Seeing Chinese Cities through Big Data and Statistics

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Abstract

China has historically been an agricultural nation. China's urbanization rate was reported to be 18% in 1978 when it began its economic reforms. It has now become the second largest economy in the world. Urbanization in China increased dramatically in support of this economic growth, tripling to 54% by the end of 2013. At the same time, many major urban problems also surfaced, including environmental degradation, lack of affordable housing, and traffic congestion. Economic growth will continue to be China's central policy in the foreseeable future. Chinese cities are seriously challenged to support continuing economic growth with a high quality of life for their residents, while addressing the existing big city diseases. The term "Smart City" began to appear globally around 2008. Embracing the concept allows China to downscale its previous national approach to a more manageable city level. By the end of 2013, China has designated at least 193 locations to be smart city test sites; a national urbanization plan followed in March 2014. The direction of urban development and major challenges are identified in this paper. Some of them are global in nature, and some unique to China. The nation will undoubtedly continue to build their smarter cities in the coming years. The first integrated public information service platform was implemented for several test sites in 2013. It provides a one-stop center for millions of card-carrying residents to use a secured smart card to perform previously separate city functions and consolidate data collection. The pioneering system is real work in progress and helps to lay the foundation for building urban informatics in China. This paper also discusses the evolving research needs and data limitations, observes a smart city in progress, and makes some comparisons with the U.S. and other nations.

Keywords: Urbanization, Smart City, Statistics, Big Data, Urban Informatics, China

Seeing Chinese Cities through Big Data and Statistics

Background and Overview

China has historically been an agricultural nation. Its urbanization rate was reported to be about 11% in 1949 and 18% in 1978. Subject to differences in definition (Qiu, 2012), the U.S. urbanization rate was estimated to be at 74% in 1980 (U.S. Census Bureau, 1990).

1978 was also the year China began its economic reforms known as "Socialism with Chinese characteristics." It introduced market principles and opened the country to foreign investment, followed by privatization of businesses and loosening of state control in the 1980s.

In the last 36 years, China leapfrogged from the ninth to the second largest economy in the world in gross domestic product (GDP), surpassing all other countries except the U.S. (Wikipedia, "List of countries by GDP (nominal)"). The poverty rate in China dropped from 85% in 1981 to 13% in 2008 (World Bank, "Poverty headcount ratio at $1.25 a day").

Through expanding population and land annexation, urbanization in China increased dramatically in support of this economic growth. Table 1 reproduces the State Council of China (2014) report about the growth of Chinese cities from 193 in 1978 to 658 in 2010. Wuhan became the seventh megacity in 2011. No U.S. city qualified to be a megacity in 2012 (U.S. Census Bureau, "City and Town Totals: Vintage 2012"). The urbanization rate in China tripled from 18% in 1978 to 54% by the end of 2013 (National Bureau of Statistics of China, 2014).

Table 1. Number of Chinese Cities 1978-2010

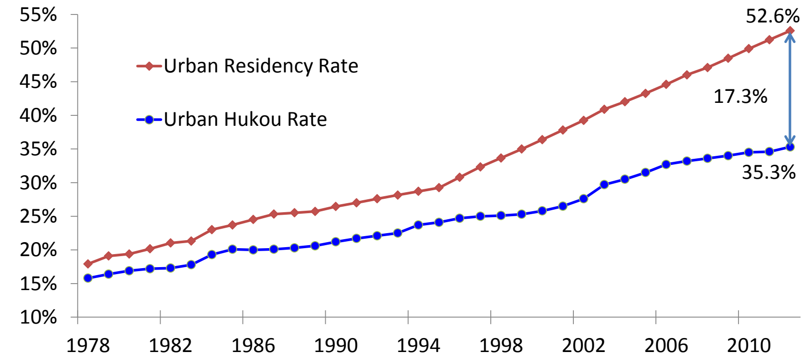
	Population	1978	2010
Cities		**193**	**658**
	≥10 million（Megacity）	0	6
	5-10 million（Extra Large City）	2	10
	3-5 million（Extra Large City）	2	21
	1-3 million（Large City）	25	103
	0.5-1 million（Mid-size City）	35	138
	≤0.5 million（Small City）	129	380
Towns		**2,173**	**19,410**

Source: The State Council of China (2014)

Migration of rural workers to meet the urban labor needs accounted for most of the growth of the Chinese urban population to 711 million. However, under the unique Chinese household registration system known as Hukou (Wikipedia, "Hukou System"), the registered rural residents living in the city are not entitled to the government benefits of the city, such as health care, housing subsidy, education for children, job training, and unemployment insurance. Conversion from the rural to urban registration status has been practically impossible.

This disparity has become a major concern for social discontent in a nation of almost 1.4 billion people. Although 52.6% of the Chinese population lived in cities in 2012, only 35.3% were registered urban residents. The gap of 17.3% is known as the "floating population," amounting to 234 million people and well exceeding the entire U.S. labor force of 156 million people. Figure 1 shows that this gap has been widening since 1978.

Figure 1. Urban Residency Rate and Urban Houkou Rate (1978-2012)

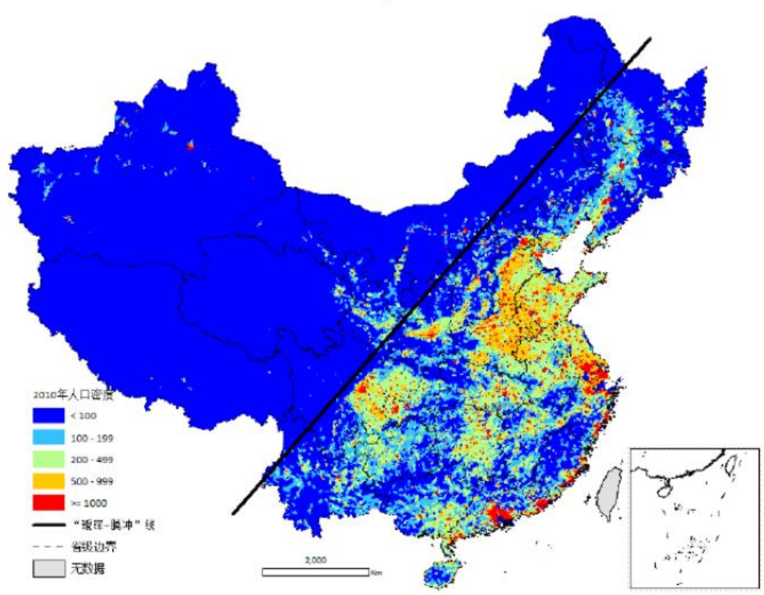


Source: The State Council of China (2014)

