A STUDY ON GEOSPATIAL INDUSTRY SIZE IN CHINA

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ABSTRACT: With the development of its economy in China, the demand for geospatial applications in various fields has been greatly increased in recent years. And the geospatial Industry has been emerged as new and active factor in information service sector. During the past ten years, thousands of companies and institutes have involved in the business for technology development and provide services. It is important both for the government and business managers to understand the general situation of the industry, such as its size and work population, etc.A research was carried out for the geospatial industry with the support of the State Bureau of Mapping and Surveying (SBMS) of China recently. Within the research, we have conducted an industrial survey with the assistant of SBMS, and interviewed key players in the industry, and through documentary study and analysis, and finally we obtain some basic data of the China's geospatial industry. In 2006, the geospatial industry of China, including the disciplines of surveying, mapping, remote sensing, photogrammetry, geographic information systems and car navigation, was over 40 billion Yuan (about $5.3 billion). And there were over 10,000 companies and institutes with at least of 300,000 people working in this industry. The study analyzes the geospatial industry of China in a wide range based on the study.

1. BACKGROUND

With the development of its economy in China, the demand for geospatial applications in various fields has been greatly increased in recent years. The market of geospatial technology, including the disciplines of surveying, mapping, remote sensing, photogrammetry, geographic information systems and car navigation, has been greatly increased during past ten years. And now, the geospatial technology is rapidly becoming an indispensable part of information industry in the country. As the technology affects to many business sectors and is involved in many departments, and also as it will be an even greater surge for the industry, it has been attracting attention from both government policy makers and business people in the country.

There is a series of questions related to the industry need to be addressed. How big is the industry? How many people working in the industry? And what is the industry structure? While it is quite difficult to answer these questions since there are no unified and authoritative definition and no statistical indictor system of geospatial industry in the country.

Some organizations and companies have made researches on global or regional geospatial industry size or its branches. For example, NOAA & ACCRES & NASA made a survey on American spatial industry in 2000(Charles Mondello,2004).The Department of Labor (DOL) of the United States published an estimate value of American spatial industry size in 2004. Canada GIAC made a survey on Canada spatial industry size in 2004. These practices provide reference to our study and survey in China's geospatial industry.

In China, a number of studies on geospatial industry had been carried out both by organizations and individuals. In 2005, the State Bureau of Mapping and Surveying (SBMS) of China, a policymaker and management body for mapping related business in the country, conducted a statistic on mapping and surveying industry and obtained the value (12 billion Yuan) which is the only authoritative data of geospatial related industry in China. The National Remote Sensing Center (NRSCC), GIS Software Testing Qualifications Board of the Ministry of Science and Technology, and the GIS Association of China had conducted surveys on GIS related industry in 2003. Cao Chong (2001), Zhou Ruxin (2004) and other scholars also have estimated and forecasted the GNSS industry size. Chinese Center of Information Industry Development (CCID) releases the Global Navigation Satellite Systems (GNSS) market size yearly. But up to now, there is no authoritative and overall statistical data for geospatial industry in the country.

Much of the above study on geospatial industry size refers to one branch of industry and mainly uses questionnaire survey method. The questionnaire survey method reflects the approximate output value of the entire industrial through a certain number of samples, therefore it exists inevitable sampling error. If the sampling number is certain, the broader the survey scope, the greater the error. If the survey scope is certain, the fewer the selected samples, the greater the error (suppose the obtained value from questionnaire survey is true). Therefore, the study tries to narrow the scope of survey down by dividing the industry into small parts, and at the same time, selecting more samples to reduce error. Furthermore, the study also uses other research methods such as on-the-spot investigation, comparison, analysis and verification, etc. After obtaining the output value of the industry, the study estimates the working population and companies and institutes number of China's geospatial industry.

2. RESEARCH SCOPE AND METHOD

The geospatial industry acquires, integrates, manages, analyzes maps, distributes, and uses geographic, temporal and spatial information and knowledge. The industry includes basic and applied research, technology development, education, and applications to address the planning, decision-making, and operational needs of people and organizations of all types (AAG&GITA, 2006). According to SBMS, geospatial industry is a kind of high-technology industry which is an integration of modern surveying technology and information technology. It uses geospatial technology to produce and develop geospatial information resource, provides geoinformation service, and operates geoinformation products. Geospatial industry includes all the companies and institutes which refer to the related hardware, technology, service and products (SBMS, 2006).

