Valuation of Enterprise Data Assets by Using the Improved Multi-period Excess-earnings Method

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Abstract: With the arrival of the information age, data assets owned by enterprises are becoming increasingly abundant and important. In order to better manage and utilize these data assets, this article first comprehensively considering the factors that affect the value of enterprise data assets, then establishes a new data asset value evaluation system by using the improved multi-period excess-earnings method, and apply it in combination with case studies, so as to achieve the goal of improving the value evaluation of enterprise data assets and making the evaluation results of enterprise data assets more accurate.

Keywords: Data assets; Asset valuation; improved Multi-Period Excess-Earnings Method; Analytic hierarchy process

1. Introduction

With the development and popularization of digital information technology, the amount of data owned by enterprises is becoming more and more huge. As a new factor of production in the era of big data, data can create a lot of profits for enterprises when it is transformed into assets and fully utilized. It is increasingly important to reasonably mine the value of data assets and improve the security management system of data assets. However, not all data can be a beneficial asset for the business. In general, a data asset is data recorded by physical or electrical means that is in the possession or management of an individual or company and is expected to provide the company with an inflow of operating profits. Different from other traditional assets, due to the reusability, processability, value variability, timeliness, information sharing and other characteristics of data assets, the prices formed by the use of various components of data assets in various scenarios are also very different. Therefore, how to more accurately evaluate the data converted into assets and realize the utilization and development of data assets has become an important goal of enterprise data management.

2. Comparison of Data Asset Valuation Methods

2.1 Cost Approach

The cost approach is one of the conservative traditional methods for evaluating data assets. The basic principle of this method is to estimate the value of enterprise data by conducting detailed accounting of the company's assets and liabilities. The basic formula is as follows:

$$Valuation\ of\ assets = replacement\ cost \times (1 - depreciation\ rate) \quad (1)$$

The application of cost approach requires recording previously disclosed financial data, which is more suitable for industries with clear asset inputs such as traditional manufacturing, and less suitable for enterprises with large amounts of data assets. Due to the fact that the cost approach focuses more on the past investments and expenditures of enterprises, without considering their future profitability, the accuracy of the evaluated enterprise data asset value results is not high. In addition, for data assets, their value is often influenced by factors such as the market position, supply and demand relationship, and technological innovation of the enterprise. Using cost approach to evaluate the value of data assets may result in a general underestimation of the evaluation value, making practical operations difficult.

2.2 Market Approach

The market approach applies the principle of substitution, which determines the value

of a company by comparing it with peers or similar companies in the open market. The basic formula for evaluating data assets using the market approach is as follows:

$$Data\ asset\ value = data\ asset\ value\ of\ similar\ enterprises \times Correction\ coefficient \quad (2)$$

Although the market approach takes into account factors such as supply and demand and industry competition, the evaluation of data assets using the market approach is greatly constrained in the current market context. There are two specific manifestations: firstly, there are few trading cases of data assets in the market, making it difficult to select comparable trading cases; Secondly, correcting the differences in asset values between comparable transaction cases and the evaluated data, there are currently some difficulties in determining the correction index, making it difficult to carry out practical operations.

2.3 Income Approach

The income approach is a commonly used method for evaluating the value of enterprise data assets. The object of enterprise data asset valuation is the future profitability of the enterprise, and the income method based on the predictable future cash flows of the enterprise can obtain a relatively reasonable valuation result after considering risks and discount rates comprehensively. The basic formula for evaluating data assets using the market approach is:

$$P = \sum Ft \times (1+i)^{-n} \quad (3)$$

Where P is the evaluation value of the data asset; T is the t-th year in the future; Ft is the amount of income for the t-th future income period of the data asset; N is the remaining economic lifespan; I is used to represent the discount rate.

However, this method also has some shortcomings. Firstly, the income approach relies on accurate financial forecasts and assumptions. If the predicted data is inaccurate or overly optimistic, the resulting valuation may deviate from the actual situation. In addition, the income approach cannot fully consider non-financial factors that cannot be directly reflected in a company's cash flow. Relying solely on the income method for enterprise valuation can lead to a lack of data asset value [1-2].

