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AHP기법을 활용한 중국 지방정부 공공데이터 자산의 상업적 가치평가 대한 비교연구

윤가명*, 심재연**
중국 구이저우 혜주 빅데이터 유한회사 고급엔지니어*, 세한대학교 경영학과 교수**

A comparative study on the business value assessment of local government open data assets in China based on AHP technique

Jiaming Yin*, Jae-Yeon Sim**
senior engineer, GuiZhou HuiZhu Big Data Co., LTD*
Professor, Dept. Of Management, Sehan University**

요 약 본 연구는 데이터 생태학 이론에 기초하여 중국 지방자치단체의 공개 공공 데이터를 연구 대상으로 삼았다. 데이터 자산가치 평가방법을 데이터 비즈니스 운영의 새로운 관점에서 비교하였다. 계층적 분석방법(AHP)을 사용한 평가모형을 이용한 연구결과는 전통적인 비용, 수익 및 시장 방법보다 정부 개방형데이터 자산의 상업적 가치를 더 객관적으로 반영할 수 있었으며, 데이터 가치지수를 종합적으로 평가할 수 있다는 장점을 보여주었다. 그리고 지역 데이터 가치에 대한 종합적인 검색결과를 더 잘 반영되고 있었다. 자료를 보면 지방정부의 데이터 가치평가지수는 지역의 디지털 경제발전지수에 비례하여 디지털 경제에 대한 효과가 나타났다. 본 연구는 지방정부의 데이터 가치를 이해하는데 기여하였다. 이로 인하여 데이터 혁신 및 데이터 비즈니스 운영모델구축을 촉진하고, 사회복지를 개선하며, 데이터 실현을 위해 디지털 경제의 빠른 발전을 촉진하는 연구 및 실천하는 계기를 만들고자 하였다.

주제어 가치 평가, AHP기법, 데이터 자산, 데이터 생태학 이론, 개방형 데이터

Abstract This study is based on data ecology theory and takes Chinese local governments' open public data as the research object. Data asset value assessment methods are compared from a new perspective of data business operations. The results show that the assessment model constructed using the hierarchical analysis method (AHP) can more objectively reflect the commercial value of government open data assets than the traditional cost, revenue and market methods, has the advantage of a comprehensive assessment of data value index, and better reflects the findings of a comprehensive index of regional data value. The data show that the local government data value assessment index is positively proportional to the region's digital economy development index, highlighting the driving effect on the digital economy. The results of the study provide a good help for the identification of local government data value rights. The research and practice of promoting the construction of data innovation and data business operation models, improving social well-being and promoting the rapid development of the digital economy to achieve data realisation provides a good reference.

Key Words Value Assessment, AHP, Data Asset, Data Ecology Theory, Open Data

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Corresponding Author: Jae-Yeon Sim
(Sehan University)
Email: simjy@sehan.ac.kr
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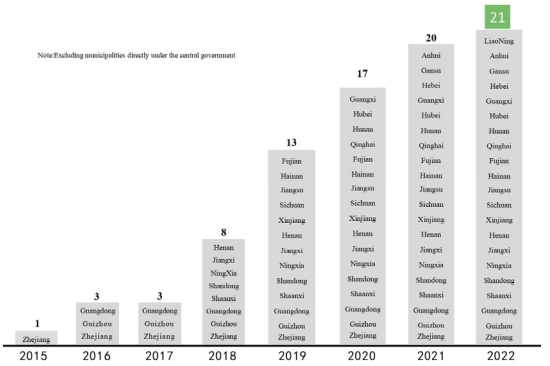
1. Introduction

As data becomes an important factor of production in digital economy, it is very important for government to act as a data catalyst [1]. The United States promotes innovation through social use of public data [2]. China incorporates data into production factors, promotes the open sharing of government data and enhances the value of social data resources [3]. South Korea promotes the improvement and development of national economy through social use of public data [4]. IDC (International Data Corporation) released a forecast that the total amount of global data will reach 175ZB by 2025 (1ZB = 1024 exabyte) [5], which will further promote the explosive development of artificial intelligence, big data, Internet of Things and other digital technologies.

In 2019, the added value of digital economy in 47 countries around the world reached 31.8 trillion US dollars, accounting for 41.5% of GDP [6]. In 2019, OECD announced that South Korea ranked first in the world in the government open data index [7], and South Korea proposed to invest KRW 170 trillion in five years, and jumped to become one of the five major powers in science and technology in 2030 [8]. In 2021, the scale of digital economy in China will reach RMB 45.5 trillion, accounting for 39.9% of GDP, and its position in the national economy will be more stable and its supporting role will be more obvious [9]. In order to promote the compliant and efficient circulation and use of data [10], it is necessary to build an open and win-win international cooperation pattern in the digital field [11], and help Chinese local government data opening (as shown in Figure 1) to drive the sustainable development of digital economy.

