Hindawi
Mobile Information Systems
Volume 2022, Article ID 3842587, 11 pages
https://doi.org/10.1155/2022/3842587

Research Article

Evaluation of Urban Economic Benefit Value Calculation Method Based on Smart City

Weihang Zhu [1] and Manting Wang [2]

[1] *Faculty of Social Sciences, Hong Kong Baptist University, Kowloon Tong Hong Kong Special Admin, istrative Region, Hong Kong, China*
[2] *School of Software & Microelectronics, Peking University, Beijing 21447977, China*

Correspondence should be addressed to Weihang Zhu; 21447977@life.hkbu.edu.hk

Received 28 June 2022; Revised 8 August 2022; Accepted 20 September 2022; Published 28 September 2022

Academic Editor: Yanyi Rao

Economic growth has not only made life more comfortable for people but has also increased the demands and expectations of the living environment. Urban planning, layout, construction, transportation, environmental protection, etc. are increasingly attracting the attention of the government. Due to the increase in residents, there are many problems in cities, such as traffic congestion, smog, etc. The relevant departments hope to use intelligent means to effectively alleviate these problems, and many cities have achieved good results. As a part of urban economics research, analyzing the economic benefits of a city helps to study how to develop the city. Smart sensor and communication technology is an advanced technology for smart manufacturing and the Internet of Things. As an advanced sensor tool, it is of great significance for exploring the economic benefits of smart cities. This paper discusses the calculation method of urban economic benefit value based on smart cities and evaluates the calculation method. The purpose of this paper is to find out the calculation method applicable to the urban economic benefit and to propose an effective evaluation method for the urban economic benefit, so as to have a more complete and effective calculation and evaluation of the urban economic benefit. This paper introduces the smart city, combining intelligent sensing and communication technology, and designs the economic benefit calculation method and evaluation model. Finally, this paper designs an experiment of economic benefit calculation and evaluation. First, 18 cities in China are used as examples to explore the relationship between indicators and GDP. It is concluded that there is a long-term and stable relationship between GDP and household savings balance at the end of the year and that this does not exist with the average number of on-the-job workers. Then we took Wuhan Metro Line 5 as an example to evaluate its economic benefits. The experiment shows that the largest weight value is the investment return period, with a weight of 0.54, and the evaluation level of Wuhan Metro Line 5 is 4.

1. Introduction

In order to pursue a better living environment and living conditions, young people like to move to cities, which leads to the emergence of a series of social problems such as transportation, medical care, and the environment. The 21st century is an information society, so the construction of cities has also introduced information technology, which also includes intelligent sensing and communication technology, which has greatly improved the construction efficiency and operation of cities, and smart cities have emerged with the development of information. Cities are the birthplace of social progress and the main carriers of economic, social, political, cultural, and technological development. Economic benefits are the ratio of labor input to output. The purpose of economic activities is to improve economic benefits. The improvement of urban economic benefits is the focus of urban economic activities.

The economic benefit of a city is the sum of the various benefits of a comprehensive city. In order to correctly evaluate and measure the city's economic benefits, the indicators of the city's economic benefits must be scientifically designed and evaluated. The economic interests of the city are related to the city's input and output. From a macro point of view, the input factors of a city are generally the number of employees, investment in fixed assets, energy consumption, etc., and the output factors are GDP, fiscal revenue, etc. The scientific evaluation of the urban economic effect is an important research topic, and the effect needs to be quantified in this process, so the calculation method of evaluating the urban economic benefit is very important. The creation of smart cities is important for the implementation of sustainable urban development.

The innovations of this paper are: (1) The calculation method and evaluation model of urban economic benefits based on smart cities are proposed, combining intelligent sensing and communication technology, and the calculation of urban economic benefits is designed with various analysis methods. (2) Based on the calculation method and evaluation model designed in this paper, experiments are carried out, and several cities are used as experimental objects to calculate and evaluate their urban economic benefits.

2. Related Work

With the continuous expansion of the urban population and the continuous progress of the industry, many problems have emerged in the city, such as traffic congestion, environmental pollution, etc., so smart cities have emerged. Paganelli et al. propose a framework that enables developers to model smart things as web resources and develop applications on top of them. Finally, Paganelli et al. conducted testing activities to test the effectiveness of the framework in smart cities [1]. Daniel et al. provide an obscure technique that uses various catalog parameters to dynamically match how vision sensors are stored [2]. Pasolini et al. represent two essential elements in Italian town practice. Cities need adequate planning to find out and must reduce transmission time to determine if the transmission has been lost [3]. Bates and Friday present a case study on creating a campus-scale "living lab" using existing IoT infrastructure to promote energy conservation and environmental sustainability [4]. In this article, Wu et al. intend to propose a smart city development framework with Chinese characteristics in big data, providing key steps for building smart city infrastructure and realizing opportunities for efficient urban governance [5]. Yeh surveyed Taiwanese cities that have participated in at least one smart city initiative at the Smart Community Forum. The study provides practical guidance for cities and technology providers to develop smart city plans, but the downside is that the design questionnaire is not comprehensive [6].

3. Calculation Method of Urban Economic Benefit Value Based on Smart City

3.1. Smart City

3.1.1. The Concept of Smart City. From the perspective of the fictitious source, "smart cities" develop their innovations on the basis of information technology, provide solutions for cities to realize walking, and provide basic ideas for optimizing and developing the city's operating system. "Smart city" is gradually being used to describe an urban development model based on information technology that promotes urban innovation [7, 8].

Smart cities take the pursuit of comprehensive and sustainable economic, social, and environmental development as the basic direction. Taking the artificial intelligence and human wisdom of information technology as an important means, through the comprehensive integration of various types of urban resources, can promote the innovative development of the city and, secondly, promote the optimal allocation of the city's core resources and the operation and development of the city, creating an all-round smart city.

3.1.2. Urban Development and Evolution. From the perspective of the development and evolution of cities, the emergence of smart cities is an important manifestation of the continuous evolution of urban forms driven by the advancement of human science and technology [4]. As shown in Figure 1, different human technology levels correspond to different social and urban forms.

It can be seen from Figure 1 that the first stage of the city was primitive tribes, and the earliest part of the city was caused by factors such as trade, religion, and politics; the second stage is the countryside or town; the third stage is the industrialized city, which is facilitated by the development of modern industries; the fourth stage is the digital city, which is facilitated by the development of the Internet; and the fifth stage is the smart city. A smart city is an important embodiment of social progress. The level of human productivity represents the ability of humans to transform the natural world. With every breakthrough improvement in human labor tools, human productivity has greatly improved, and it has also brought about ever-changing changes in the form of human society. Technological progress has driven the changes in social form and urban development model.