In addition to the social inequity caused by the Hukou system, there is an increasing geographical divide. Figure 2 shows that the eastern region of China is more densely populated than the rest of the nation (Beijing City Lab, 2014).

Five out of the six megacities in 2010 are located on the east coast. These megacity clusters occupy only 2.8% of the nation's land area, but contain 18% of the population and 36% of the GDP. While the east coast is increasingly suffocated by people and demand for resources, the central and the western regions lag behind in economic development and income.

Figure 2. Population Density of China in 2010



Source: Beijing City Lab (2014)

Reliance on urban land sale and development to generate local revenue during the reform process has led to high real estate and housing prices and conflicts with the preservation of historical and cultural sites in all regions. Conversion of land from agricultural use is also raising concerns about future food supply.

At the same time, "big city diseases" surfaced and became prevalent in China, including environmental degradation, inadequate housing, traffic congestion, treatment of sewage and garbage, food security, and rising demand for energy, water and other resources. Many of these issues have been discussed domestically and internationally (e.g., Henderson, 2009; Zhang, 2010a and 2010b; United Nations Development Program, 2013).

So, where is China heading in terms of economic growth and urbanization? The answer to this question is unambiguous. The urbanization goal of 51.5% for the 12th Five-Year Plan (2011-2015) has already been exceeded (National People's Congress, 2011).

The 2014 Report on the Work of the Chinese Government (K. Li, 2014), which is similar to the annual State of the Union in the U.S., states that "economic growth remains the key to solving all (of China's) problems" and urbanization is "the sure route to modernization and an important basis for integrating the urban and rural structures."

On March 16, 2014, the State Council of China (2014) released its first six-year plan on urbanization for 2014-2020. The comprehensive plan covers 8 parts, 31 chapters, and 27,000 words, providing guiding principles, priorities for development, and numerical and qualitative goals. Under this plan, China sets a goal of 60% for its urbanization by 2020.

In other words, in China's pursuit of moderate prosperity and harmony, economic growth and urbanization will continue to be its central policy in the foreseeable future. However, more balanced efforts are pledged to manage the big city diseases and to improve the quality of life.

Approach and Goals

In the early days of reform, China took the trial-and-error approach of "feeling the rocks to cross the river" when infrastructure and options were lacking. Over time, the original simple economic goals were challenged by conflicting cultural and social values. More scientific evaluations are needed to minimize costly mistakes made by instinctive decisions.

After 30-plus years of reform, Chinese President Xi Jinping (2014) acknowledged that "…the easier reforms that could make everyone happy – have already been completed. The tasty meat has been eaten up. The rest are tough bones to crack." In other words, difficult choices will have to be made in China's reform process.

Chinese Premier Li Keqiang (2014) pledged to carry out "people-centered" urbanization in his 2014 work report and cited three priorities on three groups of 100 million people each:

- Granting official urban Hukou status to 100 million rural people who have already moved to cities;
- Rebuilding rundown, shanty city areas and villages inside cities where 100 million people currently live (Figure 3 shows an image of contrasting buildings in Shanghai, the largest city in China);
- Guiding the urbanization of 100 million rural residents of the central and western regions into cities in their regions.

Figure 3. Contrasting Buildings in Shanghai

Source: UN-Habitat (2014)

Table 2 reproduces the 18 key numerical goals for 2020 along with the 2012 benchmarks under the national urbanization plan.

There are now two key goals in regard to the urban population: raising the level of residents living in cities to 60% and the level of registered urban residents to 45%, thereby reducing the floating population from the current 17.3% to 15% in six years. The other key goals promote the assimilation of migrant rural workers into city life, improving urban public service and quality of life, and protecting land use and the environment.

There are less specific qualitative goals in the national urbanization plan. For example, Chapter 17 mandates “Three Districts and Four Lines” in each city. The three districts are defined as areas forbidden from, restricted from, and suitable for construction respectively. Four types of zones will be drawn by color lines: green line for ecological land control; blue line for protection of water resources and swamps; purple line for preservation of historical and cultural sites; and yellow line for urban planning and development.

How these districts and zones will be created and sustained has not been specified.

China is pressing forward with concurrent modernization in agriculture, industrialization, information technology, and urbanization. Under the urbanization plan, the central government is responsible for strategic planning and guidance. Authority is delegated to the provincial and municipal levels through political reform. Local administrators are encouraged to innovate, build coalitions, make pilot tests, formulate action plans, and implement orderly modern urbanization under local conditions.

