8.5% comes from primary industry, a percentage extremely high for a modern city. It is worth noting that primary industry still employs above 40% of the working population, for a total of more than 6 million people.

Climate

Chongqing has a subtropical climate, very humid and influenced by monsoon. Summers are very hot and humid, while winters are generally temperate with limited precipitations. The city is famous also for its frequent thick fog and for its limited amount of annual sunshine hours, less than half of Beijing which is more than 1000 km north.

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FIGURE 6 – Chongqing's temperature (Celsius degrees) and precipitations (mm). Monthly average data for the period 2000-2011.



Source: Personal elaboration of the author on NSBC data

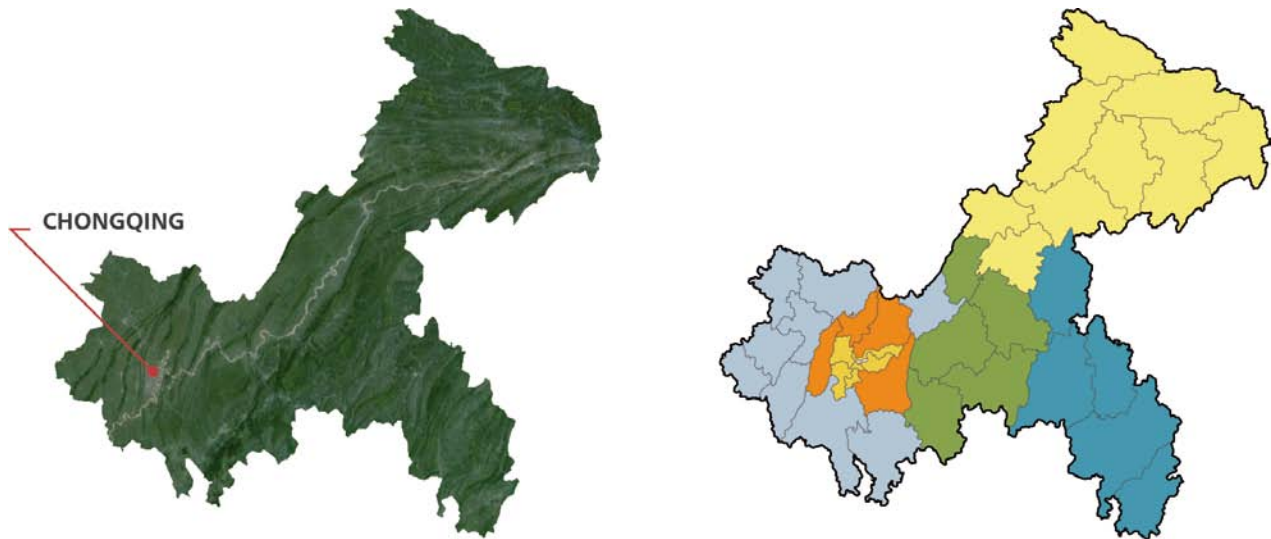
Data availability and aggregation

The correct accounting of Chongqing's population is particularly problematic. The whole municipality covers an area comparable to that of Austria, large part of which is scarcely populated or rural, with a predominance of agricultural activities, thanks also to the high productivity of the land.

The whole municipality hosts a total of around 29 million people (data NSBC). This number is often mistaken for the population of the city of Chongqing, a confusion that arises from the statistical practices described above. The disaggregation of the data shows that considering only the urban districts, the total population goes down to 15.7 million and almost 5 million of these are considered rural population. The remaining 10.8 million would position the city above the 10 million threshold, but a deeper analysis of the city structure leads to consider even this number as an overstatement (author's elaboration of NSBC data).

Despite this final amount being calculated according to a more strict interpretation of statistical urban population data, it still seems incorrect to describe Chongqing's reality, especially with the purpose of an analysis of urban metabolism. The true Chongqing is in fact significantly smaller than the one resulting from the simple accounting of urban districts. Some of these districts are mainly rural and present urban settlements located far away from the main core of the city, with visible large discontinuities of the built-up area. Figure 7 shows a comparison between a satellite image of the whole province and a map of the administrative divisions of the territory; the yellow and the pink parts together indicate the actual Chongqing city. This last area is visible in the following Figure 8.

FIGURE 7 – Satellite view of the whole municipality of Chongqing and map of the administrative divisions.