3.1.3. Elements of Smart City. The smart city system is composed of the interconnection and combination of human wisdom and several intelligent and intelligent city subsystems. The core components of a smart city can be summarized from five aspects: strategy, society, economy, support, and space [9]. The connection between human wisdom and the city's smart system is mainly reflected in the five aspects of the city's strategy: society, economy, support, and space. They are reflected in the smart city system as five major subsystems, as shown in Figure 2.

3.2. Calculation Method of Urban Economic Benefit Based on Intelligent Sensing and Communication Technology.

There are many calculation methods for urban economic benefits, here are some of them to introduce.

3.2.1. Principal Component Analysis (PCA). The PCA method starts from the correlation between many features involved in the same problem, that is, the "overlapping" of the information of each feature and new features with nonoverlapping information to reflect most of the

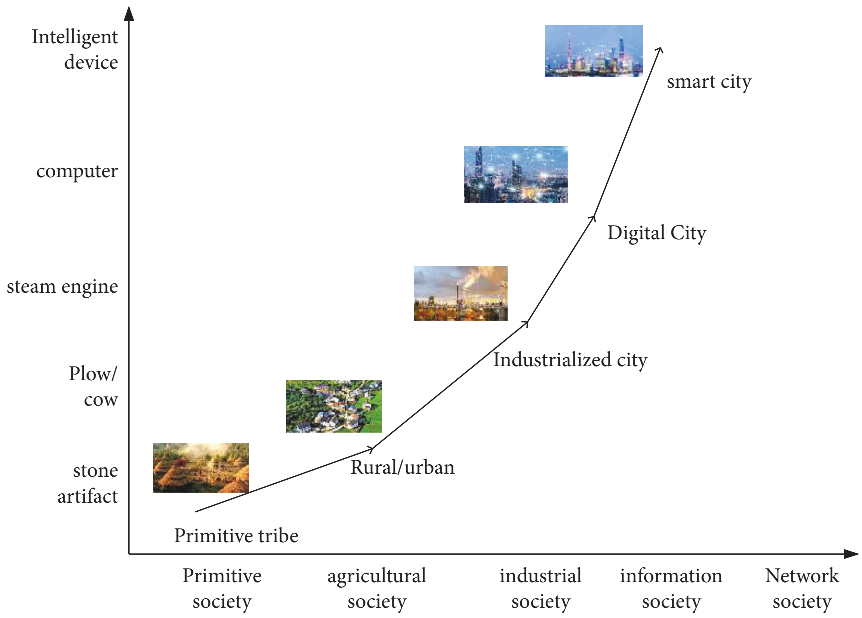

Figure 1: Urban development process.

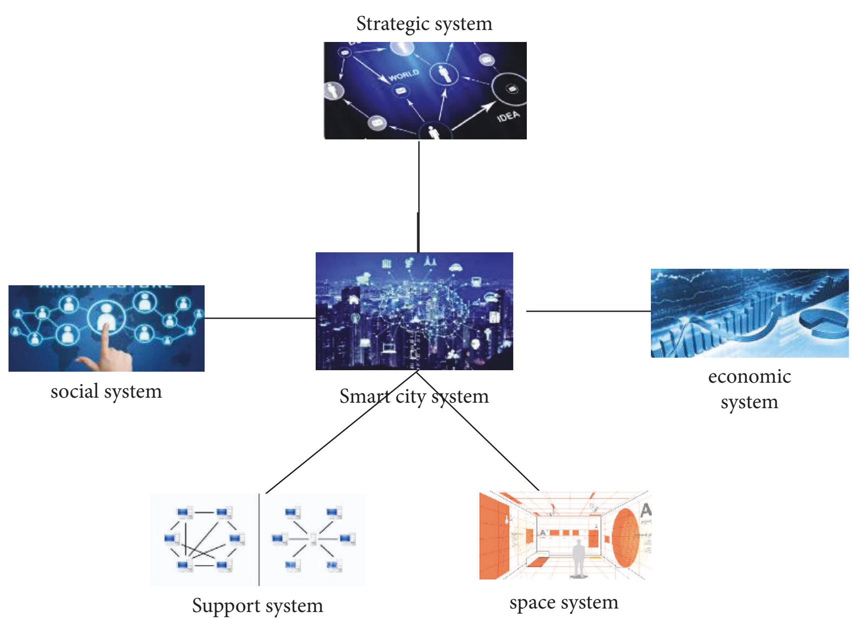

Figure 2: Elements of a smart city.

information provided by the original features, and then solves the problem by analyzing a small number of new features. The basic idea of PCA is to map multiple features onto several synthetic features, the purpose of which is to reduce elements [10]. PCA is to construct a series of linear combinations of the original variables in order to maximize the variance [11].

(1) Principal Component Export. Letting $X = (X_1, X_2,,, X_n)^T$ be an n-dimensional random vector, and $E(X) = r$, perform K-L transformation on X to reduce dimensionality.

$$\begin{cases} Y_1 = r_{11}X_1 + r_{21}X_2 + \ldots + r_{n1}X_n = R'_1X \\ Y_2 = r_{12}X_1 + r_2X_2 + \ldots + r_{n2}X_n = R'_2X \\ \ldots\ldots \\ Y_n = r_{1n}X_1 + r_{2n}X_2 + \ldots + r_{nn}X_n = R'_nX \end{cases} \quad (1)$$

$$R'_1 = (r_{1i}, r_{2i},, r_{ni})\,(i = 1, 2, n).$$

According to the principle of principal components, $Y_i = R'_iX$ should be maximized as much as possible, and each Y_i should be independent of each other. Among them, Y_1 has the largest variance, and it gets smaller and smaller in sequence. Indicator Y_1 is the first principal component of the original variable, Y_2 is the second principal component, and so on, and the variances of these components decrease in turn. The K-L transform is discussed below.

