The determinations of remote sensing satellite data delivery service quality: A positivistic case study in Chinese context

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Abstract. With the development of remote sensing technology, remote-sensing satellite has been widely used in many aspects of national construction. Big data with different standards and massive users with different needs, make the satellite data delivery service to be a complex giant system. How to deliver remote-sensing satellite data efficiently and effectively is a big challenge. Based on customer service theory, this paper proposes a hierarchy conceptual model for examining the determinations of remote-sensing satellite data delivery service quality in the Chinese context. Three main dimensions: service expectation, service perception and service environment, and 8 sub-dimensions are included in the model. Large amount of first-hand data on the remote-sensing satellite data delivery service have been obtained through field research, semi-structured questionnaire and focused interview. A positivist case study is conducted to validate and develop the proposed model, as well as to investigate the service status and related influence mechanisms. Findings from the analysis demonstrate the explanatory validity of the model, and provide potentially helpful insights for future practice.

1. Introduction
Since 1988, the first remote sensing satellite FY-1A had been launched; China has made considerable development in satellite industry in recent years, forming a satellite industry chain from manufacture of space, ground and terminal products to operation service. This has contributed significantly to economic development and other social undertakings. The satellite application is at the end of the remote sensing satellite industry chain, and plays a decisive role in the development of remote sensing satellite industry. Remote sensing satellite data delivery service is a typical process of value co-creation. Thus, similar to Internet service, the marginal cost of remote sensing satellite data delivery service approaches zero. Consequently, improving the service quality of remote sensing satellite data delivery service is an important way to promote the development of remote sensing application and China’s satellite industry.

Service quality is quite different from products quality, which has caused widespread concern of researchers. Remote sensing satellite data belongs to high-tech product, which requires professional skill to operate. What’s more, as the number of satellites increases, the application areas of satellites enlarges, the extent of satellite application becomes deeper and the satellite industry chain expands, current satellite service mode can’t meet the increasing demand. We need to combine traditional service theories with remote sensing satellite industry, to enhance service capability of remote sensing satellite data delivery and enlarge its application depth and breadth.

This article first analyzes characteristics of remote sensing satellite data, and a hierarchy conceptual model of the determinants of remote sensing satellite data delivery service quality was proposed. Then
firsthand data was collected by field research, semi-structured questionnaire and focused interview. Finally content analysis was applied to analyze these data and tested and verified the proposed model.

2. Remote sensing satellite data delivery service

2.1. Characteristics of remote sensing satellite data
Remote sensing satellite data is different from consuming goods in product types. Its user is mainly enterprise and public institution, who is different from common consumers in many aspects, such as concerning points, consuming behaviours and so on. Combined with general service characteristics, service targets and service procedure, this article analyses the characteristics of remote sensing satellite data delivery service from the following aspects:

2.1.1. Intangibility. Service is a process whose emergence and termination have great uncertainties. Although auxiliary tools or load-bearing objects will be applied during the service, the whole process is intangible and can’t be kept or replayed. Remote sensing satellite products compose a set of solutions centering on satellite images whose physical property is intangible. Sequentially the service is intangible with intangible products as service contents.

2.1.2. Simultaneity of production and consumption. Service is a process of joint participation between providers and consumers. Service consumers enjoy the service in the same course as the provider provides the service. For remote sensing satellite data delivery service, providers and customer must participate simultaneously. Providers should provide products and solutions and assist customer in solving problems according to users’ demands. During such interaction, both parties of service jointly finish the production and consumption of service.

2.1.3. Interaction and customization. Customization is a marketing variable, referring to the ability to deliver service to customer individually. If service is standardization instead of customization, little interaction is needed between provider and customer. Remote sensing satellite data delivery service includes generating satellite images with specific area and accuracy according to customers’ demand. Hence, remote sensing satellite data delivery service enjoys high degree of interaction and customization.

2.1.4. Information technology dependence. Remote sensing satellite belongs to high-tech industry, and its development largely depends on remote sensing technology. Meanwhile, communications technology, GPS, GIS, database technology and virtual reality technique are integrated into the service delivery process. This requires that designers of the service pay close attention to the development of remote-sensing technology and other related technologies. Moreover, it has higher requirement for professional skill of the service staff and basic remote sensing knowledge of the customer.

2.1.5. The way of service delivery. As communication technology developed, far-distance trading becomes possible. In particular, the popularization of Internet promotes the adoption of e-service, as Internet makes it delivery convenient and fast. The core product of remote sensing satellite is satellite image, which is usually in digital form and can be delivery through Internet. The process of remote sensing satellite data delivery includes acquiring customer demand, product customization and diffusion, payment and after-sale service.

