Data Asset Value Assessment Literature Review and Prospect

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Abstract. With the development of the internet, Cloud Computing and other new generations of information technology, the society has entered the era of Big Data from the Information Age, the role of Big Data is becoming more and more powerful in human decision-making support, and the exchange of big data property rights value has become a new hot spot for social and economic development. This paper analyzes the connotation, extension and the basic characteristics based on the value dimension of data assets, combs the research results of scholars in the value evaluation of data assets at home and abroad, and puts forward the development direction of the value evaluation of data assets in the future around the natural value-added, externality and multi-dimensional value characteristics of data assets, in order to pave the way for future scholars.

1. Introduction
The rapid development of the new generation of information technology has led the digital economy to stride forward. Through radio frequency identification (RFID) and other information sensing technologies, the Internet of things realizes the interconnection of everything with data, accelerating the process of digitization of the world; Through ultra-wideband, ultra-high speed and ultra-low latency data transmission, 5G will turn the Internet of everything anytime and anywhere into reality, supporting the rapid development of the Internet of things; Cloud computing provides powerful computing power through distributed computing, parallel computing and other technologies, realizing instantaneous processing of huge amounts of data while reducing IT costs. Artificial intelligence mines data value through machine learning, deep learning and other technologies, and converts unordered data into decision information. Data is developing towards the trend of more convenient data collection, faster data processing and more perfect data application. The huge economic value contained in data needs to be realized urgently.

On November 1, 2019, the fourth Plenary session of the 19th CPC Central Committee put forward the data as the fourth factor of production after land, labor and capital in official documents, fully affirming the asset value of the data. How to evaluate the value of data assets has become one of the hot topics among scholars. This paper will introduce the connotation and extension of data assets in
detail, analyze and summarize the present situation of data assets value evaluation, and try to make a good conclusion for scholars in this field.\(^1\)

## 2. Related concepts and characteristics of data assets

### 2.1. Related concepts of data assets

The data capitalization can realize the direct delivery and transaction of data resources, which is beneficial to fully release its economic value. But not all data can be converted into data assets. The cloud computing and big data institute of the China Institute of Information and Communications defines data assets as "physically or electronically recorded data resources, such as documents, electronic data, which are owned or controlled by an enterprise and can bring future economic benefits to the enterprise" \(^1\). From the perspective of value generated by data, data does not produce benefits directly. Only by developing the information contained in data can value be generated. The raw data could release valuable information to the enterprise after the steps of data collation, processing, cleaning, analysis and visualization. In addition, the clear ownership of property rights is the premise of the circulation of data assets. Only the clear ownership and use right of data can reasonably distribute the income generated by data. Therefore, data assets is data whose property ownership is clear go through the data capitalization process including data processing, data cleaning, data mining. The identification process of data assets is shown in figure 1 below:

![Figure 1 Identification process of data assets](image)

| Concept       | Definition                                                                 | Concept connotation or distinction                                  |
|---------------|----------------------------------------------------------------------------|---------------------------------------------------------------------|
| Web Information | Everything that can be digitally or digitally simulated and that can be       | The network information product exchange happens between the upstream and downstream enterprise, the |

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\(^1\) This paper is one of the achievements of the project of "Research On Data Assets Right Confirmation Under Big Data Environment" (project number: 16BTQ075) which approved by National Social Science Fund of China in 2016.
2.2. Characteristics of data assets

As a new factor of production, data is traded in the market, which makes the data assets have asset attributes. From the composition of data assets, Only through data analysis and mining of massive, valuable and diversified data can information with economic benefits be produced. The above-mentioned characteristics are the basic characteristics of big data. Therefore, the raw data before the data assets are capitalized is a subset of big data. In addition, The value of the transaction of data assets lies in the transfer of intelligence information, so the essence of data assets is an information commodity. In summary, data assets have the characteristics of information commodity, assets and big data. Among them, the characteristics of quasi-public goods of information commodities and the basic characteristics of big data bring externality and natural increment of data assets. Details are shown in table 2:

| Characteristics of data assets | Concept connotation | Impact on value assessment |
|-------------------------------|--------------------|---------------------------|
| **Asset characteristics**     | Resources formed by past transactions or events, owned or controlled by the enterprise, that can bring potential benefits to the enterprise in the future. | Data can be traded as assets in the market |
| **Basic characteristics of big data** | "4V Characteristic", that is, volume, varity, Velocity, and value | Information value of data assets |
| **Characteristics of quasi-public goods** | Limited non-exclusive and non-competitive | The cost of reproduction is extremely low, easily causes the property right ownership unclear, causes the data asset value increment part to be difficult to determine. |
| **Externality**               | The use of data assets can bring the effect of positive market feedback, and consumers consume data assets, not only to bring their own utility, but also to others. | The more consumers consuming data assets, the greater the value of data assets. |
| **Natural value added**       | Raw data and derivative data are generated in large quantities every moment, which can creating new value. | The value of data assets changes dynamically every moment. |
| **Multidimensional**         | The information contained in the index assets can have the objective attribute of satisfying human existence and development in many aspects. | The information contained in the data assets has different value quantities for different people. |
3. Current status of the data asset valuation study