Through literature research, it is found that there are more studies on the value evaluation of "data technology" in this field, and less studies on the perspective of "data commerce" of government open data. To understand the true value of data, make wiser investment decisions, and use data to gain competitive



[Figure 1] China Local Government Data Open Table

advantage [12], it is more focused on the business perspective. JingRan Yang and others put forward that the data can be divided into three categories: personal, government public and enterprise data [13]. This study takes the open public data of local governments in China as the research object. From the perspective of data business operation, it compares traditional value assessment methods and constructs a set of more suitable data asset business value assessment models. It can help local governments activate the value potential of data, guide social capital investment, reduce the cost of local government information construction and improve social service capacity. At the same time, it improves the effectiveness of investment decisions and commercial operations, promotes technological innovation and value co-creation, and provides a reference for data realisation. It is of great significance to guide and promote the continuous optimization, innovation and development of enterprises, enhance the competition level of enterprises, form a benign market competition mechanism, and truly achieve the goal of healthy and sustainable development of the industry [14].

2. Literature review

This study is based on the Data Ecosystem Theory, developed by internationally renowned data management and data governance expert Malcolm Chisholm in his

2012 book 'Managing Reference Data in Enterprise Databases'. It is necessary to establish a healthy and balanced data ecosystem through data sharing, data governance and data value creation. The economic process of valuing core data assets in the data ecosystem [15] is defined by institutions as data resources that are legally owned or controlled, can be measured, and bring economic and social value to organizations [16]. There are also institutions defined as the government or entities entrusted by the government to produce, and anyone can freely access, use, modify and share for any purpose [17]. The value evaluation is mainly from the aspects of openness, applicability and sociality [18].

Currently, the definition of the value of government open data assets means that government agencies actively open the data collected, produced and managed by them to the public in an open, transparent and convenient way, and promote the innovative application and reuse of data by the government, enterprises, social organizations and individuals through data opening, data exchange and data sharing, so as to maximize social public interests and economic values [19]. It is mainly divided into three categories: economic value, social value and political value [20]. Scholars at home and abroad mainly focus on data asset quality evaluation [21], data asset evaluation index system [22], data asset income evaluation [23] and so on. International research also tends to the technical field, and less explores the research on the commercial value evaluation of data assets under the compliance use of government open public data. Therefore, this study has continuity, practicability and applicability.

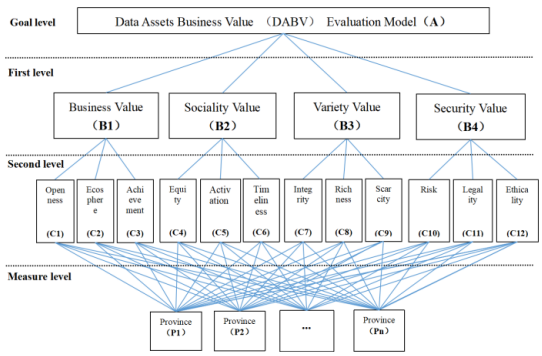
2.1 Commonly used data asset value evaluation methods and comparison

The comparison of methods is shown in Table 1.

By comparison, it is found that the traditional cost method, income method and market method do not consider enough the commercial and social value factors of government opening public data. In order to better reflect the data value, an evaluation model from the perspective of commercial operation is constructed by considering the diversity and security factors of Big Data 4V.