2.2. Hypothesis model for remote sensing satellite data delivery service quality
As information technology has been merged into the service industry, boundary between service and product is vaguer. Customers of remote sensing satellite data delivery service are usually groups with specific professional demands. In the process of data delivery, completed products consultation and technical support is indispensable. In conclusion, the process of remote sensing satellite service
combines e-service and traditional service together. Its characteristics of long cycle, high interaction and frequent reciprocation lead to multi-dimension of remote sensing satellite data delivery service.

Based on what has been mentioned above, and service performance model proposed by Grönlund, this paper proposed a hierarchical model listing all possible determinants of remote sensing satellite data delivery service quality. As is shown in table 1, this hypothesis model includes three main dimensions: service expectation, service perception and service environment, 8 sub-dimensions, and 24 factors.

| Dimension                  | Sub-dimension               | Factor                                           |
|----------------------------|-----------------------------|--------------------------------------------------|
| Service perception (SP)    | Service interaction (SP1)   | Attitude of service employee (SP1-1)             |
|                            |                             | Behaviour of employee (SP1-2)                    |
|                            |                             | Professional skills (SP1-3)                     |
|                            |                             | Service process and assurance (SP1-4)           |
|                            |                             | Ability of customization (SP1-5)                |
|                            |                             | Service climate (SP1-6)                         |
| Software and hardware facility (SP2) | Web service ability (SP2-1) |                                               |
|                            |                             | Hardware facility (SP2-2)                       |
|                            |                             | Data process ability (SP2-3)                    |
|                            |                             | Data management ability (SP2-4)                 |
| Service outcome (SP3)      |                             | Waiting time (SP3-1)                            |
|                            |                             | Image quality (SP3-2)                           |
|                            |                             | Demand satisfaction (SP3-3)                     |
| Service environment (SC)   | Government support (SC1)    | Data sharing and distribution policy (SC1-1)    |
|                            |                             | Policy and financial support (SC1-2)            |
| Industry climate (SC2)     |                             | Development phase (SC2-1)                       |
|                            |                             | Intensity of competition (SC2-2)                |
| Service expectation (SE)   | Internal incentives (SE1)   | Past experience (SE1-1)                         |
|                            |                             | Specification in demand (SE1-2)                 |
|                            | External incentives (SE2)   | Alternative service (SE2-1)                     |
|                            |                             | Social factor (SE2-2)                           |
|                            |                             | Word of mouth (SE2-3)                           |
|                            | Organizational behaviours (SE3) | Marketing strategy (SE3-1)                    |
|                            |                             | Potential service ability (SE3-2)               |

3. Methodology

Questionnaire is widely employed in service quality research. Structured questionnaire can improve reliability and validity of research. However, as little research focused on the research of service quality of remote sensing satellite data delivery, it's hard to design a well-structured questionnaire to investigate the service quality of remote sensing satellite data delivery. Focus group is an important way to get first hand customer data. Compared with questionnaire, interview can get more unexpected information. Lacking of related research on service quality of remote sensing satellite data delivery service, this paper chose interview to collect research data. In order to test and explain the proposed hypothesis model, content analysis was applied to mine the interview records. The outline of interview was designed according to the hypothesis model.
3.1. Interview design

The interview was built on the proposed hypothesis model in section 3.2. For each determinant in the model, there was a corresponding question item in the interview outline. The interview outline included both semi-constructed questions and open questions. Semi-constructed questions are based on the determinants proposed in the hypnosis model. The answers for open questions are unexpected and free from researcher’s subjective attitude. Determinants ignored by researchers will be acquired by the open question. The outline was modified during the interview progress to create a good atmosphere and discover new opinions.

Time for each interview was about 2 hours. The whole interview progress was recorded. After interview, we typed the record into words without any revision, restoring interview progress as much as possible.

3.2. Data analysis

Content analysis is a summarizing, quantitative analysis of messages that relies on the scientific method, and is not limited as to the types of variables that may be measured or the context in which the messages are created or presented. It has been widely used in social science. In this paper, content analysis was applied to mine the interview records.

We adopted a common used method to code the data. Two doctoral students in service quality field were responsible for coding. They reached agreement on outlines and hypothesis model. After one student had finished analyzing and coding, the other would check the result. In case of disagreement on certain coding, they would reach an agreement by discussing.

Table 2 was a coding sample. The coding steps were as follows: For each record (row 1), carefully examined it based on the interview outlines, and we extracted sentences (row 2) which could reflect the factor in the proposed model, then mapped it with factors (row 3) in table 1.

| Interview records | Content                                                                 | Factor |
|--------------------|------------------------------------------------------------------------|--------|
| Interview1.txt     | The satellite data delivery service sector lacks of efficiency         | SP1-4  |
|                    | and look like a bureaucracy.                                           |        |
|                    | Service process is not standard, and full of uncertainty. Our          |        |
|                    | SP1-4 service demand can’t be responded in time. I hope they can       |        |
|                    | SP1-2 build effective communication channel, standardize service       |        |
|                    | process, and reduce uncertainty.                                       |        |
| Interview2.txt     | Compared with foreign remote sensing satellite data, our              |        |
|                    | SP3-2 data quality should be improved a lot.                           |        |

4. Results and analysis

A total of 13 focus group interviews were conducted. 11 of the focus groups were from the satellite data consuming department, and 2 of the focus groups were from the satellite data providing department. Altogether, 41 people from different departments took part in the interview, including frontline workers and department leaders. Thus, the collected data covers main aspects of remote sensing satellite application, enhance the research’s reliability and validity as well.