The author divides the current data asset value evaluation into four types, namely, the traditional intangible asset evaluation method faction, the intangible asset evaluation method improvement faction, the quantitative impact factor evaluation faction and the algorithm evaluation faction. Among them, the traditional intangible assets appraisal scholars refer to the use of one or more traditional intangible asset evaluation methods to evaluate the value of data assets, such as market method, cost method and income method; The improvement of intangible assets evaluation method refers to the adaptive improvement based on the traditional intangible assets evaluation method by adding various adjustment coefficients according to the characteristics of data assets. Quantitative impact factor evaluation method refers to finding out the value influencing factors of data assets at first, then determining the weight of each value influencing factor according to the analytic hierarchy process, and then determining the value evaluation model of data assets. Algorithm evaluation refers to the use of classification, clustering, regression and other machine learning methods to calculate the value of data assets.

3.1. Traditional intangible asset evaluation faction

Liu Lianghui (2002) thinks that data assets are different from intangible assets. The cost composition and profit size of the data assets are uncertain because of the virtual product production process, and the way of bringing excess income to the enterprise is different from the intangible assets. Therefore, we should adopt the historical cost method in the development stage, and use the market method to measure the excess benefits of the data assets in the application stage [8]. Tong Yonggang (2008) believes that the measurement of data assets should be continuous, and the additional expenditure on the new value of data assets should be included in the book value of data assets [9]. Zhang Yongmei (2015) thinks that financial data assets are a kind of self-made intangible assets that can be profited but not easily quantified, so the replacement cost method is used to evaluate the value of financial data assets [10]. Li Ru (2017) believes that the cost of data assets should be recognized in different stages by means of external purchase, active acquisition, passive acquisition, etc [11]. Xu Yi (2017) recognized that the cost of data assets is a dynamic index, and the cost of data assets mainly comes from the construction cost and operation and maintenance cost of data collection, storage and processing system [12]. Li Yonghong (2017) refined the traditional intangible asset value evaluation method according to the characteristics of the Internet, and added the operating cost, comparable asset market value, future income and other influencing factors to the Internet enterprise data asset value evaluation [13].

It can be seen from the research of the above scholars that the scholars of this faction measured the value of data assets by using the traditional intangible assets valuation methods such as cost method, income method and market method alone or in combination. Some scholars directly to data assets shall be regarded as intangible assets, and some scholars can realize data assets differented from intangible assets because of the value-added features of data assets, but there is no explanation for how to estimate the value-added content of the data assets.

3.2. Intangible asset evaluation method improvement faction

Liu Qi (2016) proposed modifying the market method to evaluate the value of data assets. On the basis of the value of the similar big data assets, quantitative adjustment of different factors such as technology level, value density and data capacity [14]. Zhu Dan (2017) realized that data assets have spillover value. Based on the traditional cost method of intangible assets, he comprehensively considered the cost and expected use premium of data assets, and modified the asset value by adding influencing factors on the value of government data assets, so as to put forward the value evaluation model of government data assets [15]. Le Huang (2018) adds production cost, operating cost, data realization factor, premium rate coefficient, number of users of platform, network node distance, user activity coefficient, market adjustment coefficient and other value adjustment coefficients on the basis of comprehensive consideration of data assets cost and income, and pioneering the introduction of platform activity coefficient and other parameters into platform-type data asset value evaluation model.
[16]. Chen Tingting (2013) modified the income method to introduce the spillover value generated by the brand into the value evaluation of the trademark[17].

It can be seen that above scholars approve that the data assets are obviously different from the intangible assets, and realize the necessity of evaluating the value increment of the data assets, and the various value adjustment coefficients will be added when the traditional intangible assets evaluation method is used to evaluate the data assets.