(2) Contribution Rate and Cumulative Contribution Rate of Principal Components. Letting $Y = (Y_1, Y_2,,, Y_n)^T$ be a random vector composed of n principal components, then:

$$p_k = \lambda_k / \sum_{i=1}^{n} \lambda_i = var(Y_k) / \sum_{i=1}^{p} var(X_i). \tag{2}$$

This process describes distributing all of the $X_1, X_2, , , X_n$ data obtained from the main unit's kth, and p_k is the total contribution amount of the large unit $Y_k k$th. The sum of the contribution rates of the first j principal components is the information ability of the first j principal components, usually $j< k$, if the cumulative share rate of the first component of j is equal to or equal to 85%, the initial variable may be replaced by the first primary component of j [12, 13].

3.2.2. Cluster Analysis

(1) Similarity Measure. When judging whether things are similar, a scale is needed, and this scale is called a similarity measure. Distance is a measure of similarity. It is judged whether two samples belong to the same class according to the difference in distance between samples. The smaller the distance, the more similar.

Letting the eigenvectors of the two samples X and Y be:

$$X = \begin{bmatrix} x_1 \\ x_2 \\ \cdots \\ x_n \end{bmatrix} = (x_1\, x_2 \ldots x_n)^{\mathrm{T}}, \tag{3}$$

$$Y = \begin{bmatrix} y_1 \\ y_2 \\ \cdots \\ y_n \end{bmatrix} = (y_1\, y_2 \ldots y_n)^{\mathrm{T}}. \tag{4}$$

There are various methods for measuring the distance between X and Y, such as Euclidean distance, included angle cosine distance, etc. The most common method is Euclidean distance. Euclidean distance, that is, the actual distance between two points in m-dimensional space and the distance in two-dimensional space. Its calculation formula is as follows:

$$d_{ij}^2 = (X - Y)^T (X - Y) = \sum_{k=1}^{n} (x_k - y_k)^2 \tag{5}$$

(2) Clustering Algorithm. There are many types of clustering algorithms, the following focuses on the dynamic clustering algorithm [14, 15]. The dynamic clustering algorithm first selects multiple samples as cluster centers and then classifies them according to the clustering criteria. During the clustering process, the cluster center will continue to change until it becomes appropriate. The basic process is shown in Figure 3.

Other methods can also be used to select initial cluster centers and to select initial classification methods. After classification, judge the rationality of the classification and decide whether to modify it [14]. Therefore, many clustering algorithms have emerged to judge whether the classification is reasonable. For example, the criterion function of the K-means algorithm is as follows:

$$\mathrm{J} \sum_{j=1}^{k} \sum_{i=1}^{n_j} \left\| \mathrm{X_i} - \mathrm{Z_j} \right\|^2 \mathrm{X_i} \in \mathrm{S_j}. \tag{6}$$

3.2.3. Cointegration Test

(1) Unit Root Process. First, the stationary stochastic process is expressed as follows:

$$Y_m = \mu + \varepsilon_m + \psi \varepsilon_{m-1} + = \mu + \psi(L) \varepsilon_m. \tag{7}$$

The root of $\psi(L) = 0$ is outside the unit circle, and ε_m is a white noise process with mean 0 and variance 3. Differentiating the stationary process once:

$$\begin{aligned} (1 - L) Y_m &= (1 - L)\mu + (1 - L) B(L) \varepsilon_m, \\ \psi(L) &= (1 - L) B(L). \end{aligned} \tag{8}$$

At this time, $\psi(1) = 0$, so when $\psi(1) \neq 0$, keep the horizontal variable nonstationary.

(2) Cointegration Test Process. If a linear combination is found, the variable after the linear combination of the nonstationary random process is in a stable state, then there is a cointegration relationship between the nonstationary processes, otherwise, it does not exist. The residual-based test method is to find a linear combination and judge whether the random process after the combination is stable [15, 16]. The basic idea of the covariance relationship is that a linear combination of two or more variables can exhibit stability even if they are not equal. Before performing the cointegration test, use the ADF unit root test to test the stationarity of the two-time series. The common test method is the unit root test method. The unit root test is a test for the existence of a unit root in a sequence, which can indicate that the unit root process in the sequence is unstable, leading to spurious regression in regression analysis.

3.3. Evaluation Method of Urban Economic Benefit Based on Intelligent Sensing and Communication Technology. The purpose of the analysis and calculation of a project is to give a corresponding qualitative or quantitative evaluation based on the results of the discussion, so as to provide decision-makers with guiding suggestions and a decision-making basis. There are two key issues in the evaluation method, one

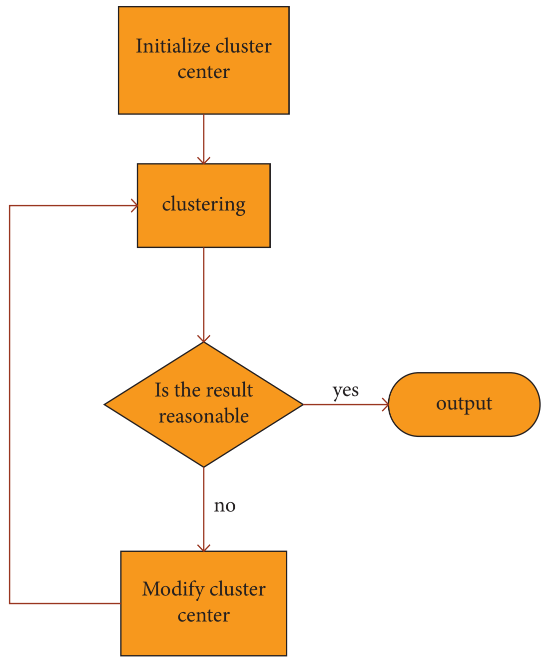

Figure 3: Dynamic clustering algorithm.

is the effective establishment of the index system, and the other is the proper selection of the evaluation method. Next, a comprehensive evaluation method for economic benefits is given.

3.3.1. Urban Economic Benefit Evaluation Index System. According to the characteristics of the city itself, combined with the classification results identified by the cost-benefit analysis, an evaluation index system of urban economic benefits is established. The evaluation of these index systems can effectively reflect the overall situation and development law of the economic benefits of urban rail transit projects, so as to analyze the existing problems and give reasonable suggestions [17]. Figure 4 shows the specific index system.

(1) Benefit to Cost Ratio. Benefit-cost ratio refers to the ratio of the discounted value of all internal benefits to the sum of all internal costs since the operation of the city project, as shown in the following formula:

$$\mathrm{BCR} = \frac{\sum_{i=0}^{n}\left[B_t/(1+i)^t\right]}{\sum_{i=0}^{n}\left[C_t/(1+i)^t\right]}. \tag{9}$$

In the formula, BCR represents the benefit-cost ratio, t represents the operation year after the project investment and construction are completed.