According to the above definitions, geospatial industry includes all or part of GIS industry, remote sensing (RS) industry, GNSS industry, surveying industry and mapping industry, etc. The study decomposes the indicator of the geospatial industry size by analyzing the development status of each industry branch, and then uses different survey and research methods to each indicator, or uses a variety of survey methods to a target indicator. By comparison and certification, the study ultimately obtains the value of the entire geospatial industry. The methods used including questionnaire survey, on-the-spot investigation, expert visit, internet data collection, comparison analysis, and sampling study of GIS application system.

2.1 Indicator Decomposition and Modification for Industry Size

Indicator decomposition for geospatial industry size refers to the current status of the major industrial activities, as well as the consideration of the data availability.

SBMS classifies the surveying management into ten aspects: geodetic surveying, engineer surveying, cadastral surveying, real estate surveying, administrative boundary surveying, aerial photogrammetry，photogrammetry and remote sensing, GIS project, map compilation and marine surveying. These ten categories are also the business scope of companies and institutes with qualification on surveying and mapping. Based on the above, incorporating some related business, the study decomposes the indicator of surveying industry size as following: aerial photogrammetry（PSVa）, photogrammetry and remote sensing (PSVr), GIS project(PSVg), map compilation(PSVm) , geodetic and survey(PSVs) which including geodetic surveying, engineer surveying, cadastral surveying, real estate surveying and administrative boundary surveying. The formula is:

$$P_{SV} = PSVa + PSVr + PSVg + PSVm + PSVs$$

P_{SV} –Surveying industry size；PSVa- aerial photogrammetry；PSVr- photogrammetry and remote sensing；PSVg –GIS project；PSVm- map compilation；PSVs –geodetic surveying, engineer surveying, cadastral surveying, real estate surveying and administrative boundary surveying.

GIS are automated systems used to capture, edit, store, manipulate, analyze and display a variety of spatial data. By analyzing the major components of GIS: hardware, software, data and technical staff, decomposes the indicator of GIS industry size into three parts: GIS software (PGs), GIS data (PGd) and GIS hardware (PGh), namely:

$$P_{GIS} = PGs + PGd + PGh$$

P_{GIS} –GIS industry size；PGs-GIS software；

PGd-GIS data; PGh- GIS hardware;

Remote sensing refers to the observation and collection of data without the sensor being in physical contact with the object being studied, such as the study of the Earth from distant vantage points, via satellite or aircraft. There are two kinds of remote sensing, one is aerial remote sensing, and the other is satellite remote sensing. Currently, the major industrial activities of remote sensing industry include remote sensing data acquisition, manipulation, application and service provision of aerial image data and satellite image data. Remote sensing software research and development is also involved. The hardware of satellite launch and ground receiving is not included in the study.

In current china, excepting the CBERS satellites data and Beijing-1 Micro-satellite data, most of industrial application of satellite image data, especially high resolution image data are depend on other countries. Data acquisition by arial remote sensing is inspected by SBMS. The image data applications and value-add services are also the important content of the RS industry. Besides, remote sensing software is important but its industry development is on the first stage. Based on the above analysis, remote sensing industry indicator is decomposed into three: satellite image data receiving, agent service (PRs), aerial photogrammetry（PRa）and remote sensing data process and application service(PRd).

$$P_{RS} = PRs + PRa + PRd$$

P_{RS} –Remote sensing industry size；PRs –Satellite image data receiving and agent service；PRa- aerial photogrammetry and service；PRd- remote sensing data process and application services

GNSS is a geospatial technology that enables a portable hand-held device to provide a precise location almost anywhere on the earth by processing signals with a constellation of satellites. According to CAO Chong(2001), the application of GNSS refers to many fields, including car monitor, car navigation, consuming products, OEM products, voyage, aviation, information services and surveying/GIS according to the application field. Considered the intersection with other industry branches,GNSS industry size indicator is divided into surveying/GIS application indicator (PGNsg) and the other application indicator (PGNg).

$$P_{GNSS} = PGNg + PGNsg$$

P_{GNSS}–GNSS industry size indicator; PGNsg- surveying/GIS application indicator