Source: Satellite image is a personal elaboration of the author of a snapshot from Google Earth software; the map is modified from original image available on Wikipedia

FIGURE 8 – Satellite view of the Central Chongqing area and its nearest districts. The picture shows large rural areas and clear discontinuities between the main agglomerates.



Source: Personal elaboration of the author of a snapshot from Google Earth software

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The aggregate population of the area is around 8 million, 6.5 of which urban (author's elaboration of NSBC data). The evident discontinuities between this urban area and other settlement suggest considering this as the proper city of Chongqing, while

excluding the rest of the municipality, but also some of the rural districts.

In light of this data, Chongqing should not be considered in the category of megacities.

5 Shenzhen

According to the definition of urban population stated above, Shenzhen is the fourth and last Chinese megacity, with a total population of 10.4 million in 2010. Besides the dimension, Shenzhen is definitely one of the most interesting cities of the country, because of its unique growth path and of the future perspective of the whole area to which the city belongs.

The city is part of Guangdong province, the richest and most populous province in China. It is located on the Pearl River Delta, a densely populated area that hosts nine very large urban settlements, and shares a border with the special administrative region of Hong Kong. The position of the city played a crucial role in its fast development.

The city occupies the area of the pre-existing Bao'an county. The name appears very late in historical documents and the city technically did not exist until the end of Maoist era. The city, in fact, has been officially founded only in 1979. At the time, Shenzhen was still nothing more than a group of fishermen's villages, with a population of around 315,000 and a per capita GDP of around 606 RMB per year (Data NSBC at current prices – roughly 75 Euro at September 2013 exchange rate), while the economy of the neighboring Hong Kong was already flourishing.

The success of Shenzhen's economy can be traced back to the economic reforms promoted by Deng Xiaoping between the end of the 70's and the beginning of the 80's. These new policies started a general opening of China to foreign investments

and to some early attempts of market economy; furthermore, they recognized the comparative advantage of the coastal regions in terms of capability to carry on a fast-paced development. Four special economic zones (SEZ – cfr. Ge, 1999) were selected in these regions; Shenzhen was one of the chosen sites, and arguably the most successful⁷.

In the first phase after the opening of the SEZ, the area attracted investments mostly from internal sources, often connected to branches of the central government. Thanks to the favorable location, the most part of foreign capitals came from Hong Kong to finance labor intensive processing or manufacturing industries.

Towards the mid 80's, the local government started issuing a series of reforms to promote the development of a more competitive export-oriented economy and to attract foreign investment. This period also sees the beginning of a pioneering land market (first in China), the construction of the first large infrastructures and the early phases of development of a local high-tech industry. This last industry experienced a stunning development, growing a tenfold in about a decade and attracting more foreign investments, in large part still coming from Hong Kong. Besides the vibrant manufacturing and high-tech industries, Shenzhen developed a parallel service oriented economy which grew constantly over the years and recently surpassed industry for share on the local GDP.

Finally, Shenzhen is also an important logistic center for the area and for the whole south of China; its

⁷ According to the NSBC indicators, the other three SEZs (Xiamen in Fujian province, Zhuhai and Shantou in Guangdong province) experienced sustained urban and economic growth, but at a rate significantly lower than Shenzhen.

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port is one of the most trafficked in the world, rivaling with the Hong Kong one located only few kilometers away.