〈Table 1〉 Commonly used data asset valuation methods and comparison tables

Evaluation method	Concept definition	Calculation formula	Merit	Shortcoming	Applicable scenarios	Research literature
Law of Costs	A method of data cost collection.	P=TC×(1+R)×U Among them: P-evaluation value; TC-Total cost of data assets; R-Data Asset Cost Return on Investment; U-data utility.	Easy to operate; Easy access; Easy financial treatment.	The estimated value is low; Potential data value is difficult to identify.	1. There is no significant market value data; 2. It is not for the purpose of trading.	Deloitte,2019 [24] Fei-Teng Lin 2020[25] Hangzhou Digital Alliance,2023 [26]
Income method	The value of income or expenditure savings that can be brought by data is estimated.	$P=\sum_{t=1}^{n} F_t \frac{1}{(1+i)^t}$ P-evaluation value; Ft-the amount of income in the t-th income period in the future; N-residual economic life; t-year t in the future; i-Discount rate.	It can truly and accurately reflect the value of data assets; If the expected income is estimated accurately, the value of data assets is easier to predict	It is difficult to predict the income and risk accurately; It is easily influenced by subjective judgment factors, The social value of data is not considered enough.	1, t the expected future income of the evaluated assets can be predicted and measured in currency; 2. Data consumers; 3. The enterprise itself.	China Asset Appraisal Association,2019 [27] Kim Ok-ki et.al,2021 [28] PWC,2022 [29]
Market approach	A valuation method based on comparable market transaction cases and correction systems of the same or similar data assets.	Appraised value = comparable data asset turnover × Σ correction coefficient -The turnover of comparable data assets is the transaction turnover of the same or similar data assets under the active public trading; -Correction factor: used to correct the differences between the underlying data assets and comparable cases;	It reflects the current market situation and is more easily accepted by buyers and sellers.	Comparable cases rely on analogy; It is difficult to evaluate the inclusiveness of open data.	1, Active data market; 2, For the purpose of trading; 3, There are a lot of transactions and data accumulation.	Deloitte,2019 [24] PWC,2022 [29] Xiaoqin Zhu,2023 [30]



[Figure 2] Data Assets Business Value Evaluation Indicator System

3. Research Methods

3.1 Model design

Analytic Hierarchy Process (AHP)is used to quantitatively evaluate the value of data assets [24]. Fu Shan puts forward 12 influencing factors from the dimensions of utility, cost, strategy and transaction [31], Gartner [32], and Liang Yan puts forward AHP + fuzzy comprehensive evaluation method [33]. This study is constructed from four dimensions: business, society, diversity and security. The specific steps are as follows:

3.1.1 Constructing structural model The evaluation index system

The Business value of data assets is constructed by 12 indexes of Business, Society, Variety and Security Value dimensions (as shown in Figure 2).

3.1.2 Building a weight scale table

Based on "DABV", T.L. Saaty's 1-9 scale method scale is adopted, as shown in Figure 3.

Scale	Meaning
1	Indicates that two factors are equally important
3	Indicates that one factor is slightly more important than another
5	Indicates that one factor is significantly more important than another
7	Indicates that one factor is more important than another
9	Indicates that one factor is extremely important compared to another
2、4、6、8	The median of the adjacent judgments mentioned above

[Figure 3] T.L. Saaty's 1-9 scale method scale

3.1.3 Constructing judgment matrix

According to the "DABV" division, the judgment matrix was constructed (as shown in Table 2), and let the matrix A = (aij) ($0 < i \leq n$, $0 < j \leq n$) satisfy; (i) aij > 0; (ii) aji = 1/aji (i, j = 1, 2, ..., n) is called a positive reciprocal matrix (see aii = 1, i = 1, ..., n), and T.L. Saaty's 1-9 scale method was adopted.

〈Table 2〉 Judgment Matrix Table of Business Value Evaluation of Data Assets

Goal level	First level	Business Value B1	Sociality value B2	Variety Value B3	Security Value B4
Data Assets Business Value (DABV) A	Business Value B1	1	2	3	7
	Sociality Value B2	1/2	1	1/2	5
	Variety Value B3	1/3	2	1	3
	Security Value B4	1/7	1/5	1/3	1
Data Assets Business Value (DABV) A		Second level	C1	C2	C3
	Business Value B1	C1	1	3	4
		C2	1/3	1	2
		C3	2/4	1/2	1
		Second level	C4	C5	C6
	Sociality Value B2	C4	1	2	3
		C5	1/2	1	3
		C6	1/3	1/3	1
		Second level	C7	C8	C9
	Variety Value B3	C7	1	3	8
		C8	1/3	1	7
		C9	1/8	1/7	1
		Second level	C10	C11	C12
	Security Value B4	C10	1	2	4
		C11	1/2	1	2
		C12	1/4	1/2	1

3.1.4 Consistency test of judgment matrix

The weight of each scale is checked for consistency, and the consistency ratio CR is calculated to evaluate its consistency. The formula is as follows:

$$\lambda \max = \sum_{i=0}^{n} \frac{[A\omega]_i}{n\omega_i} \quad (1)$$

$$CI = (\lambda max - n) / (n - 1) \quad (2)$$

$$CR = CI / RI \quad (3)$$

3.1.5 Calculation of index weight and index

Industry experts and scholars are invited to compare the importance of the first and second influencing factors in pairs, and then obtain the judgment matrix between the target layer and the criterion layer [34], as shown in Table 2.