PGNg –the other application excluding surveying/GIS;

There are professional and non-professional mapping companies and institutes in China. Some professional mapping companies and institutes belong to SBSM and others not. The study decomposes the mapping industry size into the following three indicators: 1) professional mapping companies and institutes in surveying department (PCs); 2) other professional mapping (PCns); 3) non-professional mapping (PCo). The formula is:

$$P_C = PCs + PCns + PCo$$

P_C-mapping industry size；PCs- professional mapping in surveying department；PCns- other professional mapping；PCo-non-professional mapping

The use of other technologies related to GIS applications, such as CAD technology for geographic data editing and processing, 3-D imaging technique for geographic information display, IT for achieving geographic information internet services, including LBS and Internet map services. This part is recorded as indicators P_O.

The indicator decomposition of China's geospatial industry size is as shown in table 1. It should be pointed out that, with the

development of Internet and mobile communication technology, GIS, RS and GNSS technology often use integrately. Modern surveying technology also refers to "3S" technologies. Therefore, the above indicators have intersected parts and need to be modified. P_{GIS} is the indicator of GIS project applications which doesn't involve the isolated data process, application and service. The geoinformation application without GIS system development is calculated in surveying industry. The RS application integration with GIS should be removed, and the indicator PRd is modified as PRd' which indicates RS application without use GIS technology. Surveying and GIS applications (PGNsg) in GNSS industry is also need to be removed. In surveying industry, RS industry related aerial photography (PSVa) and photogrammetry and Remote Sensing (PSVr), GIS industry related GIS project(PSVg), mapping industry related map complication(PSVm) are all need to be removed. The modified indicators are shown in table 1.

Industrial Branch	Industry size decompostion	Decomposed Indicator	Modified Indicator
Surveying Industry	Geodetic and survey(PSVs) which including geodetic surveying, engineer surveying, cadastral surveying, real estate surveying and administrative boundary surveying. Aerial photogrammetry Photogrammetry and remote sensing GIS project Map compilation	PSVs; PSVa; PSVr; PSVg; PSVm	PSVs
GIS Industry	GIS application	P_{GIS}	P_{GIS}
Remote Sensing Industry	Satellite image data receiving and agent service Aerial photogrammetry Remote sensing data process and application service	PRs; PRa; PRd	PRs; PRa; PRd'
GNSS Industry	Car monitor, car navigation, consuming products, OEM products, voyage, aviation, information services Surveying/GIS	PGNg; PGNsg	PGNg
Mapping Industry	Professional mapping in surveying department Other professional mapping Non-professional mapping	PCs; PCns PCo	PCs PCns PCo
Other Geospatial Industry	Such as CAD technology application, 3-D imaging technique application; IT application for geoinformation internet services, including LBS and Internet map services.	P_O	P_O

Table 1 Decomposition and modification of industry size indicator

With the modified indicators, there exists the following formula:

$$P_{Sum}=P_{GIS} + PRs + PRa + PRd' + PGNg + PSVs + PCs + PCns + PCo + P_O$$

2.2 Accessing Method for Indicators

Based on the different characteristics of each industry branches, considering the data availability, the study integrates direct and indirect research methods to obtain the value of each indicator. Direct research methods including questionnaires survey, on-the-spot investigation, expert visit and sampling study, indirect methods include: Internet data collection, comparison analysis, calculating with existed authoritative data, the survey data verification and revision.

Software, data, hardware and services are the main components of GIS industry. It is difficult and complex to find out the output value of each component. By comparison, GIS software is provided by the software vendor, usually with a clear price. In addition, foreign and Chinese researcher (Andrew U. Frank, 1991; Douglass A. Smith & Roger F. Tomlinson, 1992; Zhong Ershun, Zhou Ning, 1994) conducted economic analysis on GIS project. By GIS software output value and its proportion in GIS application, GIS industry size can be calculated. This approach avoids the complicated breakdown of data, hardware and services, and be relatively simple.