Table 2. Numerical Goals of 2014-2020 National Urbanization Plan

Indicator	2012	2020
Urbanization Level		
1. Permanent Residency Urbanization Rate（%）	52.6	60
2. City Registration Urbanization Rate（%）	35.3	45
Basic Public Service		
3. Children of Rural Migrant Workers Receiving Education（%）		≥99
4. Urban Unemployed, Rural Migrant Workers, and New Workers Receiving Free Job Training（%）		≥95
5. Social Security for Permanent Urban Residents（%）	66.9	≥90
6. Health Insurance for Permanent Urban Residents（%）	95	98
7. Housing Security for Permanent Urban Residents（%）	12.5	≥23
Infrastructure		
8. Public Transportation in Cities of Over 1 Million Residents（%）	45*	60
9. Urban Public Water Supply（%）	81.7	90
10. Urban Sewage Treatment（%）	87.3	95
11. Urban Garbage Treatment（%）	84.8	95
12. Urban Family Broadband Coverage（megabit per second）	4	≥50
13. Integrated Urban Community Services（%）	72.5	100
Resources and Environment		
14. Per Capita Urban Construction Land Use（square meter）		≤100
15. Urban Renewable Energy Consumption（%）	8.7	13
16. Urban Green Buildings as Share of New Buildings（%）	2	50
17. Urban Green Area in Developed Areas（%）	35.7	38.9
18. County-Level or Above City Meeting National Air Quality Standards（%）	40.9	60

Notes：

① *2011 data

② Social Security Coverage: Permanent resident does not include under 16 years old and students

③ Urban Housing Security: Includes public (subsidized), policy-dictated commercial, and renovated housing

④ Per Capita Land Use National rule: standard urban use 65.0—115.0 sq. m.，new cities 85.1—105.0 sq. m.

⑤ National Urban Air Quality Standards：On top of 1996 standards, add PM2.5 and ozone 8-hour average concentration limits; adjust PM10, nitrogen dioxide, lead concentration limits

Source: The State Council of China (2014)

Conversion from rural to urban Hukou registration is now officially allowed and encouraged, but the process will be defined by the individual cities, under the general rule that the conversion will be more restrictive as the population of the city increases.

Implementation of the urbanization plan will be complex and challenging. "Feeling the rocks to cross the river" is no longer adequate as a stand-alone approach. There is recognition that today's urban development requires a proactive, data-driven strategy that must be efficient and innovative with intelligent use of the latest technologies and information.

Emerging Role of Statistics and Technology

The national urbanization plan provides an unprecedented opportunity for statistics and technology to support and monitor the implementation of policies in China. Chapter 31 prescribes the role of defining metrics, standards, and methods to establish a sound statistical system, monitoring the activities dynamically, and performing longitudinal analysis and continuing assessment of the progress of urbanization according to the development trends.

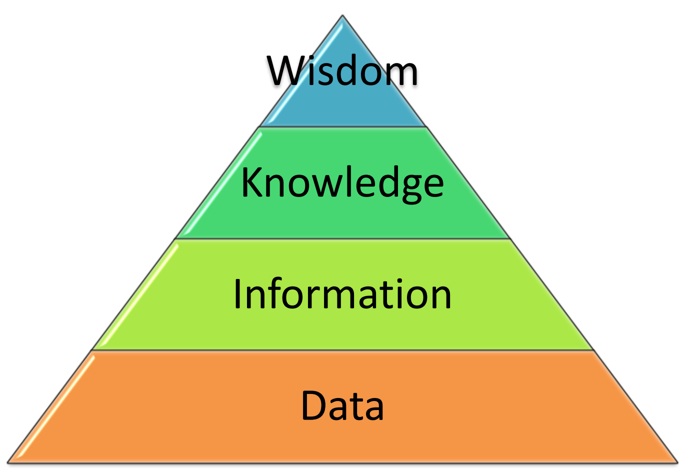
The specification of dynamic monitoring and longitudinal analysis reflects advanced thinking, compared to the current static, cross-sectional reports. Yet how the statistical monitoring system will be implemented also remains unclear at this stage.

There are many ways to cross a river. "Feeling the rock" is a popular Chinese euphemism for taking a trial-and-error approach when the Chinese economic reform began in 1978. While it is still an important part of scientific discovery, total reliance on trial and error can be inefficient, costly, and even dangerous for the governance of a nation or a city.

More preferable is to measure the depth of the river at different times, collect relevant and reliable data, analyze the results scientifically to search for ideal crossing points, evaluate the pros and cons of the options, and make informed, intelligent decisions so that many can cross the river fairly and safely.

Many developed nations have been using this data-driven approach to manage knowledge for their businesses (e.g., Sain and Wilde, 2014). It is the assumed approach that China will also take for governance in this paper. Figure 4 shows a Data-Information-Knowledge-Wisdom (DIKW) hierarchy model for this process.

Figure 4. The DIKW Hierarchy Model



Source: Wikipedia, "DIKW Pyramid"

The foundation of scientific knowledge and wisdom is to observe facts and collect data. However, data in their raw form have little or no meaning by themselves. Not all data have adequate information value or are useful for effective decision making.

Statistics, both as a branch of science for knowledge discovery and a set of measurements, provides context and value by converting useful data into relevant information. Knowledge is gained and accumulated from information, and used as the basis for making wise decisions. The decisions will not be correct all the time, but the scientific process promotes efficiency and minimizes errors, especially when conducted with integrity, objectivity, and continuous improvement.

Technology is not explicitly shown in the DIKW model because the concept was practiced well before modern information technology began to emerge in the 1950s. Today the base of the pyramid is greatly expanded by technology, and the transformation of data into information is accelerated. However, the process is also contaminated by hype, useless data, and misinformation (Harford, 2014; Wu, 2014).

a. Traditional Statistics and Big Data

Census data have been used for governance of nations for centuries. A census is comprehensive, but data collection is costly and time consuming for producing static results at a point in time. Random surveys were later introduced based on probability theory to produce scientifically reliable information with proper design and a relatively small amount of data.

Together censuses and random surveys form the statistical foundation based on structured data (Webopedia, "Structured data") in the 20th century. Developed nations have used them effectively for policy and decision making, with design and purpose, over the past hundred years.

At the turn of this century, massive amounts of data began to appear in or were converted from analog to digital form, allowing direct machine processing (Hilbert and Lopez, 2012). At the same time, huge storage capacity and computing power became available at reasonable cost. It is defined in this paper as the beginning of the Big Data era. Big Data was not a well-known term in China until Tu (2012) published the first Chinese-language book on the topic.