(2) Economic Internal Rate of Return. The economic internal rate of return is calculated as shown in equation (2).

$$\sum_{t=0}^{n}\frac{B_t}{(1+\mathrm{IRR})^t}\sum_{t=0}^{n}\frac{C_t}{(1+\mathrm{IRR})^t}. \tag{10}$$

IRR stands for economic internal rate of return.

(3) Net Discounted Present Value of Economic Benefits. It refers to the introduction of time value, that is, the sum of costs and benefits after all the internal costs and benefits involved in the calculation are converted to the calculation time point. Letting the social discount rate be i, then the formula for calculating the net present value of economic benefits NPV is:

$$\mathrm{NPV} = -C_0 + \sum_{t=0}^{n}\frac{B_t - C_t}{(1+i)^t}. \tag{11}$$

(4) Payback Period. The payback period is the period from the year before the net present value appears nonnegative to the start of the project. The smaller the value, the shorter the period for the project to recover the cost and the faster the net profit. According to different issues, returns are divided into social investment return period and commercial investment return period; according to the investment composition of return, they are divided into profit return period and income return period. When a dynamic payback period is used for the calculation, the social discount rate has a large influence on this value [18]. The higher the discount rate, the longer the project's payback period. The calculation method is as formula (4).

$$\sum_{t=1}^{p_t}(B_t - C_t) * (1+i)^{-t} \geq 0. \tag{12}$$

3.3.2. Establishment of Economic Benefit Evaluation Model

(1) Evaluation Method. The existing evaluation methods can generally be divided into three types: parametric evaluation method, nonparametric evaluation method, and comprehensive evaluation method. The essence of the parameter evaluation method is to analyze the operation efficiency of a project by constructing the relationship between the benefit function and the cost function. The comprehensive evaluation method refers to a comprehensive overall evaluation of the object system described by the multi-attribute structure. Figure 5 shows the classification of comprehensive evaluation methods.

The city is a huge and complex system, and the evaluation of its economic benefits needs to be comprehensively evaluated from all angles in order to obtain representative and referenced evaluation conclusions. The urban economic benefit index system has the characteristics of high dimension, multidimension, difficult to determine the weight and has imperfect industry standards. Based on the above characteristics, the projection pursuit method in the statistical analysis method is selected to comprehensively evaluate the economic benefits of the city. The principle is to use computer technology to project multi-dimensional data into low-dimensional subspaces and analyze the data structure to explore and analyze multi-dimensional data in low-dimensional space. Based on this method, this paper will establish an urban economic benefit evaluation model.

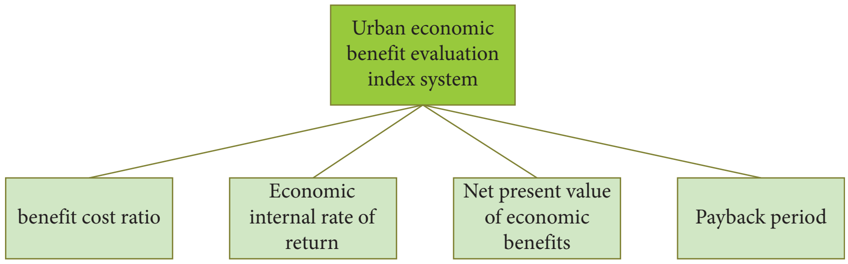

Figure 4: Evaluation index system of urban economic benefit based on intelligent sensing and communication technology.

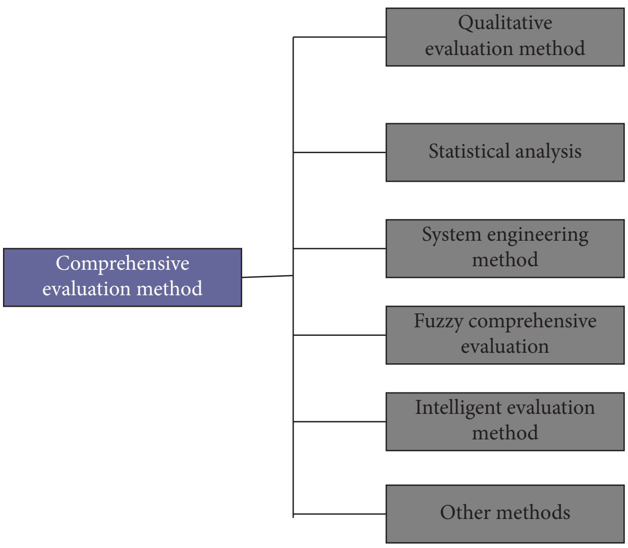

Figure 5: Classification of comprehensive evaluation methods.

(2) Model Establishment. According to the calculation result of the index, the index value of the grade is given according to the experience of experts, and the distance to the central threshold of each evaluation grade is calculated, statistically obtained index evaluation data are shown in Table 1.

For the index evaluation data set, let the kth level of the jth index be l_{jk} ($j = 1,2, \ldots, m$; $k = 1,2, \ldots, n$), m is the number of indexes 4, m 5 for the number of levels. The steps to establish an evaluation model for it are as follows:

Since the dimensions of each indicator are not the same or the numerical range is quite different, the data is normalized before modeling.

$$x'_{jk} = \frac{x_{jk}}{x_{k\max}}. \tag{13}$$

In the formula, $x_{k\max}$ represents the maximum value of the kth index sample.

Then do a linear projection. If $(r_1, r_2, , r_m)$ is an m-dimensional vector, set the projected eigenvalue of the index j in a one-dimensional linear space to Z_i, which is expressed as the formula:

$$Z_i = \sum_{k=1}^{m} r_k x'_{jk} \tag{14}$$

Table 1: Grade evaluation indicators.