Many companies and institutes are involved in surveying industry, but all are managed by SBSM. It is relatively easy to conduct survey. In addition, SBSM has 2005 statistics data of surveying industry and its breakdown. Chinese satellite remote sensing data industry is characterized with few and concentrated companies and institutes, and the on-the-spot investigation is appropriate to access the output value directly. Mapping industry companies and institutes is classified by data availability. The output value of professional mapping companies and institutes in surveying department can be obtained by statistics; output value for other professional companies and institutes can be obtained by conducting sampling survey. Because there are many industry branches and some existed estimate data about GNSS industry, using indirect methods, collecting and analyzing these research data, conducting interviews is appropriate way to update the value. Table 2 identifies accessing methods of the study to the indicators of the geospatial industry size.

3 PROCESS AND RESULTS OF INDICATOR OBTAINING

3.1 Value Access for Surveying Industry Indicators

The companies and institutes with qualification on surveying and mapping are the major providers in surveying production and services market. with the support the Information Center of SBMS, the author conduct a questionnaire survey to the 9,096 qualified companies and institutes, 5,981 companies and

institutes send back the questionnaire, and the feedback rate is about 66%. According to the result, the total output value of the Surveyed companies and institutes is about RMB 20 billion Yuan(about $2.5 billion) in 2006.

Branch Industry	Indicator	Method for Indicator
GIS Industry	P_{GIS}	Internet data collection; Analyzing the existed GIS software industry value; On-the-spot investigation of the main three GIS software company; Documentary records research; Survey for GIS project cost structure
RS Industry	PRs PRa PRd'	On-the-spot investigation of the main company; Arithmetical operation with the existed statistics data Arithmetical operation with the existed statistics data
GNSS Industry	PGNg	Modified the existed research data; comparison analysis; data correction; Expert visit;
Surveying Industry	PSVs	Questionnaire survey; Calculated by the data of different year; Arithmetical operation
Mapping Industry	PCs PCns PCo	Investigation; Questionnaire survey; Ignore
Other Industry	P_O	Ignore

Table 2 Methods for accessing indicator of industry size

Indicators	Character	2005	2006
PSVa+PSVr	Aerial photography, mapping Photogrammetry and Remote Sensing	0.83($0.1)	1.2($0.15)
PSVg	Geographic information projects	0.5($0.063)	0.7($0.09)
PSVm	Mapping	1.1($o.14)	1.6($0.2)
PSVs	Others except 3 indicators below		16.5($2.1)

Table3. Calculated Results for the Indicators Unit: Billion Yuan(Billion Dollar)

According to 2005 annual report of SBSM, the total output value of survey industry is 12 billion Yuan (about $1.5 billion). The output value of aerial photography, mapping Photogrammetry and Remote Sensing (PSVa + PSVr) is RMB 0.83 billion Yuan (about $104 million), accounting for 7%; the output value of geographic information projects (PSVg) is RMB 0.5 billion Yuan (about $63 million), accounting for 4%; the output value of mapping is RMB 1.1 billion Yuan (about $0.14billion), accounting for 9%. Supposed that each part of surveying industry has the same growth rate from 2005 to 2006, the indicators value of 2006 are calculated out and shown in table 3.

3.2 Value Access for GIS Industry Indicators

Some organizations and experts in China studied the GIS software industry size and the research results are shown in table 3. The study investigates the production value of three key GIS software companies to verify the rationality of data in table 4 by some extent. The three GIS software companies in China includes ESRI China (Beijing) Ltd., Beijing SuperMap GIS Technologies Inc. and Wuhan MAPGIS Inc., The survey result shows that, sales income of the three GIS software companies have reached ￥0.2 billion RMB in 2006. Thus, the output value of 500 million Yuan of Chinese GIS software is with a large degree of rationality.

134 GIS projects from Beijing SuperMap GIS Technologies Inc. are selected to make sampling survey of the ratio of GIS software to GIS project. All these GIS projects are distributed in more than 16 provinces, such as Beijing, Guangdong, Shanghai, Zhejiang, Hebei and etc, and refers to more than 10 industries, such as Land Resource, Digital Cities, Transportations, Telecom, Pipeline, Statistics and etc. by looking up the original contract and make visit to Contact person, and getting the cost of GIS software and the cost of total project, the study finds the average proportion of GIS software cost in GIS projects is 25.3%(not including the hardware cost). Furthermore, more than 30 people including GIS project managers and GIS sales, all had at least 2 year GIS work experience, are interviewed or questionnaire surveyed by email and telephone call. The purpose of the survey is to get the average proportion of the cost of GIS software in cost of total project (including the hardware). The result of survey is about 10%.