3. Construction of Data Asset Value Evaluation System

The value of data assets is difficult to calculate through a single method or model. To more accurately evaluate data assets, it is necessary to use multiple factors from different dimensions to evaluate the value of data assets. To a certain extent, intangible assets include data assets. Therefore, when studying data asset evaluation methods, this article first uses the multi period excess return method to calculate the value of enterprise intangible assets [3], and then uses the Analytic Hierarchy Process to divide enterprise data assets from the overall income of intangible assets, in order to evaluate the value of enterprise data assets [4]. The improved multi period excess return method combined with Analytic Hierarchy Process has the following formula:

$$V = \left(FCF - E_a - E_b - E_c\right)_t \times (1+i)^{-t} \times K \quad (4)$$

Among them, V represents the value of data assets, FCF represents free cash flow, Ea, Eb, and Ec respectively represent the contribution values of fixed assets, current assets, and other intangible assets other than data assets of the enterprise, i is the discount rate, and t is the number of years; K is the data asset sharing rate.

3.1 Determination of Important Parameters in The Model

Free cash flow (FCF) refers to the maximum amount of cash flow created by a company in its production and operation activities that can be distributed to capital investors, which is the balance of cash flow generated by the company's operating activities minus capital expenditures.

The contribution value of assets mainly consists of the contribution value of fixed assets, the contribution value of current assets, and the contribution value of other intangible assets. Among them, the contribution value of fixed assets Ea includes the income from fixed assets investment, depreciation compensation of

fixed assets, etc. Since fixed assets are usually of low liquidity and poor liquidity, the return rate is the latest five-year loan interest rate of the Central Bank; The contribution value Eb of current assets is equal to its investment return. As current assets generally refer to assets held by enterprises that can be quickly realized in the short term and have small value fluctuations, their investment return rate is generally measured using the one-year central bank loan interest rate; The contribution value of other intangible assets Ec includes intangible assets on the balance sheet with a specific amount and intangible assets off the balance sheet that are difficult to measure with a constant specific amount. Since the intangible assets on the balance sheet are similar to fixed assets, and the intangible assets off the balance sheet are mainly labor resources, the five-year treasury bond bond interest rate is selected as the return on investment of intangible assets on the balance sheet, and the average annual talent contribution rate in China is taken as the contribution rate of intangible assets off the balance sheet.

Considering the impact of time on asset value, the discount rate i can be calculated using the social average rate of return method, which can objectively reflect the present value of the overall assets of the enterprise.

The following parameter calculation formula can be derived from this:

$$FCF = Operating\ Cash\ Flow - Capital\ Expenditures \tag{5}$$

$$Ea = Annual\ Average\ Amount\ of\ Fixed\ Assets \times Return\ on\ Fixed\ Assets\ Investment + Depreciation\ Compensation \tag{6}$$

$$Eb = Annual\ Average\ Amount\ of\ Current\ Assets \times Return\ on\ Investment\ in\ Current\ Assets \tag{7}$$

$$Ec = Annual\ Average\ Amount\ of\ Intangible\ Assets \times Return\ on\ Investment\ of\ Intangible\ Assets + Annual\ Average\ Amount\ of\ Off\ Balance\ Sheet\ Intangible\ Assets \times Off\ Balance\ Sheet\ Intangible\ Asset\ Investment\ Return\ Rate + Amortization\ Compensation \tag{8}$$

$$I = Rf + \beta\ (Rv\ Rf) \tag{9}$$

In formula (9), Rf is the risk-free rate of return, usually using the five-year treasury bond bond interest rate; Rv is the social average return on assets; β means the risk coefficient of the enterprise.