Unstructured data (Wikipedia, "Unstructured data") are typically created by sensors, social media, e-Commerce, and automated sources. Here the meaning of data may expand beyond numbers to include text, map, image, sound, and multimedia. Their sheer volume and dynamic nature provide enormous possibilities for application. On the other hand, incomplete and unstructured data are difficult to process and may even be meaningless to analyze in the absence of design and purpose. Although data mining is commonly mentioned as a promising approach to extract information for commercial purposes, their reliability and value can be suspect, especially for the purpose of governance (e.g., Marcus and Davis, 2014; Lazer, Kennedy, King, and Vespignani, 2014). Few of the key numerical goals in the national urbanization plan can be measured meaningfully or reliably by unstructured data.

Integration of structured data derived from administrative records to create longitudinal data systems was the first realized benefit of Big Data for government statistics.

Under the Longitudinal Employer-Household Dynamics (LEHD) program, the U.S. Census Bureau merges unemployment insurance data, social security records, tax filings and other data sources with census and survey data to create a longitudinal frame of jobs. It is designed to track every worker and every business in the nation dynamically through the relationship of a job connecting them, with data updated every quarter. The comprehensive longitudinal summaries protect confidentiality. They provide insights about patterns and transitions over time, which are not available from the traditional cross-sectional statistics.

Similar efforts to build longitudinal data systems for education (Data Quality Campaign, n.d.) and health care (Wikipedia, “Health Information Technology for Economic and Clinical Health Act”) are underway in the U.S. The 2020 U.S. census will also be supplemented by the integration of administrative records (Morello, 2014).

b. National Basic Data Systems and Identification Codes

In principle, a nation is composed of its people, businesses, government, and environment, which in turn form an economy. More than a decade ago, the State Council of China (2002) issued guidance to create four National Basic Data Systems as part of e-Government - longitudinal frames of people, enterprises, and environment/geography respectively with the fourth system as an integration of the first three to form a unified macroeconomic data system.

These nationwide data systems possess the desired characteristics of a 21st century statistical system (Groves, 2012; Wu, 2012; Wu and Guo, 2013). They help to transition the Chinese government’s role from central control to service for citizens and to establish a foundation for data sharing and one-stop integrated service nationwide.

Heavy investment followed to establish and implement definitions, identification codes, standards, and related infrastructure.

Identification codes are the keys to unlocking the enormous power in Big Data (Wu and Ding, 2013). A well-designed code matches and merges electronic records, offers protection of identity, provides basic description and classification, performs initial quality check, and facilitates the creation of dynamic frames.

Figure 5. Sample Chinese Citizen Identification Card

Source: Wikipedia, “Resident Card System”

As early as 1984, China began to build an infrastructure with its citizen identification system (Wikipedia, “Resident Card System”). A sample Chinese citizen card (Figure 5) displays the citizen identification code, name, gender, ethnicity, birthdate, address, issuing agency, dates of issuance and expiration, and a photograph.

The 18-digit citizen identification code, introduced in 1999, includes a Hukou address code, birthdate, gender, and a check digit. It is issued and administered by the Ministry of Public Security. The citizen code is uniquely and permanently assigned to the cardholder. The card is capable of storing biometric information. It is increasingly required for multiple purposes, such as the purchase of a train ticket for travel.

The U.S. does not have a comparable national citizen card system. Recent renewed discussions about adding an image of the cardholder to the Social Security card was met again with controversy (e.g., Bream, 2014; Eilperin and Tumulty, 2014).

China has also established the system of National Organization Codes under the National Administration for Code Allocation to Organizations. The 9-digit organization code includes a check digit; it is a unique identification and linking variable to store and retrieve information about companies, institutions, communities, government agencies and other registered organizations in China, functioning like the Employer Identification Number in the U.S. (Wikipedia, “Employer Identification Number”).

China has laid a sound foundation for building dynamic frames through these initiatives. However, by 2008, the national approach to create Basic Data Systems was becoming too complex with too many structural, legal, and practical obstacles to overcome.

Shen (2008) reported that the Basic Data System on environment and geography was essentially complete but lacked real application. The Basic Data System on population was burdened by the inclusion of over 100 variables, each with a different degree of sensitivity. The Basic Data System on enterprises faced the strongest resistance to data sharing by various agencies with overlapping responsibilities. The Basic Data System on macroeconomics was stalled without the first three data systems in place.

The LEHD program in the U.S. went through comparable experiences. The national approach faced resistance to data sharing so that the approach had to be strategically adjusted to the state level before data can be re-assembled to the national level.

The Basic Data Systems were relegated to long-term development until the release of the national urbanization plan in 2014. Mandates are now revived and issued for their accelerated development and implementation. For example, the Basic Data System on population is expected to link to cross-agency and cross-regional information systems for employment, education, income, social security, housing, credit services, family planning, and taxation by 2020. The citizen identification code is also mandated to be the only legal standard for recording, inquiring, and measuring population characteristics in China the same year.

c. The Rise of Smart City

The term “Smart City” began to appear globally around 2008 as an extension to previous development of e-Government and digital cities. In general, a city is considered “smart” (Wikipedia, “Smart City”) when “investments in human and social capital and traditional (transport) and modern communications infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory action and engagement.” Data collection, processing, integration, analysis and application are at the core of constructing smart cities.

In practical terms, embracing the concept of smart city will allow China to downscale the original national approach to the more manageable city level, while protecting past investments and permitting aggregation to the provincial or regional level.

Table 3 describes the direction to develop smart cities as outlined in the national urbanization plan. At the end of 2013, the Chinese Ministry of Housing and Urban-Rural Development has designated 193 locations to be smart city test sites (baidu.com, "National Smart City Test Sites"). They are expected to undergo 3-5 years of experimental development.