	Very nice	Good	Commonly	Bad	Very bad
BCR	>2	[2, 1)	1	(1, 0.5]	<0.5
IRR	$>j$	$[j, 0)$	0	$(0, -j]$	$<-j$
NPV	$>m$	$[m, 0)$	0	$(1, -m]$	$<-m$
Pt	$<0.1t$	$[0.1t, 0.5t)$	$0.5t$	$(0.5t, t]$	$>t$

Then find the objective function, and locate the objective function $q(r)$ as the product of the inter-class distance $s(r)$ and the intra-class density $d(r)$, as given in the following equation:

$$q(r) = s(r) * d(r). \tag{15}$$

The formula for the distance between classes is as follows:

$$s(r) = \sqrt{\left[\frac{\sum_{j=1}^{n}\left(z_j - \overline{z_r}\right)^2}{\mathrm{n}}\right]} \tag{16}$$

$\overline{z_r}$ means the mean of $\{z(j)|j = 1,2, \ldots, n\}$. Letting the distance of projected eigenvalues be:

$$c_{jk} = \left|z_j - z_a\right| (j, k = 1, 2, n). \tag{17}$$

The formula for calculating the density within the class is:

$$d(r) = \sum_{j=1}^{\mathrm{n}} \sum_{a=1}^{n} \left(C - c_{ja}\right) f\left(C - c_{ja}\right). \tag{18}$$

Finally, the comprehensive index I of urban economic benefits is constructed, and $w = (r_1^2, r_2^2,, r_k^2)$ is used as the grade weight of each index, and the calculation formula (10) is obtained.

$$I = \pm \sum_{j=1}^{n} x_{jk} r_{\mathrm{k}}^2 . j = (1, 2,, m). \tag{19}$$

The positive polarity indicator is +, and the negative polarity indicator is −. The positive and negative polarity is defined as the larger the index data, the more positive contribution to the economic benefit is the positive polarity index, and vice versa is the negative polarity index. The larger the I value, the closer the evaluation level is to the level value corresponding to the maximum value.

4. Calculation and Evaluation of Urban Economic Benefits Based on Smart Cities

4.1. Calculation of Urban Economic Benefits Based on Smart Cities

4.1.1. Data Source and Indicator Selection. The data of this experiment comes from the China Urban Statistical Yearbook 2020. The subjects of the experiment are Beijing, Shanghai, Guangzhou, Shenzhen, Hangzhou, and the other 18 cities that have developed smart cities. The data of these 10 indicators (such as total number of people, gross product, investment in fixed assets, household savings balance at the end of the year, total industrial output value, total passenger volume, total freight volume, local fiscal revenue, number of on-the-job workers, and total wages of on-the-job workers) at the end of 2020 in these cities are counted and analyzed using MATLAB software. The reason for choosing these cities is that they are the most advanced cities in China and have developed smart cities, and some cities have also achieved some results in this regard.

4.1.2. PCA. In this step, the data is imported into a 10∗4 matrix, and then the covariance of the data after the standardization of the data range is obtained, and finally, the PCA is performed. The specific PCA method has been introduced above. The principal components are labeled from *A-J*, and the results are shown in Figure 6.

As can be seen from the figure, the cumulative contribution rate of the first four principal components reaches 96.76%, and this value is very close to 1, which proves that these four principal components contain almost all the information, so the first four principal components can be used to replace all the principal components.

Table 2 shows the principal component loading matrix.

4.1.3. Cointegration Analysis. This experiment selects the data from 2011 to 2020 for the most cointegration analysis of these time series.

(1) Cointegration Test of GDP and Household Savings Balance at the End of the Year. The sample length of the new work file is 10. The data is imported, and the variables are designed as x and y. Since the data dimensions are different, the logarithm of x and y is taken before the study. The x and y image is shown in Figure 7.

It can be seen from the figure that the x and y sequences are not stationary. Next, the unit root test is performed to see if they are stationary, and the first-order difference is performed on x and y to obtain lx, ly. The unit root test results for lx and ly are shown in Tables 3 and 4.

As can be seen from the table, the p value of the unit root test of lx is 0.0003, while that of ly is 0.0265, which means that both lx and ly have reached a stationary state, and x and y have a single integer of the same order.

(2) Cointegration Test of GDP and the Average Number of Employees. The time series from 2011 to 2020 is tested, and the average number of on-the-job employees, series X is shown on the left of Figure 8, and the GDP series Y is shown on the right of Figure 8.

It can be seen that both series are not stationary. Then, by checking the unit root of X and Y to see the specific numerical judgment, the results are shown in Table 5.

It can be seen that the two-time series are not single-integrated in the same session, so there is no long-term stable relationship between GDP and the average number of employees.

To sum up, this experiment adopts PCA and selects the first four principal components for the co-integration test. It is found that there is a long-term stable relationship between GDP and household savings balance at the end of the year.

4.2. Evaluation of Urban Economic Benefits Based on Smart Cities. In this experiment, taking the city of Wuhan as an example, according to the economic benefit evaluation model established above, combined with intelligent sensing and communication technology, to evaluate the economic benefits of Wuhan Metro Line 5. This experiment provides information on four dimensions: Benefit-Cost Ratio (BCR), Economic Internal Rate of Return (IRR), Net Discounted Present Value (NPV) of Economic Benefit, and Payback Period (1) of Wuhan Metro Line 5. 100 experts came to score the urban economic benefit index level. The evaluation results are counted and the data are normalized to obtain the results as shown in Figure 9.

Next, using MATLAB to realize the projection pursuit model, the calculation result is shown in Figure 10.

As can be seen from the figure, among the four economic benefit indicators, the largest weight is the investment return period, with a weight of 0.54, and the second is the benefit-cost ratio, with a weight of 0.48. Therefore, when evaluating economic benefits, these two items are the most important and should be placed first. And it can be seen from the second figure that the economic benefit status of Wuhan Metro Line 5 is 4. Metro Line 5 has brought great social and economic benefits to Wuhan, but it still needs financial subsidies to support operations. Therefore, it is necessary to deepen the reform, reduce costs, and increase the profitability of the project to improve the economic benefits of Wuhan Metro Line 5.