3.2 Determination of Partition Rate K under Fuzzy Analytic Hierarchy Process

The influencing factors of data assets are the basis for evaluating the value of enterprise data assets. According to the theory of enterprise value contribution and the characteristics of digital assets, the value of data assets is mainly influenced by several aspects, including the acquisition cost, data quality, and technological application of data assets. As shown in Table 1, the cost of acquiring data assets refers to the investment of resources such as manpower, technology, time, and equipment in marketing, data collection, and storage processes. Generally, the value of assets is directly proportional to their acquisition cost. Meanwhile, the quality of data directly affects the value of enterprise data assets, mainly considering factors such as data accuracy, access activity, and timeliness of data updates. The processing, management, and innovation of data can measure the effectiveness of data asset technology application, and the better the application effect, the higher the value of data assets.

Establish a judgment matrix based on the hierarchical structure in Table 1. The judgment matrix can compare the factors that affect the value of enterprise data assets pairwise, reflecting the relative importance of all factors and avoiding the problem of difficult comparison and estimation due to the mixed nature of factors. Firstly, relevant asset appraisal experts and enterprise managers are invited to rate each element in the form of a survey questionnaire and assign specific values according to a proportional scale. The importance scale of the scoring is based on the nine-level scale method shown in Table 2, with values taken between 1-9 and its reciprocal.

After scoring, summarize the expert scoring results to obtain judgment matrices A, A1, A2, and A3. Calculate the maximum eigenvalue max, consistency factor CI, random consistency factor RI, and consistency ratio CR for each judgment matrix. The values of Ri are shown in Table 3. When the obtained CR value is less than 0.1, it is considered that the judgment matrix has passed the consistency test. If the consistency test result is not qualified, factor reassignment is required until it passes the test. Normalize the feature vector with the maximum eigenvalue to obtain the weight value, repeat the above steps to calculate step by step along the hierarchical structure, and finally obtain the weight vector WAi= (WA1, WA2, WA3) for the criterion layer and the weight vector WAii= (WAi1, WAi2, WAi3) for the scheme layer [5].

Table 1. Table Of Hierarchical System of Enterprise Data Asset Value Factors

Decision objectives	Criteria layer factors	Plan level factors
Enterprise Data Asset Value (A)	Data acquisition cost A1	Data acquisition cost A11
		Data storage cost A12
		Marketing cost A13
	Data Quality A2	Data Accuracy A21
		Data activity A22
		Data timeliness A23
	Technical Application A3	Data Processing Technology A31
		Data Management Technology A32
		Application of innovative technology A33

Table 2. Importance Scale

Importance scale	Comparative meaning
1	Two factors have equal importance
3	The former is slightly more important than the latter
5	The former is clearly more important than the latter
7	The former is more strongly important than the latter
9	The former is extremely important than the latter
2，4，6，8	Median value

In order to obtain a correct and reasonable sharing rate, we will continue to blur the weight vector and ask enterprise experts to comprehensively evaluate and score the performance of enterprise data asset plan layer factors within the boundary based on the percentage system. Among them, 100-70 represents strong, 70-40 represents moderate, and 40-0 represents weak. From this, the judgment matrix B is obtained. The weight WAii of the nine factors is multiplied by their corresponding evaluation matrix Bi to obtain the comprehensive evaluation matrix PAi of the scheme layer. Finally, the weight vector WAi of the criterion layer is multiplied by the overall evaluation matrix PAi of the scheme layer and divided into hundreds to obtain the data asset sharing rate K.

Table 3. Judgment Matrix Random Consistency Factor RI

Scale	1-2	3	4	5
RI	0.52	0.89	1.12	0.52
Scale	6	7	8	9
RI	1.26	1.36	1.41	1.46

4. Case Analysis

4.1 Introduction to Case Company Y

Y Company is based in the field of comprehensive express logistics services, focusing on developing procurement, production, circulation, sales, after-sales and other businesses. In recent years, with the company's investment in the comprehensive logistics operation network of cloud computing and big data technology, Y enterprise has accumulated many data assets in the production and circulation stages. While guiding daily business, it has gradually become a core asset that brings economic profits to the enterprise. Therefore, the above method can be used to estimate its value. Considering the temporal variability of data asset values, the benchmark date for this evaluation is determined to be December 31, 2022.