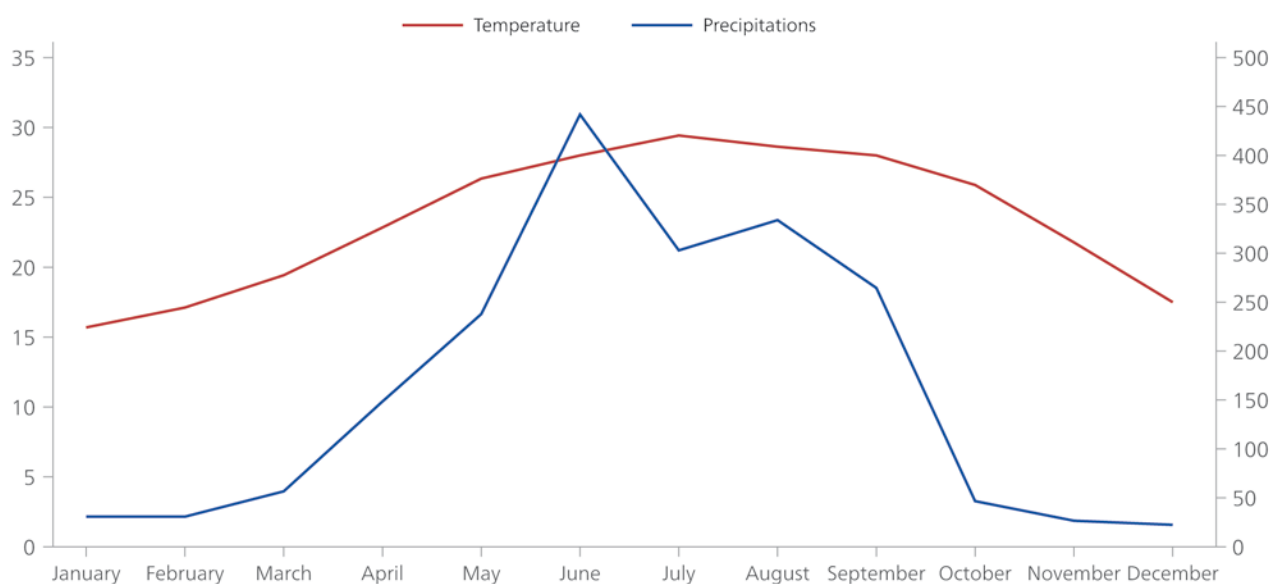
As of today, Shenzhen has a total population of around 10.4 million, about 76% of which is composed of migrants. In 2010 the per capita GDP reached 94300 RMB (11500 Euro at September 2013 exchange rate), higher than Beijing and Shanghai. Services account for 53.5% of the GDP and the rest comes from industry, while agriculture is basically absent, with only around 3000 employees in 2010. GDP related to construction activities is now down to around 3%, but was above 25% in the first years of the city development.

Climate

Shenzhen has a sub-tropical climate, humid, warm and influenced by monsoon.

Since late autumn to the end of winter, temperatures are fresh and the weather is relatively dry, compared to the rest of the year. Spring and summer are warm/hot and humid, with frequent precipitation and occasional heavy rains. The graph below reports the average monthly values for temperatures and precipitations, calculated on the data of 2000-2010.

FIGURE 9 – Shenzhen's temperature (Celsius degrees) and precipitations (mm). Monthly average data for the period 2000-2010.



Source: Personal elaboration of the author based on the daily values provided by the Shenzhen Meteorological Bureau

Data availability and aggregation

The availability of data on Shenzhen appears good. The Local branch of NBSC publishes a statistical yearbook for the city. A few scientific papers analyzing aspects of Shenzhen's urban metabolism have been published in English in the last 10 years and other researches are available in Chinese.

Differently from previously described cities, Shenzhen area can be considered as a whole continuous urban settlement. The city jurisdiction includes six main urban districts and does not include any county or smaller city. Moreover, according to NBSC data, the entire population of all the six districts is urban. A visual analysis of the city confirms the statistical

information. The satellite image of the city, in fact, does not show any evident discontinuity (see Figure 10). Notably, there is no real discontinuity even between Shenzhen and the neighboring city of Dongguan, north of Shenzhen, as clear sign of a trend that sees the cities of the area growing into a unique conglomeration. According to the UN-Habitat 2013 report (UN-Habitat, 2013), the Guangdong Provincial Government already announced a plan to evolve the whole Pearl River Delta into a mega-region that will include the nine large urban settlements in the area (Guangzhou, Shenzhen, Foshan, Dongguan, Zhongshan, Zhuhai, Jiangmen, Huizhou and Zhaoqing), for an aggregate surface of 40,000 km² (see Figure 11).

FIGURE 10 – Satellite view of the extended Guangzhou area.



Source: Personal elaboration of the author of a snapshot from Google Earth software

FIGURE 11 – Satellite view of the Pearl River Delta region.



Source: Personal elaboration of the author of a snapshot from Google Earth software

Given the absence of rural areas from the official statistics, the data on the city should be reasonably consistent and easier to cross reference with other

official statistics provided by the NBSC or by different sources.

6 Guangzhou

Guangzhou, also known as Canton, is the capital of Guangdong province, the richest and most populous province in China. It is located on the Pearl River Delta, a densely populated area that hosts eight more large urban settlements, including Shenzhen, described above.

The city's history dates back more than 2000 years and it has been historically the dominant city of the area. The city has always been an important center of political power, maintaining jurisdiction on the area for more than 2000 years up to today. Favored by the position on the internal part of the Pearl River Delta, the city grew as commercial center and the most important port in South China. For a certain period the city was the only port authorized to commerce with the rest of the world, a condition that made Guangzhou a city with more than 1 million inhabitants and a flourishing economy.