3.1.6 Weighted Index Score

The secondary index score was carried out, and the primary index score was calculated by weighting.

According to the judgment matrix in Table 2, the maximum characteristic root λmax = 4.184 and characteristic vector ω_1 = (1.949, 0.861, 0.948, 0.242)T were analyzed by SPSSAU, and CI=0.061, RI=0.890, CR=0.069, CR < 0.1 were checked once, so the judgment matrix passed the consistency test. See Table 3.

〈Table 3〉 Weight index table for business value evaluation of data assets

Level (A)	Level (B)	Weight	Level (C)	Weight	Total weight of each index	Sequence
Data Assets Business Value A	Business Value B1	0.487	Openness C1	0.164	0.080	5
			Ecosphere C2	0.297	0.145	3
			Achievement C3	0.539	0.263	1
	Sociality Value B2	0.215	Equity C4	0.525	0.113	4
			Activation C5	0.334	0.072	6
			Timeliness C6	0.142	0.030	9
	Variety Value B3	0.237	Integrity C7	0.637	0.151	2
			Richness C8	0.302	0.072	7
			Scarcity C9	0.061	0.014	11
	Security Value B4	0.061	Risk C10	0.571	0.035	8
			Legality C11	0.286	0.017	10
			Ethicality C12	0.143	0.009	12

3.2 Business Value Index of Data Assets

$$A = B_1 * \sum_{i=1}^{3} c_i * k_i + B_2 * \sum_{i=4}^{6} c_i * k_i + B_3 * \sum_{i=7}^{9} c_i * k_i + B_4 * \sum_{i=10}^{12} c_i * k_i$$

c_i: secondary weight index; k_i: dimensionless value

〈Table 4〉 Standardized Index of Business Value of Open Data Assets of Local Governments in China

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Beijing	0.164	0.248	0.265	0.525	0.002	0.071	0.189	0.180	0.061	0.571	0.286	0.143
Shanghai	0.072	0.248	0.180	0.525	0.007	0.142	0.058	0.031	0.061	0.571	0.286	0.143
Tinjin	0.087	0.198	0.109	0.262	0.000	0.071	0.038	0.012	0.030	0.571	0.000	0.143
Chongqing	0.086	0.149	0.042	0.262	0.000	0.071	0.111	0.003	0.061	0.571	0.000	0.143
Zhejiang	0.078	0.297	0.539	0.525	0.334	0.142	0.291	0.175	0.061	0.571	0.286	0.143
Guizhou	0.059	0.223	0.274	0.525	0.008	0.142	0.187	0.195	0.061	0.571	0.286	0.143
Guangdong	0.078	0.248	0.252	0.525	0.022	0.142	0.637	0.004	0.061	0.571	0.286	0.143
Shaanxi	0.016	0.000	0.022	0.131	0.000	0.035	0.000	0.002	0.030	0.571	0.000	0.143
Shandong	0.078	0.124	0.272	0.262	0.034	0.071	0.072	0.302	0.061	0.571	0.286	0.143
Ningxia	0.039	0.000	0.017	0.000	0.000	0.000	0.021	0.000	0.000	0.571	0.000	0.143
Jiangxi	0.041	0.025	0.005	0.131	0.000	0.035	0.001	0.002	0.015	0.571	0.000	0.143
Henan	0.067	0.000	0.025	0.000	0.000	0.000	0.007	0.022	0.000	0.571	0.000	0.143
Sichuan	0.067	0.074	0.030	0.262	0.001	0.071	0.232	0.004	0.015	0.571	0.143	0.143
Jiangsu	0.140	0.124	0.047	0.525	0.000	0.071	0.006	0.000	0.061	0.571	0.143	0.143
Hainan	0.128	0.050	0.017	0.131	0.000	0.071	0.017	0.032	0.015	0.571	0.000	0.143
Fujian	0.110	0.173	0.304	0.262	0.012	0.071	0.067	0.088	0.030	0.571	0.143	0.143
Guangxi	0.128	0.074	0.247	0.262	0.001	0.035	0.098	0.009	0.015	0.571	0.000	0.143
Hebei	0.071	0.124	0.049	0.262	0.003	0.071	0.338	0.044	0.030	0.571	0.143	0.143
Anhui	0.000	0.025	0.000	0.000	0.000	0.035	0.005	0.000	0.000	0.571	0.000	0.143
Liaoning	0.036	0.000	0.000	0.000	0.000	0.035	0.001	0.001	0.000	0.571	0.000	0.143