Year	Output Value Estimation	Source
2002	￥0.2 billion	Li Ying, Market Working Committee China Association of GIS
2005	>￥0.3 billion	Domestic Spatial Information System software Evaluation Committee of China
2006	￥0.5 billion	Cao Yujie, China Computer World Research (CCW Research)

Table 4 The research list of GIS software industry size (Billion Yuan)

Indicators	Category	Output value	Method
PCs	The first category	=1.1($0.14)	Make survey
PCns	The second category	>0.5($0.063)	Questionnaire survey of 6 key companies and institutes
PCo	The third category	Ignore	Too much companies and institutes and not the major operation, it is difficult to obtain
PC	Total	>1.6($0.2)	

Table 5 Method and value for mapping industrial Indicators Unit: Billion Yuan(Billion Dollar)

According to the above study, the output value of Chinese GIS Projects(excluding hardware cost) is 2 billion Yuan. If including hardware cost, the output value reaches to 5 billion Yuan in 2006. Namely, PGIS =5 billion Yuan (about $0.6billion).

3.3 Value Access for RS industry indicators

Currently, the industrialization application of satellite RS data in China mainly depends on the abroad. Remote sensing data provided by meteorological satellite and the marine satellite, which is made by China own, are mainly used in social public welfare services. Satellite data of "CBERS satellites" and "Beijing No.1" are mainly used in science research and government application field. There is a long way to its Industrial application. Through on-the-spot investigation to four key companies which are engaged in satellite remote sensing data reception and reselling, the study gets the Chinese satellite RS industry output value of over 0.18 billion Yuan. Namely, PRs>0.18 billion Yuan (about $0.02billion).

3.4 Value Access for GNSS industry indicators

Some Chinese experts and company made research and forecast on GNSS industry size (CAO Chong, 2001-2006; ZHOU RuXin, 2004; CCID, 2006). By comparing and analyzing the results of the research, it is found that CAO Chong (2001) and CCID had more detailed research on the industry branch and the estimate value is larger than other research result. Both CAO Chong and CCID estimates that the Chinese GNSS industry output value is more than 20 billion Yuan (about $2.5billion) in 2006. ZHOU RuXin's estimate on GNSS industry is relatively small that Chinese GNSS output reached only 10 billion Yuan (about $1.3billion) in 2005. From the estimated time, the data from CCID is the latest, but its classification, as well as the estimated value of the whole industry and its breakdown, is approximately the same as that of CAO Chong. Therefore, the study makes an expert visit to CAO Chong. According to the visit, the estimation and forecast of China's GNSS industry size in 2001 is based on global GNSS industry development status and trends. In 2000, the United States closed the GPS SA policy that would greatly promote the development of the global GPS industry. But in the following years, the global GNSS industry has not developed at the expected speed. So the real development rate is lower than the forecast. In 2006, CAO Chong makes a survey on China's GNSS companies. By selecting representative companies with different types and scale as a typical abstract data validation, CAO Chong makes analysis and revises the original forecast value by using the updated information.

The corrected result shows that China's GNSS industry size is 12 billion Yuan (about $1.5 billion) in 2006, of which surveying / GIS application is about 1 percent.

Namely: PGNg = 11.8 billion Yuan. (about $1.5billion)

3.5 Value Access for Mapping Industry Indicators

The study decomposes the mapping industry indicator into three categories: the first category is professional mapping companies and institutes belonging to SBSM, the second is professional mapping organizations belonging to other department, the third is non-professional mapping related companies and institutes. The total output of the first category mapping companies and institutes is 1.1 billion Yuan (about $0.14billion)(by SBSM). The six key mapping companies and institutes of the second category are selected for sampling survey. The result of the survey shows that the output value has reached 500 million Yuan (about $63million). The third category involves many companies and institutes which geospatial-related business is not major and is difficult to make statistics. The study doesn't calculate the output value of this part. The value of mapping industry indicators is shown in table 5 below.

3.6 Summary combined with the output value

Based on the above study, the value of indicator of China's geospatial industry breakdown is shown in table 6 below.