5. Discussion

Urban economic benefits refer to the comprehensive comparison of the input and output of all economic activities in the urban space within a certain period, and it is a national benefit that integrates production and various needs. The economic benefit index is an indicator of urban economic activities. It has the function of regulating and controlling urban economic activities and can induce the combination mode of urban production factors and the

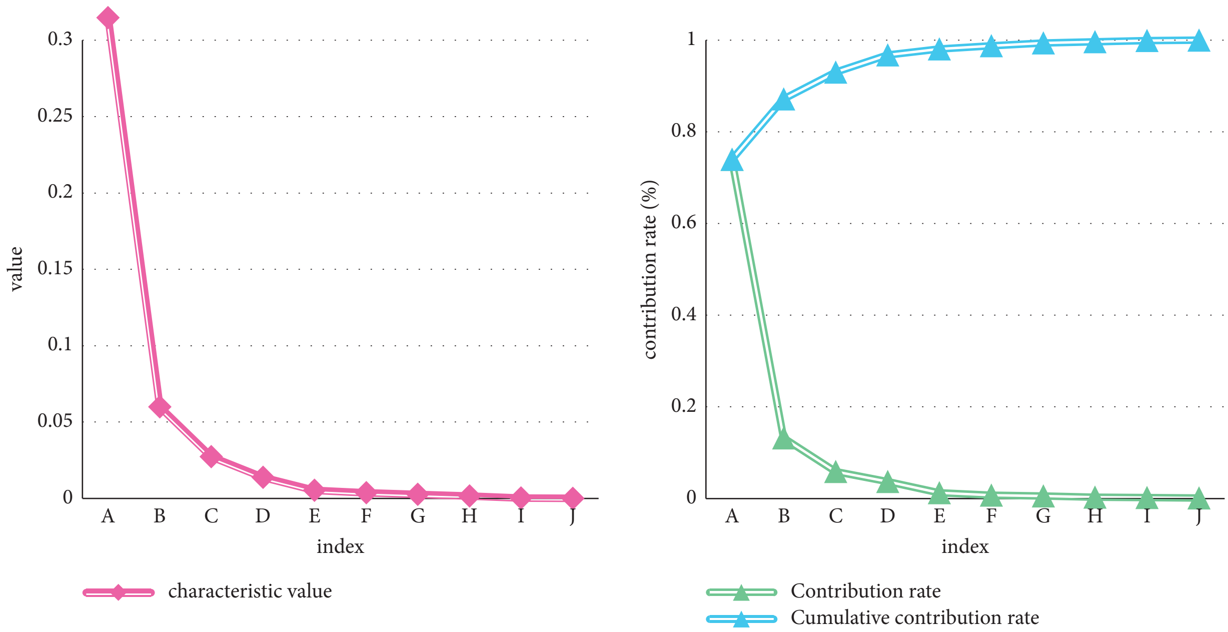

FIGURE 6: Pca results.

TABLE 2: Principal component loading matrix.

Index	A	B	C	D
Total number at the end of the year	−0.1967	−0.3756	−0.3209	−0.1423
Gross domestic product	0.4763	−0.1479	−0.1726	0.6281
The gross industrial output value	0.2344	−0.1162	−0.4493	0.2683
Total passenger volume	0.2879	−0.1605	−0.3092	−0.6217
Total freight volume	0.3318	−0.1821	−0.3105	−0.2492
Local fiscal revenue	0.6612	0.1362	0.4628	−0.1527
Investment in fixed assets	0.0635	0.2297	0.0921	−0.2216
Savings balance of residents at the end of the year	−0.1206	−0.1501	0.1744	0.0538
Number of on-the-job employees	0.0103	0.8193	−0.4382	0.0042
Total wages of on-the-job employees	0.1785	−0.0154	0.1612	−0.0291

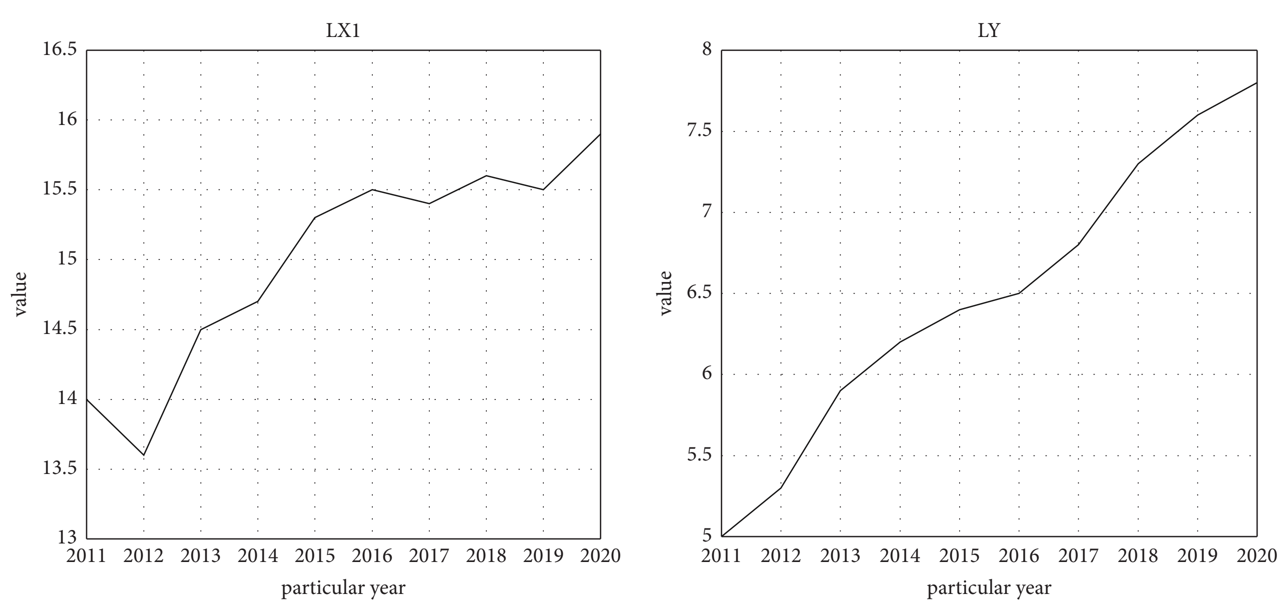

FIGURE 7: x, y trend graph.

Table 3: Unit root test results for lx.

		T-statistic	Prob.*
The augmented Dickey–Fuller test statistic		−5.7247	0.0003
Test critical values	1% level	−3.9281	
	5% level	−3.0372	
	10% level	−2.6913	

Table 4: The unit root test results of ly.