The importance of the city as national trade center began to decline when other major ports were opened on Chinese coasts, after the British victory in the Opium war. The port itself finally lost its central role with the rise of Hong Kong as the international port for the area.

After the foundation of People's Republic of China, Guangzhou was subject to a particularly harsh series of socialist reforms, since the rich city was seen as a negative example of capitalism and consumption (a similar bias against cities was, according to some scholars, common in the Chinese policies of that period – see for instance Bernstein, 1977). The local economy then was pushed from commerce towards the typical public owned heavy industry system of the period. By the end of the Maoist period, the city had definitely lost its centrality and even suffered a lower industrial development, compared to other centers.

With the economic reform and "open door" policies started in 1979, Guangzhou started growing rapidly, thanks to fiscal advantages and to its favorable position (similarly to what has been said above for Shenzhen and because of the proximity with Shenzhen itself and Hong Kong). Since 1978 to 2010, the local GDP grew at an average rate around 19%, with the constant increase of the share of tertiary industry.

The population grew rapidly as well, from less than 3 million in the beginning of the 80's to today's almost 10 million. This growth led to the inclusion in the urban structure of two county-level cities, Huadu and Panyu, and to the interconnection with the large neighboring cities Dongguan and Foshan. Despite the rapid growth, the centrality of Guangzhou in the area is challenged. The city has in fact been subject to the competition with the fast developing cities of the region, especially the two special economic zones of Shenzhen and Zhuhai, and of the two special administrative regions of Hong Kong and Macau.

Still, the economy of the city remains vital, with a per capita GDP in 2010 of 87500 RMB (11300 Euro at September 2013 exchange rate), lower than Shenzhen's one, but still high compared to most Chinese cities and more than 20% higher than Beijing and Shanghai's one.

Tertiary industry generates around 61% of the GDP, while secondary industry a bit more than 37%. Primary industry has been decreasing to below 2% of the local GDP but still employs almost 600,000 people, around 8.5% of the total working population.

Climate

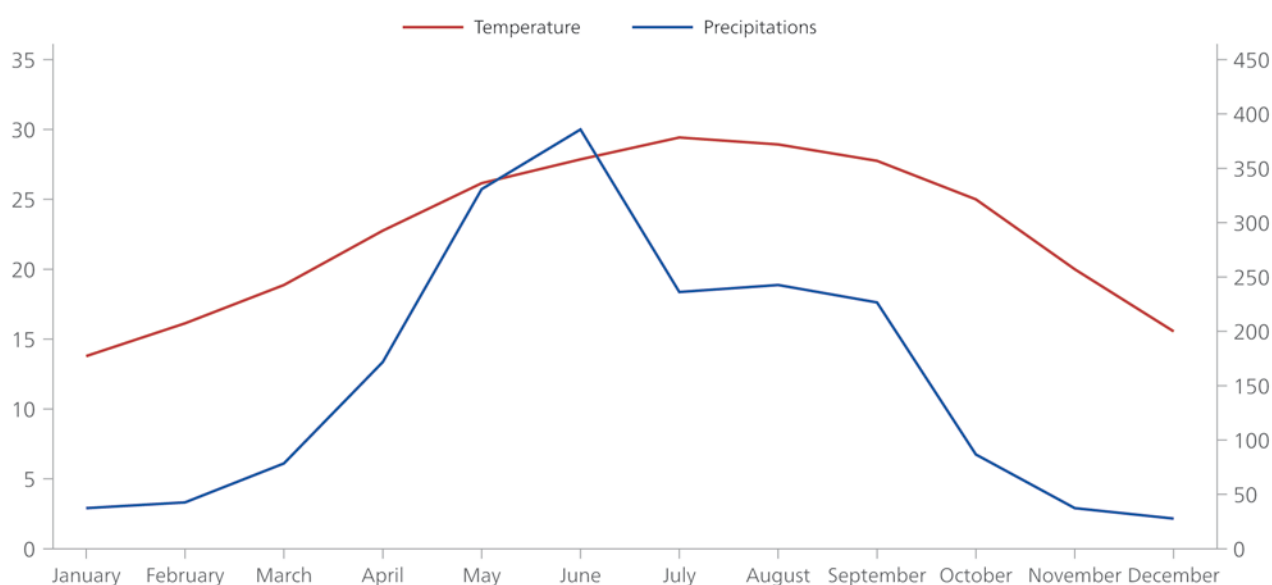
As for the nearby Shenzhen, the climate is sub-tro-

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pical, humid, warm, and influenced by Asian monsoon. Since late autumn to the end of winter, temperatures are fresh and the weather is relatively dry, compared to the rest of the year. Spring and summer are warm/hot and humid, with frequent pre-

cipitation and occasional heavy rains. The graph below reports the average monthly values for temperatures and precipitations, calculated on the data of 2000-2011 made available by the NBSC.