The Chinese Ministry of Science and Technology has also named 20 smart city test sites (Xinhuanet.com, 2013). They are expected to spend three years to develop templates of cloud computing, mobile networks, and related technologies for broad implementation.

Table 3. Direction of Smart City Development

01	**Broadband Information Network** Replace copper by fiber-optics. Implement fiber-optic network covering practically all urban families at connection speed of 50Mbps, 50% families reach 100Mbps, and some families reach 1Gbps in well-developed cities. Develop 4G network and accelerate public hot spots and WiFi coverage.
02	**Information Technology for Planning and Management** Develop digital city management, promote platform development and expand functions, establish a unified city geospatial information platform and building (structure) database , build public information platform, coordinate the digitization and refinement of urban planning, land use, distribution network, landscaping, environmental protection and other municipal infrastructure management
03	**Intelligent Infrastructure** Develop intelligent transportation to guide traffic, command and control, manage adjustments and emergencies. Develop smart grid to support distributed access to energy and intelligent use of electricity by residents and businesses. Develop intelligent water services to cover the entire process from quality and safety of supply to drainage and sewage. Develop intelligent information network to manage urban underground space and pipes. Develop intelligent buildings to manage facilities, equipment, energy consumption, and security
04	**Public Service Streamlining** Establish cross-agency, cross-regional business collaboration, sharing of public service information service system. Use of information technology and innovation to develop urban education, employment, social security, pension, medical and cultural service model.
05	**Modernization of Industrial Development** Accelerate the transformation of traditional industries, promote use of information technology, digitization, and networking to transition to intelligent service models for manufacturing. Actively develop and integrate information services, e-commerce and logistics to nurture innovation and new formats
06	**Refinement of Social Governance** Strengthen the application of information to monitor market regulations and the environment, credit services, emergency protection, crime prevention and control, public safety and other areas of governance, establish and improve relevant information service system, innovate to create new model of social governance

Source: The State Council of China (2014)

Current State

The issuance of a City Resident Card is a concrete first step of implementation for aspiring smart cities to provide one-stop service and consolidate data collection.

The multi-functional card may be used for social security or medical insurance purposes, as well as a debit card for banking and small purchases. Depending on the city, the City

Resident Card may also be used for transportation, public library, bicycle rentals, and other governmental and commercial functions yet to be developed.

During the application process, the citizen identification code is collected along with identification codes for social security and medical insurance, residence address, demographic data, and family contact information, facilitating linkage to other data systems and records.

Figure 6. Sample Smart City Resident Cards

Source: Baike.baidu.com, "Resident Card"

The current smart resident cards in use in China (Figure 6) vary from city to city, but they typically contain two chips and a magnetic memory strip.

Digital China (2013), a major technology service provider in China, implemented the first integrated public information service platform for several Chinese smart city test sites in October 2013. It provides a one-stop center as an additional channel of service for millions of card-carrying residents, who can use the secured smart card to perform previously separate functions.

The city of Wuhan announced its "Wuhan Big Data Industrial Development Action Plan (2014-2018)" in April (Smarterchina.com.cn, 2014). It includes the establishment of seven cloud computing centers on governance, geo-spatial information, data management, education, multimedia, quality monitoring, and automobile network respectively.

On June 5, World Environment Day, the city of Dongguan announced the release of real-time data on four types of emission from its incineration plants in a publicly accessible website (cn-hw.net, 2014). It is the first of its kind in China.

Urban Informatics

The above pioneering activities are modest, but they are real work in progress and will lay the foundation for urban informatics in China. They represent the very early results of

China’s total investment into smart city development, which is estimated to exceed ¥2 trillion ($322 billion) by 2025 (Yuan, 2014).

Urban informatics, meaning the scientific use of data and technology to study the status, needs, challenges, and opportunities for cities, is presently not a well-known concept in China. It covers both unstructured and structured data, collected with and without design or purpose. The defining characteristics of urban informatics will be the sophisticated application of massive longitudinal data, integration of multiple data sources, and rapid and simple delivery of results, while strictly protecting confidentiality and data security and assuring accuracy and reliability.

China’s urbanization has high risks and high potential returns. Its enormous scale implies potential inefficiency and waste. Although experimentation is encouraged, urban informatics must crawl, walk, and run at the same time. The urgency leaves little time and room for research and development.

There are many challenges and needs in establishing urban informatics as a mature field of study in China. We select four major topics for discussion.

a. Need for Change in Culture

There is no assurance that internal resistance to data sharing and standards can be overcome in China despite mandates, political reforms, downscaling, and cloud computing (e.g., UPnews.cn, 2014). A major risk of a de-centralized approach is the formation of incompatible “information silos” such that the systems cannot inter-operate within or between cities.

This challenge is not unique to China. The U.S. had more than 7,000 data centers in the federal government alone in 2013; about 6,000 of them were considered “noncore.” Many of them do not communicate with each other and are costly to maintain. Although a major consolidation initiative was started by the White House in 2010, progress has been slow (CIO.Gov, 2014; Konkel, 2014).

However, open data-based governance and research are relatively new concepts in China. Although their value is recognized and advocated in the central plans, Chinese officials are not well known for their support of open data policy and data sharing, or their full awareness of modern statistical or environmental issues.

The principles of statistical quality control and management were first proposed by Walter A. Shewhart (Wikipedia, “Quality Management”) in 1924. Emphasizing the use of statistical methods and "profound knowledge," Deming (1994) made significant contributions to Japan's post-war "economic miracle" and later the quality management movement in the U.S. The International Organization for Standardization 9000 series of standards are perhaps the best known product on quality management today from the non-government organization made up of members from 162 countries including China. While these statistical principles and thinking originated in the context of industrial production, they are equally applicable to governance.

The National Bureau of Statistics of China relies heavily on data supplied by provincial and local governments. Intervention and data falsification by local authorities are occasionally reported in China (e.g., Wang, 2013), including the famed GDP. For example, the incomplete 2013 GDP of 28 out of 31 provinces and cities already exceeded the preliminary 2013 total national GDP by ¥2 trillion or 3.6% (e.g., D. Li, 2014). Credibility and public confidence in China's statistics are not high.