3.3 Data Sample Description

The data samples of this study are extracted and sorted out according to the Research Report on Open Data Utilization of Chinese Government in 2022 and the Open Data Report of Chinese Local Government in 2022, and the deadline for data update is March 30th, 2023. Excluding the lack of open data of local governments in some provinces of China, the actual effective data samples are 20. Because of the different dimensions and influencing factors of data business value indicators, standardized formula $Y_j(t)=\frac{X_i(t)-\min X_i(t)}{\max X_i(t)-\min X_i(t)}$ was used (where: i=1. 12; t=1. 12 indicators, $Y_j(t)$ is a dimensionless value), and the results are shown in Table 4.

4. Results

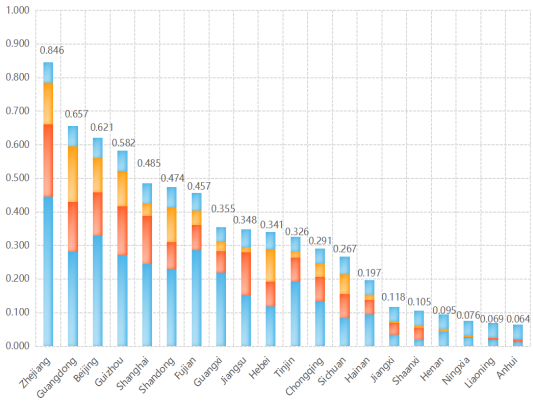
4.1 Results and Analysis of New Urbanization

After data standardization by SPSSPRO, the evaluation results and rankings of commercial value of open data assets of local governments in China are obtained by calculating weights, as shown in Table 5.

The results show that Zhejiang Province is the province with the highest commercial value index of local government open data in China, which is 0.846; Guangdong Province ranked second with 0.657 points; Beijing ranked third with 0.621 points; In the west, where data was first opened, Guizhou Province leapt to the fourth place with 0.582 points. The fifth to tenth provinces are Shanghai, Shandong, Fujian, Guangxi, Jiangsu and Hebei, with 0.485, 0.474, 0.457, 0.355, 0.348 and 0.341 respectively. As shown in Figure 4.

〈Table 5〉 Business Value Index Table of Open Data Assets of Local Governments in China

	Business Value B1	Sociality value (B2)	Variety Value (B3)	Security Value (B4)	Data Assets Business Value A	TOP
Zhejiang	0.446	0.215	0.125	0.061	0.846	1
Guangdong	0.282	0.148	0.166	0.061	0.657	2
Beijing	0.329	0.129	0.102	0.061	0.621	3
Guizhou	0.271	0.145	0.105	0.061	0.582	4
Shanghai	0.244	0.145	0.036	0.061	0.485	5
Shandong	0.231	0.079	0.103	0.061	0.474	6
Fujian	0.286	0.074	0.044	0.052	0.457	7
Guangxi	0.219	0.064	0.029	0.043	0.355	8
Jiangsu	0.152	0.128	0.016	0.052	0.348	9
Hebei	0.119	0.072	0.098	0.052	0.341	10
Tinjin	0.192	0.072	0.019	0.043	0.326	11
Chongqing	0.135	0.072	0.041	0.043	0.291	12
Sichuan	0.083	0.072	0.060	0.052	0.267	13
Hainan	0.095	0.043	0.015	0.043	0.197	14
Jiangxi	0.034	0.036	0.004	0.043	0.118	15
Shaanxi	0.019	0.036	0.008	0.043	0.105	16
Henan	0.045	0.000	0.007	0.043	0.095	17
Ningxia	0.027	0.000	0.005	0.043	0.076	18
Liaoning	0.018	0.008	0.000	0.043	0.069	19
Anhui	0.012	0.008	0.001	0.043	0.064	20