		T-statistic	Prob.*
Augmented dickey-fuller test statistic		−3.3532	0.0265
Test critical values	1% level	−3.9281	
	5% level	−3.0372	
	10% level	−2.6913	

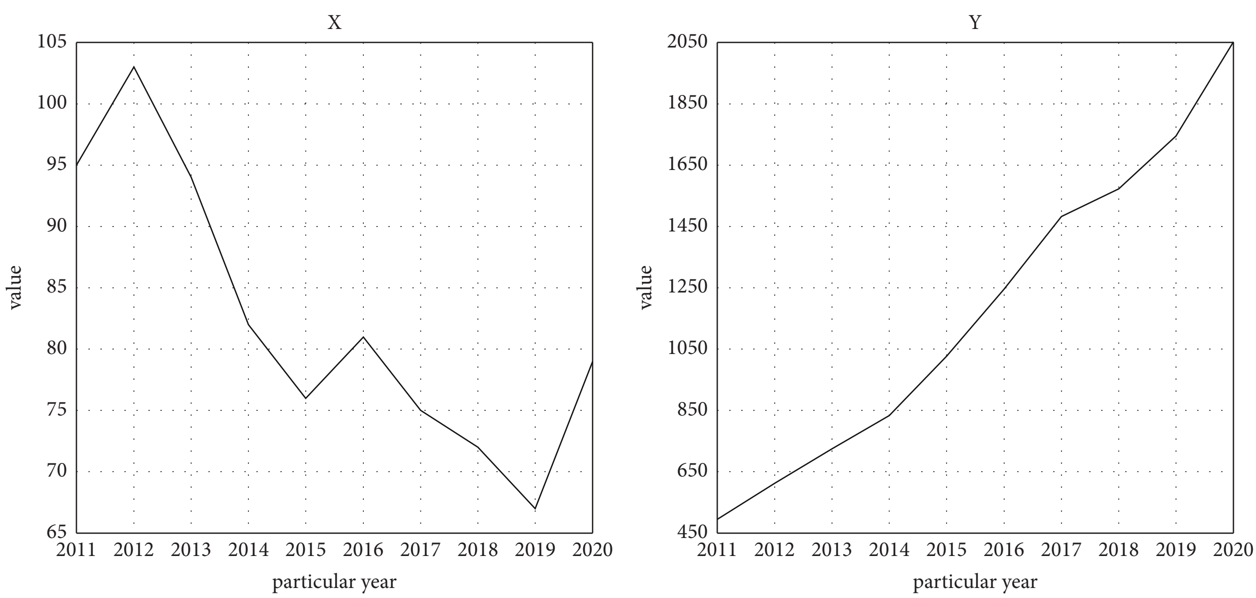

Figure 8: X, Y trend graph.

Table 5: X, Y unit root test results.

	P
X	0.5826
Y	0.9972
LX	0.0484
LY	0.1271

investment direction of resources. The new role of urban economic benefits is that it not only provides new theories and methods for urban management workers to comprehensively improve urban economic benefits and successfully realize urban modernization, but also breaks through the limitation of the concept of departmental economic benefits, and finds indirect factors, internal factors and external factors, individual factors and public factors that restrict urban economic benefits. This is to find a systematic way and a method to improve economic efficiency in an all-around way. Therefore, it is very important to explore the calculation and evaluation of urban economic benefits.

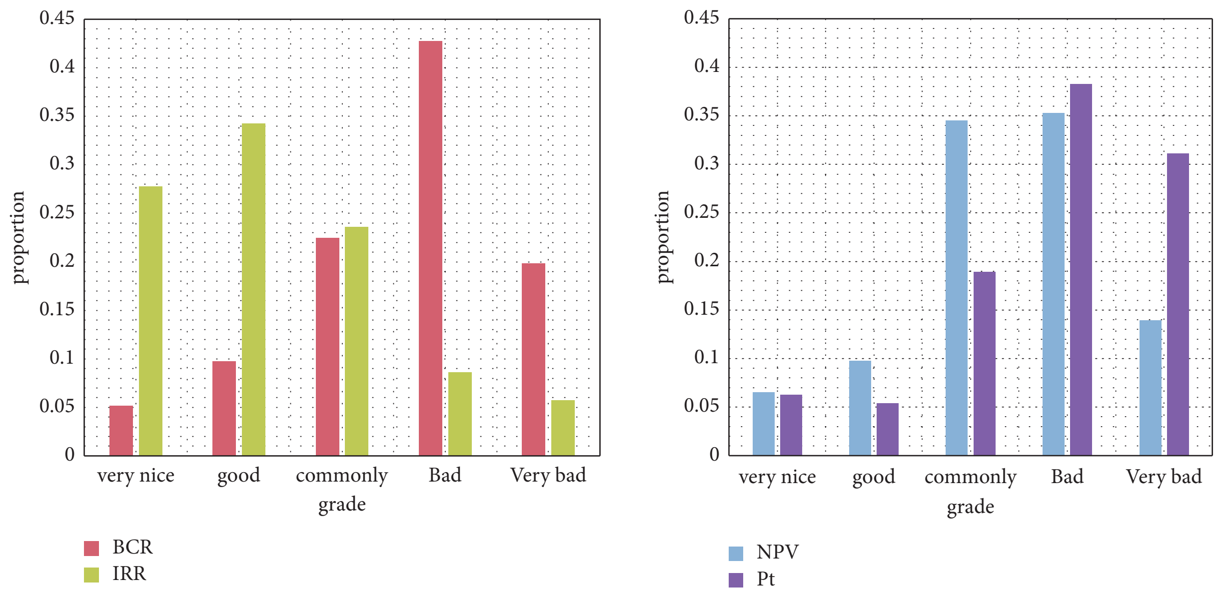

Figure 9: Expert scoring results normalized dataset.

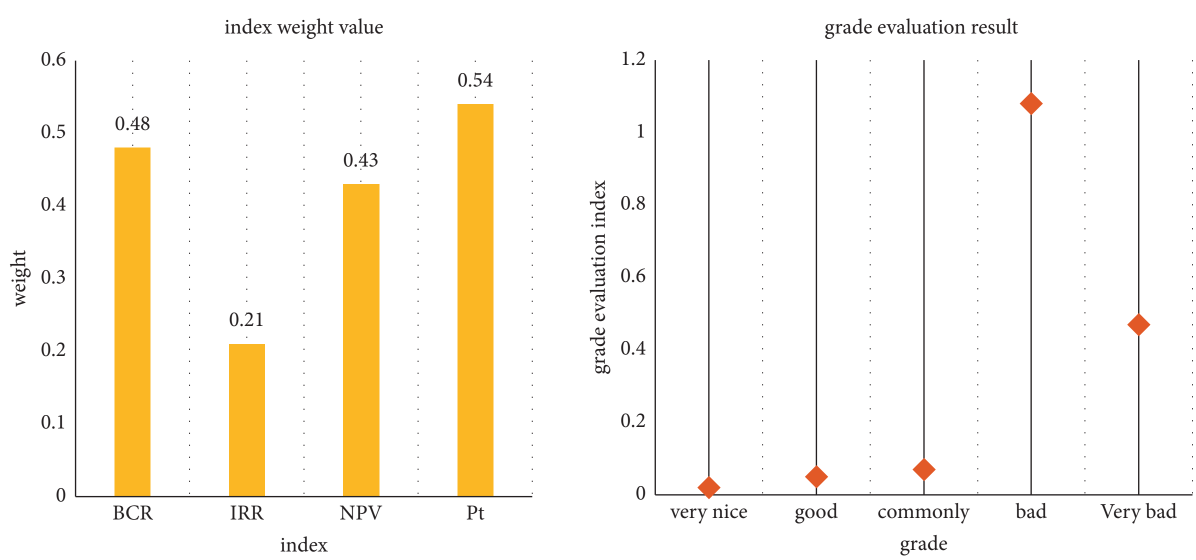

Figure 10: The weight value of the indicators and the comprehensive evaluation results of economic benefits.