Tu (2014) made an exceptional observation that China has not yet developed a culture of understanding and respect for data. It is in sharp contrast with how the city of Helsinki in Finland promotes open data with cost-sharing and regionalism (Sulopuisto, 2014). Changing this culture is a challenge without historical precedent in China.

b. Need for Statistical Thinking and Design

The Chinese statistical infrastructure is recent and fragile. The first Chinese decennial census on population began in 1990 while the U.S. started 200 years earlier; the first Chinese consolidated economic census was conducted only 10 years ago in 2004. Random surveys seldom include detailed documentation on methodology.

Requiring dynamic monitoring and longitudinal analysis by the Chinese government is refreshing in the national urbanization plan. Its implementation faces many statistical and technological issues, including record linkage and integration, treatment of missing or erroneous data, ensuring data quality and integrity, retrieval and extraction of data, scope of inference, and rapid delivery of results. Some of the terms in use, such as "talented persons," "green buildings," and "information level," do not have commonly accepted definition or standard meaning.

In the collection of data about a person, some of the characteristics such as gender and ethnicity remain constant over time; some change infrequently or in a predictable manner such as age, Hukou, and family status; some change more frequently such as education level, income level, employment, and locations of home and work; and others change rapidly such as nutritional intake, use of water and electricity, or opinion about service rendered. Measurement of these characteristics must be made with appropriate frequency, completeness, and quality so that reliable data can be collected to easily and rapidly describe and infer about the population. The definitions must be consistently applied across locations and time so that the results can be compared and meaningful temporal or spatial patterns can be discovered and studied. The base unit may extend from a person to a family or a household. These considerations also apply to an enterprise or a defined geo-space.

Not all available Big Data are relevant for governance; but Big Data include the Basic Data Systems in China. Integrated, structured data contain substantially richer information than unstructured data. Extraction of information can be optimized if it is designed and built into the top-level of the data ecosystem.

Nie, Jiang and Yang (2012) reported the disastrous consequences of mismatched records, outlying data, large variations, and unclear definitions in a Chinese national longitudinal data system on enterprises. Without proper statistical design and implementation of quality control, the data system does not support credible analysis or reliable conclusions despite the high cost of its creation and maintenance. There are few discussions of statistical design or need for quality control of data systems in China. In general, large-scale longitudinal data systems or reliable longitudinal analysis are currently lacking.

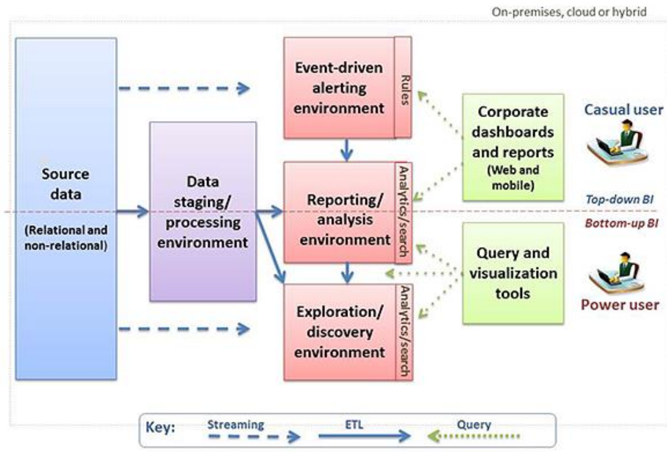
There are recent calls for exploring and understanding "Scientific Big Data" (Qi, 2014; Jiang, 2014). It is a promising sign that China may be prepared to make better use of data in scientific disciplines, in addition to the current commercial and marketing environments.

c. Need for Integration of Technology and Statistics

Yuan (2014) quoted the research firm IDC that "roughly 70 percent of government investments went to hardware installation in China, way higher than the global average of 16 percent." While China may be strong at hardware, service and software tend to lag behind. Technology and statistics are in fact disconnected.

Figure 7 shows a mature conceptual architecture for rapid delivery of business intelligence (BI) to both casual and power users, who may be government officials, academic researchers, the media, or the general public.

Figure 7. Conceptual Architecture for Information Delivery



Source: Eckerson, 2014

Rapid information delivery depends critically on the soundness of the statistical design such that the underlying data are representative, quality-assured, and properly warehoused for easy extraction, transformation, and loading (ETL). It facilitates dynamic visualization and longitudinal reporting of the status and progress on the urbanization plan, as well as system performance and customer satisfaction.

Online services based on smart resident card and one-stop center have already yielded some welcomed relief to labor-intensive administrative functions and reduction of some long waiting queues, but current static monitoring reports are not connected to data collected from online services in concept or in operation. Although statistical yearbooks are beginning to appear online, interactive queries and dynamic visualization similar to the American Factfinder (U.S. Census Bureau, n.d.) are not yet available. Intelligent mapping applications similar to OnTheMap (Wu and Graham, 2009; U.S. Census Bureau, n.d.) have also not been introduced to deliver custom maps and statistical reports based on the most recent data in real time.

d. Need for Statistical Innovation

Statistics is the scientific study of data, big or small. Although it has a long history, it is not fully developed in some areas. The common belief that a large amount of data in terms of file size will be able to provide reliable inference about a population is misguided; prevailing statistical theories do not support analyses whose data are not collected according to probabilistic design. When their representation of the population is inadequate, analyzing non-randomly collected data can result in misleading conclusions.