3.3. Quantitative impact factor evaluation faction

The quantitative influence factor assessment group puts forward the value influence factors of the data assets from the different classification angles of data assets cost, application, maintenance and so on, and carries on the weight analysis to the various value influence factors according to the analytic hierarchy process, and then establishes the data asset value evaluation model. As shown in table 3:

| The author                  | Evaluation object                  | Methods                               | Classification of Angle                                                                 | Influence factors                                                                 |
|-----------------------------|------------------------------------|---------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Zhang Zhigang (2015)        | Data assets                        | Analytic hierarchy process(AHP)       | Data asset cost, data asset application                                                  | Construction cost, operation and maintenance cost, asset classification, frequency of utilization, objects, use effect evaluation |
| Hak J. Kim (2015)           | Data assets                        | -                                    | Mapping to business value based on the characteristics of big data                       | Corresponding granularity of data volume characteristics; Data timeliness characteristic correspondence analysis speed; Data diversity corresponds to data type; Data variability corresponds to analysis reliability. |
| Shi Aixin (2017)            | Internet enterprise data assets    | AHP and principal component analysis(PCA) | Data collection, processing (construction and application) and maintenance                | Channel source, time span and geographical scope, business operation and technical operation costs, labor costs, material costs and overhead costs, R&D costs and promotion costs |
| Li Yonghong (2018)          | Data assets                        | The combination of AHP, grey relation analysis and market comparison               | Data quantity, data quality, data analysis ability                                       | Enterprise size, data coverage, data integrity, data externality, data timeliness, data relevance and information systems, talent skills, consumer needs |
| Tao Yiran (2019)            | Platform data assets               | AHP                                   | Platform Value Influencing Factors                                                      | Granularity, Diversity, Activity, Scale and Relevance of Platform Data             |
| Wang Jing (2019)            | Internet Financial Enterprise Data Assets | AHP and practical option research | Data control layer, user access layer, data application layer, data computing layer, data exchange layer, data generation layer | Internal and external users, data value-added products, data areas, data exchange components and platforms, data control platforms, data standards, data quality, light data, data security, data types, data sources |
| Guo Yiban (2019)            | Internet Financial Enterprise Data Assets | AHP and practical option research | Platform operating data, investor data assets and borrower data assets                  | Platform operating data assets, investor data assets, borrower data assets, executive data asset value, data asset volatility, data asset life cycle, data asset risk-free rate |

In addition, Gartner, the world's most authoritative information research and consultancy company, jointly released the world's first data asset evaluation model in 2016, which is based on the quantity, scope, quality, granularity, relevance, limitation, source, scarcity, industry nature, equity, nature of transactions, expected benefits and so on.
3.4. Algorithm evaluation faction

Wang Jianbo (2006) believes that the artificial intelligence method can be used to evaluate the value of data assets. Artificial neural network has high self-organizing, adaptive and self-learning ability, which can make objective evaluation and prediction of the application value of data itself. Not only can it overcome the influence of artificial factors and fuzzy randomness brought by artificial evaluation, but also ensures the objectivity and accuracy of evaluation results. Besides, it has strong dynamic, which can provide important basis for the determination of data price [25]. Zhang Chi (2018) proposed using deep learning method based on data characteristics to establish a data asset value evaluation model based on five dimensions: data granularity, activity, correlation, multi-dimensional and scale [26].

From the research of the above scholars, it can be seen that this scholar fully realizes it's data characteristics such as data dynamic, data scale, data quality that play a important role in data assets valuation and tries to use machine learning to evaluate the value of data assets.

Through the above literature research, we can get the following conclusion: Firstly, Data assets are initially regarded as intangible assets, and the value is evaluated according to the traditional intangible assets evaluation method. Secondly, since the cost method cannot accurately measure the value-added effect after the data capitalization, the operability of the income method and the market method are not applicable, scholars began to modify the traditional intangible assets evaluation method by adding various correction factors data assets different from intangible assets. Thirdly, as the boundaries between data assets and intangible assets are becoming clearer, data assets are beginning to be evaluated as a separate category. At present, the evaluation methods are mainly analytic hierarchy process, fuzzy comprehensive evaluation method, artificial intelligence method and so on. The characteristics of this kind of method are classified according to the influencing factors of data asset value and weight analysis and then valuation modelling.

4. The difficulty of data asset valuation

4.1. Difficulty of redistributing the value of property rights

It is difficult to redistribute the value of property rights due to the continuous transfer of data ownership along with the increment of data circulation. In the process of Data assets circulation, data property rights of personal data rights and data property rights will also be transferred. Specifically, data flow can realize value mining of scenario application in this circulation. While data decision, confidentiality, query, correction, blockade, deletion and compensation request are transferred among different owners along with the flow of data assets. Different property right owners can record, retrieve, sort out, label, compare, analyse and mine the data through these data rights to realize data increment. To determine the value of the increment of data assets, it is necessary to consider the change of property value, that is, the contribution of each transferor to the increment.