4.2 Determination of Evaluation Parameters for Y Enterprise

Table 4 shows the financial report data of Company Y disclosed on the Oriental Finance website for the past five years from 2018 to 2022. It is worth mentioning that due to Y Company's unprecedented major adjustment in its main business service model in 2019, costs have fluctuated abnormally. Considering the

rationality of the forecast, the 2019 data will not be considered for the current revenue and cost forecast.

According to the data in Table 4, the data for the next five years shown in Table 5 is fitted using the least squares method. Other data on free cash flow, such as period expenses and capital expenditures, are determined by the average proportion of the financial account to revenue in the past five years, and then multiplied by the predicted annual operating revenue [6]. Due to the disorderly changes in working capital obtained from the financial statements of Company Y, in order to simplify the processing, this article takes the average of 156 million yuan as the predicted value. According to formula (5), the final result is shown in Table 5.

Table 4. Table of Partial Financial Data of Company Y from 2018 to 2022 Unit: 100 million yuan

	2018	2019	2020	2021	2022
Operating income	138.56	344.41	355.01	417.40	474.30
Operating expenses	99.74	298.80	303.20	379.60	431.00
Period expenses	9.63	10.96	12.37	18.06	19.66
Depreciation and amortization	6.28	10.39	13.64	18.49	21.96
Capital expenditure	0.98	1.17	1.04	1.26	0.82
Changes in working capital	2.20	(29.36)	20.00	(15.36)	30.33
Average amount of fixed assets	37.69	55.79	79.61	117.26	138.80
Average amount of current assets	74.64	105.70	122.80	126.55	123.20
Average amount of intangible assets on balance sheet	9.91	16.29	22.94	33.90	42.68
Average amount of off balance sheet intangible assets	1.36	1.56	1.76	2.22	2.67

Table 5. Y Enterprise FCF Five Year Forecast Table Unit: 100 million yuan

	2023	2024	2025	2026	2027
Operating income	569.04	643.52	718.00	792.48	866.96
-Operating costs	491.01	546.23	601.45	656.67	711.89
-Period expenses	28.62	32.37	36.12	39.86	43.61
Profit before interest and tax	49.41	64.92	80.43	95.95	111.46
Profit after interest and tax	37.05	48.69	60.32	71.96	83.60
+Depreciation	22.37	25.30	28.23	31.15	34.08
+Amortization	1.17	1.32	1.48	1.63	1.78
-Capital expenditure	2.09	2.36	2.63	2.90	3.18
-Changes in working capital	1.56	1.56	1.56	1.56	1.56
Free cash flow	56.95	71.39	85.84	100.28	114.72

Similarly, the least squares method is used to perform regression analysis and prediction on the annual average amount of fixed assets, annual average amount of current assets, and annual average balance of intangible assets of enterprises over the past five years. The depreciation and amortization amounts are calculated using the data in Table 5. Among them, the latest five-year loan interest rate of the central bank is 4.45% announced in May 2022; The latest one-year central bank loan interest rate is 3.65%; The interest rate of five-year treasury bond is 3.52%; The average annual talent contribution rate in China is 34.5% [7-10]. The contribution values of Y Company's fixed assets, current assets, and other intangible assets other than data assets are predicted in Table 6.

According to statistics from the State Administration of Taxation, the average return on assets in 2022 was 7%; Y Company's β the risk coefficient is 0.81 and based on the formula (9) mentioned earlier, the discount rate i=3.52%+0.81 (7% -3.52%) =6.34% can be calculated.

4.3 Calculation of Data Asset Stratification Rate for Y Enterprise

Based on the hierarchical system table of enterprise data asset value factors in the model construction department, we will invite asset appraisal experts, Y enterprise data asset related professionals, and others to provide ratings. After sorting out the data, we will obtain corresponding judgment matrices. Among them, the judgment matrix A of the criterion layer factors on the value of enterprise data assets is shown in Table 7.