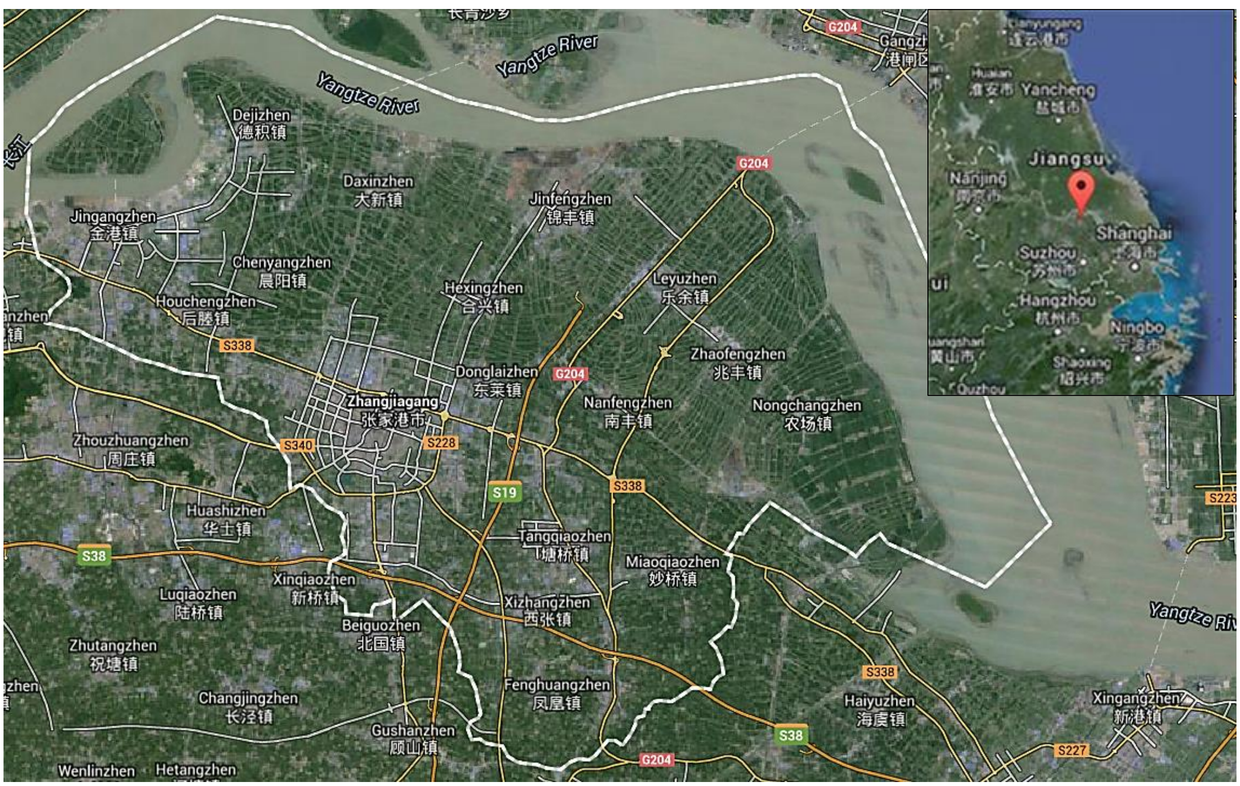
Meng (2014) proposed that three types of statistical inference require “an expanded paradigm with greater qualitative consistency and relative optimality.” Drawing conclusions from the Basic Data Systems, created in multiple phases with data from various linked sources, is an example of multi-phase and multi-source inference. Being able to provide estimates at user-selected geographic levels, OnTheMap exemplifies multi-resolution inference.

Discussions of statistical methods to preserve confidentiality started as early as 1993 (e.g., Rubin 1993), and was implemented in the OnTheMap application. However, the full potential of synthetic data as a method of protecting confidentiality remains to be explored and validated.

Zhangjiagang – A Developing Chinese Smart City

Zhangjiagang is a port city located along the Yangtze River in eastern China under the administration of Suzhou City, Jiangsu Province (Figure 8). It has an area of 999 square kilometers and a total population of 1.5 million urban and rural residents. Given its excellent harbor and richness in ore reserves, Zhangjiagang was strong in its mining, iron and steel industry, and machinery manufacturing sector, placing in the front of the top 100 counties in China. It was changed from a county to a county-level city in 1986.

Figure 8. Zhangjiagang, Suzhou City, Jiangsu Province



Source: Google Earth

The city received the UN-Habitat Scroll of Honor Award in 2008 (UN-Habitat, 2008), becoming the first county-level city to receive such an award in China. According to the Suzhou city government (2014), the 2013 GDP for Zhangjiagang city was about ¥214.5 billion, an increase of 6% over the previous year. Urban resident per capita disposable income was ¥43,400; rural per capita net income was ¥21,700, an increase of 9.3% and 11.4% respectively.

Table 4. Social/Economic Performance Targets for Zhangjiagang under the 12th 5-Year Plan