Indicator	**Output value（billion Yuan）**
PSVs	16.5
P_{GIS}	5
PRs	>0.18
PRa +PRd'	>1.2
PGNg	11.8
P_C	>1.6
P_O	Not calculated
ΔP_{Sum}	>4
P_{Sum}	**about 40($5)**

Table 6 Total of the China's geospatial industry in 2006

$P_{Sum}=P_{GIS}$ +PRs + PRa +PRd'+PGNg+PSVs+（PCs+ PCns+ PCo）+ P_O =36.3 + ΔP_{Sum}

（P_C =PCs+ PCns+ PCo）

ΔP_{Sum} includes：1) Part of output value of satellite remote sensing data industry (PRs) is not be calculated, mainly including CBERS and "Beijing No. 1" satellite data output. 2) Part of output value of aerial remote sensing photogrammetry (PRa) and remote sensing data processing services and applications (PRd') is not be calculated. 3) The ignored part of mapping industry, including part of professional mapping companies and institutes and all non-professional mapping companies and institutes. 4) Output value of other emerging industry, such as LBS, and internet map services,etc. 5) Output value of companies without qualifications for surveying and mapping which engage in geoinformation process. 6) Output value of geospatial related application by IT company which is not a small number by case study in Beijing. 7) Output value of other parts which are not calculated. All these output value of the above parts, by the estimation of experts from SBSM, is more than 4 billion Yuan. Namely,

ΔP_{Sum}>4 billion Yuan (about $ 0.5 billion)
P_{Sum} >40 billion Yuan (about $5 billion)

From the above survey and research, it can be concluded that the output value of China's geospatial industry is over 40 billion Yuan (about $5 billion). Since the study doesn't select samples from Hong Kong, Macau and Taiwan special administrative region, the result of 40 billion Yuan(about $5 billion) is only the lowest approximation of the Chinese mainland geospatial industry size. According to the result, the output value of geospatial industry is 8.4 percent of that of Chinese software industry, 1.2 percent of high-tech industry, 0.19 percent of Chinese GDP in 2006.

4 WORKING POPULATION AND NUMBER OF COMPANIES AND INSTITUTES

Working population is a key indicator to describe the industry size. According to the definition of the overall labor productivity in economics, the working population can be calculated by the geospatial Industry output and the overall labor productivity as formula 4-1.

WP= V/P
(Formula 4-1)

WP: Average Number of Staff and Workers;
V: Value Added of Geospatial Industry;
P: Overall Labor Productivity of Geospatial Industry

Since the Chinese surveying industry is one of the key branches of the geospatial Industry, it also refers to all other industry branches, such as GIS industry, RS industry, GNSS industry and mapping industry. The study uses the overall labor productivity of surveying industry as the approximation of the geospatial industry labor productivity. For the surveying industry labor productivity is 116,214 Yuan per person in 2005(SBSM, 2005) and the total output of the geospatial industry is 36.28 billion RMB in 2006. According to formula 4-1, the working population of China's geospatial industry in 2006 is 312,182.

Number of companies and institutes is another indicator of industry size. There are two categories of companies and institutes in geospatial industry, one is with qualification on surveying and mapping, and the other is not. According to SBSM, there are over 9,096 companies and institutes with qualification on surveying and mapping in China. Besides, there are still a large number of companies and institutes without qualification. It is found out by case study of Beijing that there are over 1,000 geospatial-related companies and institutes, among which there are only 185 companies and institutes have qualification on surveying and mapping. Therefore, It is estimated that there are more than 10,000 companies and institutes in China.

5 CONCLUSION

Under the situation of poor data availability, the study decomposes and modifies the indicator of industry size according to the characteristics of different industry branch and its data availability. By accessing value of each indicator, the study finally obtains the value of geospatial industry size (more than 36.3 billion Yuan). Based on the value of industry size and overall labor productivity, working population of geospatial industry is calculated out as 312,182. The number of companies and institutes is estimated more than 10,000.

For the growing demand of geographic information, continuous innovation of geoinformation technology, increasingly rich of geographic information resources, increasing number of geoinformation professionals, the China's geospatial industry size is developing and expanding rapidly. It's difficult to study the industry development status with traditional static method. Despite of the error, the method of indicators decomposition and modification of key industry branches adopted in the study is an effective approach to access the industry size.

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