Shi Xianwang pointed out that the value of property rights is the redistribution of rights, responsibilities and benefits [27]. To evaluate the value of data assets, first of all, it is necessary to clarify the rights of property owners to jointly own, use and dispose of the data assets and the right to obtain the income generated therefrom. The responsibility is that the subject of property rights should assume (such as the true validity of data, etc.), which means the right to the data assets must be confirmed. However, the liquidity of data makes the right of data confirmation very complicated. At present, China has not formed a reasonable and mature right mechanism of data assets.

4.2. Difficulty of evaluating the value increment of data assets

Changes in data rights structure make it difficult to evaluate the value increment of data assets. Ownership of data assets determines the distribution of data value benefits and the division of data quality and security responsibilities [28]. Data property right, like commodity, has two attributes of value and use value, so it has two forms of rights, the utilization and proprietary rights, which would be separated during the process of data circulation. According to "who produces, who enjoys; who
records, who owns” principle, data assets is owned by the data provider during the data generation phase. While in the data increment phase, the increment ownership belongs to the data processor. Different ownership of property rights will produce different range of data to be used, and the change of data right structure reflected in the circulation is difficult to grasp, which makes the value appreciation and value evaluation of data assets extremely complicated.

5. The prospects of data assets valuation

5.1. Dynamic valuation

The natural appreciation of data assets requires that the dynamic value of data assets be evaluated. On the one hand, the volume of data is growing exponentially every second, making the value of data changing dynamically. In addition to the original data generated, derived data is generated in the application process of data exchange and sharing during the process of data circulation. In the process of scenario application, data assets can still obtain new data assets at different levels, and the accumulation of such assets is theoretically infinite [3]. However, since the derived data is generated in the iteration of data sharing, its attribution problem is more complicated than the original data, and it needs to be differentiated according to the actual situation. The huge amount of original data and derived data appearing every second will increase the value of data assets, making the value of data assets increase with time. At this point, a single static value evaluation model is no longer applicable. The specific data asset valuation framework should look like figure 2:

![Data asset valuation framework](image)

Figure 2 Data asset valuation framework

5.2. Focus on spillover value

The externality of data assets requires that the spillover value generated by the data assets in circulation be assessed. Data assets have the externality of network information products and can produce the effect of positive market feedback. Unlike ordinary commodities, the externalities of network information products must be positive because consumers bring utility not only to themselves but also to others through consuming data assets. The more consumers consume the data assets, the more valuable the data assets become. This can be explained by Metcalfe’s law, which says that as the number of users increases, the value of the network increases at the rate of the square of the number of users. Therefore, the value composition of data assets should include not only the capitalization expenditure of data, but also the overflow value generated in the circulation process of data assets.

5.3. Applicable to different scenarios

The multidimensionality of data assets requires that the value of data assets be determined according to different application scenarios. The multidimensional objective attribute of data assets and the different needs of people will produce different values. In other word, the multidimensional nature of data assets will result in the same information acting on different objects to produce different values. The core value of data assets is the information contained in them. Since the information receiving ability of the object and the conditions for using the information are different, the effect of data assets containing the same information content and amount of information is different. This is not only because of the difference in the ability of different objects to receive and understand information, but
also because of the different purposes of the objects to use the data assets will lead to the difference in the utility of the data assets. Therefore, according to the different purposes of data assets, data assets should be divided into application scenarios for value evaluation.

6. Conclusion
With the digital economy developing rapidly, the huge economic value contained in data has realized gradually, and it can be seen that a large number of data assets are traded and circulated in the market. Therefore, how to evaluate the value of data assets is widely concerned by scholars. Scholars' valuation of data assets has just started in recent years. The author summarizes the current valuation methods of data assets as traditional intangible assets valuation method, traditional improved intangible assets valuation method, quantitative impact factor method and algorithm method. Data assets have experienced the progress from being identified as intangible assets at the beginning to being listed as a new category of data assets. The value increment characteristics and big data characteristics of data assets have also been converted into value impact factors, adding into the value evaluation of data assets. In order to value the data assets more accurately, it is the essential attributes of data assets that should be taken into consideration into the valuation which contains the natural increment, externality and multi-dimensionality characteristics, pointing the way to evaluate the dynamic value of data assets, focus on the spillover value generated by data assets in the circulation process, and make value evaluation according to different application scenarios.

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