		Performance Indicator	2010 Actual	2015 Target
Economic Development	1	Gross Domestic Production (¥100M)	1600	3200
	2	General Budget Revenue (¥100M)	116.06	250
	3	Service Share of GDP (%)	38	45
	4	New Industry Value as Share of Above-Scale Industrial Value (%)	21.8	50
	5	Actual Use of Foreign Investment ($100M)	10	60 (5 year)
	6	Total Imports and Exports ($100M)	250	500
	7	Total Port Throughput (M tons)	2	3
		Port Container Throughput (10K Twenty-foot Equivalent Units)	112	220
	8	Efficient Agriculture Proportion (%)	50	65
Innovation Capacity	9	Research and Development As Share of GDP (%)	2.15	>3.0
	10	High-Tech Industry as Share of Above-Scale Industrial Value (%)	32	40
	11	Large/Medium Size Enterprises as Share of R&D Institutions (%)	65	90
	12	Gross Enrollment of Higher Education (%)	65	70
	13	Average Education of New Labor (Year/Person)	15.3	16
	14	Talented Persons per 10K Persons (Person)	1380	2200
	15	Invention Patents (Piece)	95	300
	16	Science and Technology Contribution Rate (%)	55	60
Social Improvement	17	Urbanization Rate (%)	63	70
	18	Social Security Coverage (%)	Reach 100	All Covered
	19	Gini Index	0.4	<0.38
	20	Health Workers per 1K Persons (Person)	6.38	7.2
	21	Public Cultural Facilities Area per 1M People (sq. m.)	1400	1600
	22	Public Stadium Area per 10K People (sq. m.)	28000	32000
Quality of Living	23	Average Urban Resident per Capita Disposable Income (¥)	30400	53000
		Average Rural Resident per Capita Net Income (¥)	14400	26500
	24	Urban and Rural Resident Health Index (%)	96.44	>97
	25	Beds in Elderly Homes per 1K Elderly Residents (bed)	19.5	35
	26	Social Satisfaction of Public Security (%)	98	>98
	27	Information Level in Daily Life (%)	80	≥90
	28	Public Transportation Rate (%)	15.5	25
	29	Engel's Coefficient (%)	32	<30
Ecological Environment	30	Environmental Quality Composite Index (point)	98	>96
	31	Garbage Harmless Treatment Rate (%)	75	>95
	32	Per Capita Green Area in Developed Area (sq. m.)	12.98	13.2
	33	Water Consumption Reduction in ¥10K GDP vs 11th 5-Year Plan (%)	--	10
	34	Energy Consumption Reduction in ¥10K GDP vs 11th 5-Year Plan (%)	--	Assigned Targets Completed
	35	SO_2, NO_X Emission Reduction vs 11th 5-Year Plan (%)	--	
	36	COD, Ammonia Emission Reduction vs 11th 5-Year Plan (%)	--	

Notes: ¥ = Chinese yuan; $=U.S. dollars; K=Thousand; M=Million
$1 ≈ ¥6.2

Source: Zhangjiagang City Government; Digital China

The urbanization rate for Zhangjiagang was 63% in 2010, already higher than the current average in China, exerting high pressure on its city administrators to manage its population, environment, and economic development.

Table 4 shows the performance indicators and goals for Zhangjiagang's 12th five-year plan (2011-2015). Its economic output and port throughput are expected to double in the 5-year period. Zhangjiagang set up "new capabilities" and quantified research and development (R&D) in order to realize these goals. As in many other Chinese cities, science and technology is considered an important pillar supporting continued urbanization.

Chapter 8 of the Zhangjiagang 12th five-year plan also emphasizes the support of information technology for e-Government by raising the level of government applications; accelerating the construction of the Basic Data Systems; focusing on public and government data sharing and exchange systems; and further improving the level of inter-departmental applications.

One-stop Platform

Figure 9. Entry Page of Zhangjiagang Public Website

Source: Digital China

The Zhangjiagang public website was launched in October 2013 with the above goals in mind. The front page of the website (Figure 9) contains 3 channels - My Service, My Voice, and My Space. My Service provides government and public services; My Voice connects the government and the resident through an online survey and microblogging; My Space contains the user's "digital life footprint" such as personal information and record of use.

The public website combines online and offline services through the use of the smart resident card, desktop and mobile devices, and government and community service centers, offering 621 types of services by 31 collaborating government and community organizations.

The services vary by type of access device. Desktop computers offer the most comprehensive services, including queries, more than 240 online applications, and over 130 online transactions. Mobile device users may check on the progress of their applications, using General Packet Radio Service (GPRS) positioning and speech recognition technology to obtain 56 types of efficiency services such as travel and transportation.

Figure 10 is a sample My Service page, showing the location and availability of rental bicycles in the city.

Figure 10. A Sample of My Service Page

Source: Digital China

The one-stop service platform attempts to provide a unified, people-centric, complete portal, eliminating the infighting of various government agencies to build their own websites and service stations and consolidating separate developments such as smart transportation and smart health care.

The website combines a variety of existing and future smart city proposals and services. Developers will be able to link to the platform to provide their services with lower operating costs. The city government wants to have a platform to showcase information technology, introduce business services, and assist economic development, especially in e-Commerce.

The Zhangjiagang public website is designed to be an open platform for progressive development. All the applications will be dynamically loaded and flexible to expand or contract. Existing services will be continuously improved, and new functionalities added. It aims to improve public satisfaction of government service and broaden agency participation to facilitate future data sharing and data mining.

Participation of the residents in the platform will determine whether its goals will be achieved or not. In the 6-month period since its launch in October 2013, there have been 15,518 total users through real-name system certification and online registration, 31,956 visitors, and 198,227 page views. The average visit time was 11 minutes and 7 seconds. Among all the users, real-name registrants accounted for 67%, and mobile end users accounted for 44%.

Online booking of sports venues, event tickets, and long-distance travel are the most popular services to date. They show the value of convenience to the residents, who had to make personal visits in the past.

Although there is no current example of data sharing between government departments, the public website is beginning to integrate information for its residents. A user can view his/her records in a secured My Space (Figure 11).

Figure 11. A sample of My Space Page

Source: Digital China

It is already possible in the Zhangjiagang platform to create a consolidated bill of natural gas, water, electricity, and other living expenses to provide a simple analysis of household spending. Although this is elementary data analysis, it foretells the delivery of more precise future services as online activities and records expand and accumulate over time.

Summary

China is in the early stage of its six-year national urbanization plan, extending its economic development to also address rising social and environmental concerns. There is a defined role for statistics and urban informatics to establish norms and conduct dynamic monitoring and longitudinal analysis. Small steps have been taken to begin data consolidation in some smart city test sites, and modest progress is beginning to appear. In the next six years, cultural changes towards an objective data-driven approach, integration of statistical design and thinking into the data systems, and innovative statistical theories and methods to fully deploy meaningful Big Data will be needed to grow urban informatics in China and to achieve balanced success in its urbanization efforts. China will undoubtedly continue to advance towards building her smarter cities with Chinese characteristics, and we will be able to see more of the Chinese cities through statistics and Big Data.

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