[Figure 4] China Local government Open Data Assets Business Value Index Table

The analysis results of the data business value evaluation model show that the top provinces are the provinces that actively promoted the opening of government data and developed digital economy in the early stage. Among them, Zhejiang Province is the province with the highest total index; Guangdong Province, as the earliest open data province in China, ranks second, and its data diversity value of 0.166 exceeds that of Zhejiang, indicating that its data activity and scarcity are the highest; Beijing ranked third with 0.621 points, and its data commercial value of 0.329 exceeded that of Guangdong Province, indicating that its data openness and results are higher than those of Guangdong; Guizhou Province has become the only western province to enter the top ten with 0.582, and its social value and diversity value are 0.145 and 0.105 respectively. Although the total index is lower than that

of Beijing, the two indexes exceed that of Beijing. The survey found that Guizhou Province is the first province in China to put forward big data development strategy, hold international big data Expo, launch big data innovation competition, introduce big data local legislation and data open business incubation, and hold many data innovation competitions every year. At the same time, comparing the index with the 2016-2022 China Digital Economy Industry Development Report released by the Ministry of Industry and Information Technology of China, it shows that the top five in total are Zhejiang, Guangdong, Beijing, Shanghai and Shandong, while the western provinces such as Guizhou and Guangxi rank the top five in increment, all of which are above 20%. It also further verifies that the value evaluation index is consistent with the digital economy data, and has a significant driving effect on the digital economy [35].

5. Conclusion

5.1 Conclusion

The results show that the evaluation model constructed by AHP can reflect the commercial value of government open data assets more objectively than traditional cost method, income method and market method, and has the advantage of comprehensive evaluation sample value index, and has more applicability of data commercial operation value and comprehensive index of regional data value. This provides a good reference and theoretical support for data-driven innovation of data business operation mode, real-time evaluation under the condition of dynamic data update, sustainable development of digital economy, and research and practice of data realization. Specific conclusions are as follows:

(1) Currently, there is no evaluation and index evaluation on the commercial value of government open data in China, and there are few studies. Most of the existing studies focus on technology and assets, and pay less attention to the commercial value of data. Under the background of vigorously developing digital economy in the world, this study constructs evaluation model, data analysis and verification from the perspective of data business. This provides a good reference and theoretical support for local governments in China and other countries to sort out the value of data and further promote social well-being and digital economy development through open data, which is also the innovation of this study.

(2) By further opening up data and digital business management, local governments can better implement government digital governance, drive social capital participation, and help government finance reduce costs and increase efficiency, which has very important practicability.

(3) By combing the existing evaluation methods and influencing factors, this paper constructs the commercial value evaluation model of government data assets, and thinks that the main influencing factors are mainly commercial characteristics, social characteristics, diverse characteristics and risk characteristics.

(4) The survey shows that all provinces with high commercial value index of local government data assets in China have issued a mass of policies and regulations on data security and compliance use. This provides reference for other local governments, actively introduces corresponding laws and regulations, and actively explores the franchise mechanism of data operation, so as to further enhance the activity of digital economy and drive economic development.

5.2 Deficiencies and Prospects

The deficiency of this study is that the current digital economy is not listed as a statistical item in the Statistical Yearbook of the Bureau of Statistics, and it is impossible to further analyze the input and output. At the same time, due to the different construction and openness of data open platform, different standards and specifications, and the lack of unified data open

platform and data label co-ordination at the national level, the data of some provinces is missing in the process of data collection, and the evaluation value of individual provinces and cities is inaccurate.

The research prospect hopes that under the global digital economy boom, we can learn from the experience of other countries, establish a national unified data open platform, and explore the improvement of data open-driven business application service mode and social management innovation. Promote local governments to build a data-driven new mechanism that enhances industry self-discipline, assists in ecological purification, and promotes industry innovation. Trying innovative models such as data business incubation and data franchise under compliance use in some fields, such as smart building, smart transportation, smart health care, etc., can reduce fiscal expenditure for local governments, improve the efficiency of digital government services, and provide high value-added continuous data services for society and enterprises.

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윤 가 명 (Jia ming Yin)

- 2020년 6월: 캐나다 퀘벡대학교 (프로젝트 관리) 석사
- 2021년 6월~현재: 세한대학교 대학원 경영학과 (경영학박사 재학)
- 2021년 12월~현재: 귀주대학 MBA 지도교수
- 2021년 12월~현재: 구저우 스마트 캐스팅 빅데이터. 고급 엔지니어
- 관심분야: 디지털경제, 데이터 비즈니스 운영, 빅데이터 관리
- E-Mail: kt-gz@163.com

심 재 연 (Jae-Yeon Sim)

- 1985년 2월: 조선대학교 회계학과 (경영학사)
- 1990년 2월: 조선대학교 대학원 회계학과 (경영학석사)
- 1995년 2월: 조선대학교 대학원 경영학과 (경영학박사)
- 1995년 3월~현재: 세한대학교 경영학과 교수
- 관심분야: 회계정보시스템, 정부회계, 인적자원관리
- E-Mail: simjy@sehan.ac.kr