The coding result is shown in table 3. There were 130 codes altogether, 5.16 for each determinant in average. The variance of coding result is 9.49, demonstrating there is obvious difference between those factors. Service process and assurance (SP1-4) got the highest coding support, while hardware facility (SP2-2)’s support coding is zero. We will analyse the coding result for service perception, service environment and expectation in the following.
Table 3. Coding result.

| Factor  | Coding numbers | Factor  | Coding numbers | Factor  | Coding numbers |
|---------|----------------|---------|----------------|---------|----------------|
| SP1-1   | 2              | SP2-2   | 0              | SC1-2   | 4              |
| SP1-2   | 2              | SP2-3   | 6              | SC2-1   | 4              |
| SP1-3   | 6              | SP2-4   | 6              | SE1-1   | 3              |
| SP1-4   | 12             | SP3-1   | 7              | SE1-2   | 6              |
| SP1-5   | 8              | SP3-2   | 9              | SE2-1   | 5              |
| SP1-6   | 2              | SP3-3   | 10             | SE2-2   | 2              |
| SP2-1   | 11             | SC1-1   | 3              | SE 2-2  | 2              |

4.1. Service perception

In service perception dimension, service results were measured in 3 aspects: waiting time (SP3-1), product quality (SP3-2) and extent to which demands was satisfied (SP3-3), the average coding number for these three items is 9, more than service perception(5.4) and software and hardware facility(5.75). Customer’s perception is result-oriented, what customers care most is whether their demand can be met. In addition, satellite data users are mainly organizations, who focus on outcome of the service most. Service process and assurance (SP1-4), customization (SP1-5) and professional skill (SP1-3) in service interaction dimension also get great support. The service process of remote sensing satellite data delivery is far from standardization, and customers can’t get professional support from the technical support staff. Customization is an important determinant of service perception. Customers with different demands should be treated differently. Compared with attitude (SP1-1) and behavior (SP1-2), professional skill (SP1-3) is more important in satellite data delivery service. As remote sensing satellite data is mainly delivered through website, service provider should pay more attention to the ease of use, responsibility and reliability of the website. What’s more, as the accumulation of satellite data, service providers are facing big data management and distribution problem. How to effectively manage the huge data and distribute them to customer efficiently is a big challenge.

4.2. Service expectation

In service expectation dimension, internal incentive (SE1) is an extremely important factor. Users of satellite data are clear of what they need, so specification in demand (SE1-2) has more impact on service expectation than past experience (SE1-1). Among the external incentives (SE2) factors, alternative service (SE2-1) imposes great impact on service expectation. Because customers have more choice options as the number of service providers increases. Organization behavior (SE3) also influences customer’s service expectation heavily. Compared with marketing strategy (SE3-1), potential service capability (SE3-2) of satellite data service provider gets more support. The reason is that customers generally believe that there is a promising future of Chinese remote sensing satellite industry.

4.3. Service environment

In China, satellite industry is mainly supported by government. So government policies have an important impact on satellite data delivery service quality. Especially the data sharing and distribution
policy (SC1-1), which decides which type of satellite data could be shared and distributed, and the cost of customer pay for the data they want. Policy and financial support (SC1-2) decide the development rate of satellite industry, which in turn affect the service quality of satellite data delivery. Industry climate (SC2) is an important determinant of remote sensing satellite data delivery service quality. Remote sensing industry is still in the early stages of its life cycle and customer focus on data quality rather than service quality. Currently, the intensity of competition (SC2-2) is quite low, and service provider’s willingness to increase service quality is quite low too.

5. Conclusion
Remote sensing satellite has been widely used in agriculture, forestry, disaster mitigation, urban planning etc., and provides great support for national economy construction. How to improve remote sensing satellite’s service quality is a fundamental concerning. This paper aims to explore critical factors of remote sensing satellite data delivery service quality and provide decision support for China remote sensing industry.

Based on the research results of former scholars and remote sensing satellite data characteristics, we built a remote sensing satellite service quality model incorporating three dimensions: service perception, service environment and service expectation. Each dimension was divided into specific items. Focus group was conducted to collect research data. Content analysis was applied to analyze the interview data. Coding result proves that the proposed model is well supported by the interview data. Our research is helpful for managers to definite composite of remote sensing satellite service quality and make clear of critical factors for service quality. Besides, this model is an effective instrument for remote sensing satellite service departments to conduct self-inspect.

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