According to the criterion layer matrix calculation, λ max=3.0387, CI = 0.01935.

According to Table 3, the RI value is 0.52, and the consistency ratio CR=0.0372<0.1, indicating that the test is passed. The weight values Wi of each factor in the criterion layer matrix are 0.1062, 0.6333, and 0.2605, respectively.

Table 6. Five Year Forecast Table of Y Company's Asset Contribution Value Unit: 100 million yuan

	2023	2024	2025	2026	2027
Average amount of fixed assets	163.46	189.83	216.2	242.57	268.94
Fixed asset return rate	4.45%	4.45%	4.45%	4.45%	4.45%
Depreciation of fixed assets	22.37	25.30	28.23	31.15	34.08
Ea	29.64	33.75	37.85	41.94	46.05
Average amount of current assets	146.33	158.13	169.93	181.72	193.52
Return on current assets	3.65%	3.65%	3.65%	3.65%	3.65%
Eb	5.34	5.77	6.20	6.63	7.06
Average amount of intangible assets on balance sheet	50.20	58.51	66.83	75.14	83.45
On balance sheet investment return rate	3.52%	3.52%	3.52%	3.52%	3.52%
Average amount of off balance sheet intangible assets	2.90	3.23	3.56	3.89	4.22
Off balance sheet investment return rate	34.50%	34.50%	34.50%	34.50%	34.50%
Amortization of intangible assets	1.17	1.32	1.48	1.63	1.78
Ec	3.94	4.49	5.06	5.62	6.17

Table 7. Criterion Layer Judgment Matrix A

A	Acquisition cost A1	Quality A2	Technology Application A3
Acquisition cost A1	1	1/5	1/3
Quality A2	5	1	3
Technology Application A3	3	1/3	1

Next, the impact of various factors in the acquisition cost, quality, and technology application solution layers were scored and data processed, resulting in the judgment matrices A1, A2, and A3 shown in Tables 8-10. The A1 matrix of the scheme layer was calculated to have λmax =3.0387 and CI = 0.01935. According to Table 3, the RI value is 0.52, with a consistency ratio of CR = 0.0372<0.1. The test is passed, and the weight values of each factor W1i in the A1 scheme layer are 0.6333, 0.1062, and 0.2605, respectively.

The A2 matrix of the scheme layer was calculated to have λmax =3.0037 and CI = 0.00185. According to Table 3, the RI value is 0.52, and the consistency ratio is CR = 0.0036<0.1. The test is passed, and the weight values of each factor W2i in the A2 scheme layer are 0.6429, 0.1222, and 0.2299, respectively.

The A3 matrix of the scheme layer was calculated to have λmax = 3.0538 and CI = 0.0269. According to Table 3, the RI value is 0.52, with a consistency ratio of CR=0.0517<0.1. The test is passed, and the weight values of each factor W3i in the A3 scheme layer are 0.1416, 0.3338, and 0.5247 respectively.

Table 8. Judgment Matrix A1

A1	Data collection cost A11	Data storage cost A12	Marketing cost A13
Data collection cost A11	1	5	3
Data storage cost A12	1/5	1	1/3
Marketing cost A13	1/3	3	1

Table 9. Judgment Matrix A2

A2	Accuracy A21	Activity A22	Timeliness A23
Accuracy A21	1	5	3
Activity A22	1/5	1	1/2
Timeliness A23	1/3	2	1

When conducting fuzzification processing, this article invited ten data technology researchers who have some understanding of Y company to conduct comprehensive scoring and obtain the judgment matrix B. The specific situation is shown in Table 11.