6. Conclusion

A smart city is the goal of the current urban development process, which requires the promotion of sustainable urban development while developing the economy. The urban economic benefit is a comprehensive evaluation of a city. In simple terms, intelligent sensing technology is a system and a sensor with information processing functions. It has the ability to collect, process, and exchange information and is an indispensable part of the information age. This article discusses the economic benefits of a smart city. This paper firstly introduces the concept and elements of a smart city, combined with intelligent sensing and communication technology, and then designs the calculation method of urban economic benefit based on PCA, cluster analysis, and cointegration analysis; and then establishes the evaluation model of urban economic benefit; finally, this paper designs an experiment. First, 18 cities in China that have developed smart cities are used as experimental objects to explore the relationship between GDP and some indicators through several analytical methods. Then, using the evaluation model of this paper, taking Wuhan Metro Line 5 as an example, to evaluate its economic benefits, it is concluded that the economic benefit status of Wuhan Metro Line 5 is 4. Therefore, it is necessary to deepen the reform, reduce costs, and increase the profitability of the project to improve the economic benefits of Wuhan Metro Line 5. Although many scholars have paid attention to the field of smart cities, the research is relatively macro and theoretical, and there is no article on the economic benefits of smart cities. From this point of view, the content of this paper is relatively innovative.

Data Availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

References

[1] F. Paganelli, S. Turchi, and D. Giuli, "A web of things framework for RESTful applications and its experimentation in a smart city," *IEEE Systems Journal*, vol. 10, no. 4, pp. 1412–1423, 2016.

[2] C. Daniel, C. Mario, P. Giovanni, and C. Duran-Faundez, "A fuzzy-based approach for sensing, coding and transmission configuration of visual sensors in smart city applications," *Sensors*, vol. 17, no. 1, pp. 1–19, 2017.

[3] G. Pasolini, C. Buratti, L. Feltrin et al., "Smart city pilot projects using LoRa and IEEE802.15.4 technologies," *Sensors*, vol. 18, no. 4, pp. 1118–1135, 2018.

[4] O. Bates and A. J. Friday, "Beyond data in the smart city: repurposing existing campus IoT," *IEEE Pervasive Computing*, vol. 16, no. 2, pp. 54–60, 2017.

[5] Y. Wu, W. Zhang, J. Shen, Z. Mo, and Y. Peng, "Smart city with Chinese characteristics against the background of big data: idea, action and risk," *Journal of Cleaner Production*, vol. 173, no. 1, pp. 60–66, 2018.

[6] H. Yeh, "The effects of successful ICT-based smart city services: from citizens' perspectives," *Government Information Quarterly*, vol. 34, no. 3, pp. 556–565, 2017.

[7] M. M. Rathore, A. Paul, A. Ahmad, and G. Jeon, "IoT-based big data: from smart city towards next generation super city planning," *International Journal on Semantic Web and Information Systems*, vol. 13, no. 1, pp. 28–47, 2017.

[8] A. Huovila, M. Airaksinen, I. Pinto-Sepp et al., "CITYkeys smart city performance measurement system," *International Journal for Housing Science and its Applications*, vol. 41, no. 2, pp. 113–125, 2017.

[9] J. Y. Fernandez-Rodriguez, J. A. Alvarez-Garcia, J. Arias Fisteus, M. R. Luaces, and V. Corcoba Magana, "Benchmarking real-time vehicle data streaming models for a smart city," *Information Systems*, vol. 72, pp. 62–76, 2017.

[10] Y. Zhang, X. Xiao, L. X. Yang, Y. Xiang, and S. Zhong, "Secure and Efficient Outsourcing of PCA-Based Face Recognition," *IEEE Transactions on Information Forensics and Security*, vol. 15, pp. 1683–1695, 2019.

[11] A. Tascikaraoglu, "Evaluation of spatio-temporal forecasting methods in various smart city applications," *Renewable and Sustainable Energy Reviews*, vol. 82, no. 1, pp. 424–435, 2018.

[12] L. Anthopoulos, "Smart utopia VS smart reality: learning by experience from 10 smart city cases," *Cities*, vol. 63, pp. 128–148, 2017.

[13] J. Wang, C. Jiang, K. Zhang, T. Q. S. Quek, Y. Ren, and L. Hanzo, "Vehicular sensing networks in a smart city: principles, technologies and applications," *IEEE Wireless Communications*, vol. 25, no. 1, pp. 122–132, 2018.

[14] M. Gasco-Hernandez, "Building a smart city: lessons from barcelona," *Communications of the ACM*, vol. 61, no. 4, pp. 50–57, 2018.

[15] Z. Lv, "The security of Internet of drones," *Computer Communications*, vol. 148, pp. 208–214, 2019.

[16] E. Przeybilovicz, W. Silva, and M. A. Cunha, "Limits and potential for eGov and smart city in local government: a cluster Analysis concerning ict infrastructure and use," *International Journal of E-Planning Research*, vol. 4, no. 2, pp. 18–36, 2017.

[17] V. Zdraveski, K. Mishev, D. Trajanov, and L. Kocarev, "ISO-standardized smart city platform architecture and dashboard," *IEEE Pervasive Computing*, vol. 16, no. 2, pp. 35–43, 2017.

[18] P. K. Sharma, S. Rathore, and J. H. Park, "DistArch-SCNet: blockchain-based distributed architecture with Li-fi communication for a scalable smart city network," *IEEE Consumer Electronics Magazine*, vol. 7, no. 4, pp. 55–64, 2018.