FIGURE 12 – Guangzhou's temperature (Celsius degrees) and precipitations (mm). Monthly average data for the period 2000-2011.



Source: Personal elaboration of the author on NBSC data

Data availability and aggregation

The correct population of Guangzhou in 2010, according to the indication given above in this report, was just below the 10 million threshold. Several publications though, including the 2013 UN-Habitat report (UN-Habitat, 2013) refer a population of more than 10 million, probably because of the inclusion of two additional urban settlements or the large rural population falling under the jurisdiction of Guangzhou.

The total rural population is above 2 million, while the two county-level cities of Zengcheng and Conghua count together approximately 940,000 urban inhabitants plus another 690,000 rural. However, a satellite image (see Figure 13) of the extended Guangzhou territory shows a clear discontinuity between the built-up area of Guangzhou and the two other cities.

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FIGURE 13 – Satellite view of the extended Guangzhou area.



Source: Personal elaboration of the author of a snapshot from Google Earth software

While there is discontinuity between Guangzhou and Zengcheng and Conghua, no interruption of the built-up environment is visible between Guangzhou and Foshan or Guangzhou and Dongguan. These last two large cities are part, with Guangzhou and Shenzhen, of the emerging Pearl River Delta mega-region mentioned above (see Figure 11). The availability and quality of data on Guangzhou appears sufficient. The Local branch of NBSC pub-

lishes a statistical yearbook for the city. A few scientific papers are available with analyses of the city's urban metabolism and metabolic efficiency. On the other hand, the presence of a rather large population (more than 20%) which is inappropriately included in Guangzhou's statistical aggregates can create dimensional problems and inconsistencies in the analysis.

7 Tianjin

The city of Tianjin started growing from a small village with the creation of the Grand Canal, an artificial waterway that connects Beijing and Hangzhou. The canal was completed during the Sui dynasty, approximately 1400 years ago. In its first few centuries, the city was a terminal for the transportation of goods from the south and an important military center.

The city was formally founded in 1404, with the construction of a series of fortifications in recognition of the city's military significance.

As another coastal city, Shanghai, Tianjin became a treaty port after the Opium War and foreign countries established here their concessions. The foreign influence and the strategic positions made of Tianjin a successful industrial and commercial center, but was associated also to a series of incidents with the local population. Like Shanghai, first the Chinese part of the city and then the foreign settlements fell under Japanese invasion.

After the foundation of People's Republic of China, Tianjin obtained the status of municipality under direct control of the government that maintains today. For the first two decades, the city suffered a period of relative decline, as most cities of the coast, due to policies favoring the development of inner regions (see also Shanghai above).

With the reform period, though, the city underwent a rapid development and took advantage of its location to become a major industrial and commercial center and a fundamental port for the north of China.

Over the last few years, Tianjin has been one of the cities with the most dynamic economy in China. The local per capita GDP reached 73000 RMB in 2010 (8900 Euro at September 2013 exchange rate), slightly below Beijing's level.