The comprehensive evaluation of the acquisition cost of data assets are as follows:

$$PA1=(0.6333,0.1062,0.2605)\times\begin{pmatrix}0.5 & 0.2 & 0.3\\ 0.4 & 0.4 & 0.2\\ 0.2 & 0.4 & 0.4\end{pmatrix}=(0.4112,0.2733,0.3154).$$

Comprehensive evaluation of data quality:

PA2= (0.6429,0.1222,0.2299) $\times\begin{pmatrix}0.8 & 0.1 & 0.1\\ 0.5 & 0.3 & 0.2\\ 0.7 & 0.3 & 0.0\end{pmatrix}$= (0.7364,0.1699,0.0937).

Comprehensive evaluation of technological applications:

PA3= (0.1416,0.3338,0.5247) $\times\begin{pmatrix}0.4 & 0.3 & 0.3\\ 0.8 & 0.1 & 0.1\\ 0.2 & 0.2 & 0.6\end{pmatrix}$= (0.4286,0.1808,0.3906).

Table 10. Judgment Matrix A3

A3	Data processing technology A31	Data Management Technology A32	Application of innovative technology A33
Data processing technology A31	1	1/3	1/3
Data Management Technology A32	3	1	1/2
Application of innovative technology A33	3	2	1

Table 11. Table of Comprehensive Scoring of Y Enterprise Data Assets

	Strong	Moderate	Weak
Data collection cost A11	5	2	3
Data storage cost A12	4	4	2
Marketing cost A13	2	4	4
Data accuracy A21	8	1	1
Data activity A22	5	3	2
Data timeliness A23	7	3	0
Data processing technology A31	4	3	3
Data Management Technology A32	8	1	1
Application of innovative technology A33	2	2	6

Multiply the weight vector of the criterion layer with the comprehensive evaluation matrix of the scheme layer calculated above to obtain PA:

PA=(0.1062,0.6333,0.2605)× $\begin{pmatrix}0.4112 & 0.2733 & 0.3154\\ 0.7364 & 0.1699 & 0.0937\\ 0.4286 & 0.1808 & 0.3906\end{pmatrix}$ =(0.6217,0.1837,0.1946) ;

Finally, the comprehensive evaluation result PA is divided into hundreds to obtain the digital asset value sharing rate K of Company Y:

(0.6217,0.1837,0.1946) × $\begin{pmatrix}100\\ 70\\ 40\end{pmatrix}$ = (0.7364,0.1699,0.0937) =82.81.

K=82.81/100=82.81%

4.4 Confirmation of Y Enterprise Data Asset Evaluation Results

As shown in Table 12, according to Formula 4, the data from 4.2 and 4.3 were integrated to obtain a data asset value of 12.298 billion yuan for Company Y on the evaluation benchmark date of December 31, 2022. Considering the book value of intangible assets disclosed in the financial statements of Company Y in 2022, data assets have become an important component of Company Y's intangible assets.

Table 12. Y Enterprise Data Asset Value Evaluation Table Unit: 100 million yuan

	2023	2024	2025	2026	2027
FCF	56.95	71.39	85.84	100.28	114.72
Ea	29.64	33.75	37.85	41.94	46.05
Eb	5.34	5.77	6.20	6.63	7.06
Ec	3.94	4.49	5.06	5.62	6.17
Discount coefficient	0.94	0.88	0.83	0.78	0.74
present value	16.95	24.09	30.49	35.95	41.03
Data asset sharing rate	82.81%				
Value of data assets	122.98				

5. Main Text

This article analyzes the shortcomings of traditional three evaluation methods in current data asset evaluation and constructs a relatively complete data asset evaluation system based on the multi period excess return method and fuzzy analytic hierarchy process from two different aspects: enterprise value and data asset sharing rate. The feasibility of the proposed method was verified through the evaluation and analysis of enterprise data assets through the case of Y company.

With the rapid development of the big data era, data assets have become increasingly important in the process of enterprise development. Evaluating the value of data

assets can also help enterprises better understand their own data resources. Based on the evaluation results of data asset value, corresponding comprehensive management measures can be taken for data assets, such as strengthening the cultivation of enterprise data processing talents and improving enterprise data innovation capabilities, in order to achieve maximum utilization of enterprise data assets and achieve greater commercial success.

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