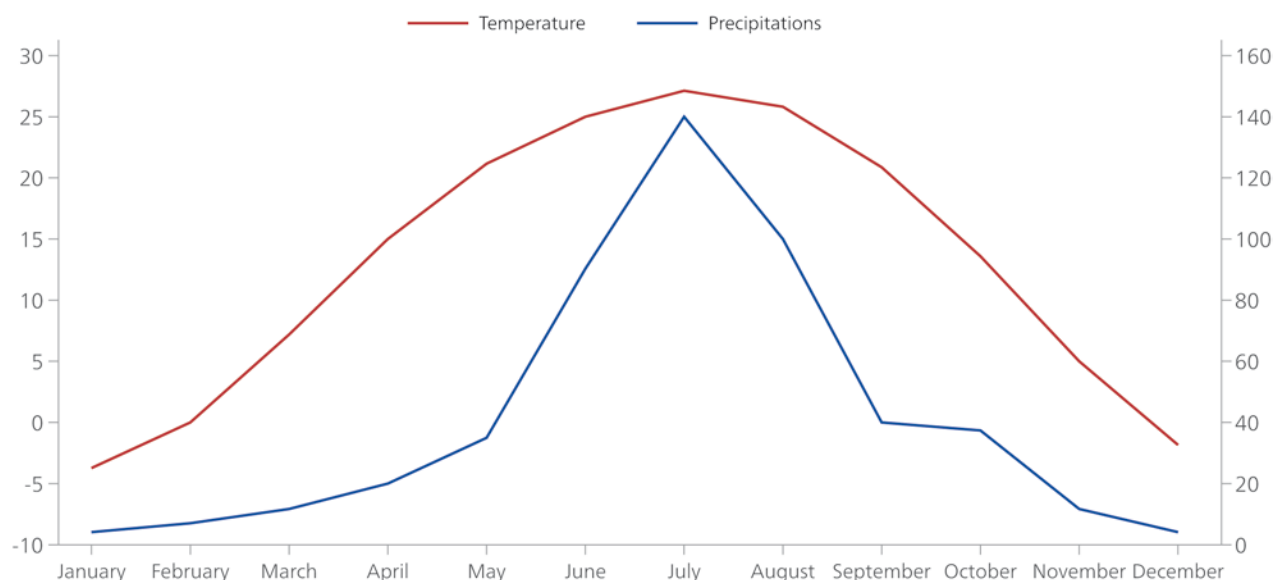
The share of secondary industry on GDP has been decreasing until the beginning of the century but has been stably above 50% since then; services have been growing at the expenses of primary industry. In 2011 primary industry generated 1.4% of GDP, while employing 10.1% of the working population (more than 730,000 people), the lowest value in history. Secondary industry accounted for 52.4% of the GDP and services for 46.2%.

Climate

The city, similarly to the nearby Beijing, has a generally dry climate, partially influenced by the Asian monsoon. Summers are hot and humid, while the rest of the year can be extremely dry. Winters are typically cold with strong winds. Spring and autumn are temperate and dry.

During spring, the city is sometimes subject to sandstorms because of the strong winds blowing from the North West desertic areas. As shown in Figure 14, precipitations are very limited and concentrated in summer.

FIGURE 14 – Tianjin's temperature (Celsius degrees) and precipitations (mm).
 Monthly average data for the period 2000-2011.



Source: Personal elaboration of the author on NBSC data

Data availability and aggregation

The whole municipality of Tianjin has a population of just less than 13 million. A more thorough analysis of the data shows that the actual urban population is limited to 10.3 million, and only 9.6 million living in the urban district of the city.

Comparing the data with the map of the city, the three counties that are part of the municipality (Ji, Ninghe and Jinghai) are located quite far from the

actual city, especially Ji county, separated by vast areas of agricultural land. Additionally, two of the urban districts Baodi and Wuqing have a rural population significantly larger than the urban one; of the two, Baodi also lies away from the urban core. In light of this data and despite its recent fast growth, Tianjin should not be considered to belong to the category of megacities yet.

FIGURE 15 – Satellite view of the whole municipality of Tianjin.



Source: Personal elaboration of the author of a snapshot from Google Earth software

8 Final notes and References

This working paper has been compiled using, as much as possible, Chinese data sources with a special care on ensuring consistency and comparability of the data. Therefore, the same source has been used for different cities wherever possible.

Most of the statistics come from the national versions of statistical yearbooks. Local versions have been used to supply missing information. Some minor inconsistencies exist when comparing national and local version of the same statistical indicator, but not relevant for the purpose of this analysis. The national version has been preferred as it relies on a simpler and clearer (although already very complex) administrative division.

Climate data are taken from national statistical pub-

lications of the NBSC, with the exception of Shenzhen, where no such data are available; Shenzhen data are elaborated from the daily values published by the local meteorological bureau.

History of cities has been drawn from a plurality of sources, including local government websites, encyclopedias (Encyclopaedia Britannica – online version, Wikipedia – English and Chinese versions) and the profile series of “*Cities*”, International Journal of Urban Policy and Planning published by Elsevier.

Satellite images are a personal elaboration of snapshots from Google Earth software, compared with publicly available maps to identify the urban districts and counties of the area.

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