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Research on the Typical Correlation Analysis Model of Input and Output in Smart Cities

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Abstract: *Based on the typical correlation between input and output of smart cities in China and abroad, this paper summarizes the effective parts extracted from a large number of current smart city construction practices. By identifying the key core elements of smart cities, the article identifies key directions for investment in smart cities in new urban areas. The paper establishes investment indicators for smart cities and post evaluation indicators for smart city output, and builds an "input-output" prediction model to study the input-output relationship of smart cities. The article deepens the interactive relationship between investment in smart city construction and the output of construction achievements, providing an effective basis for pre evaluating the implementation effect of smart city construction. This model can determine the key points of resource allocation for smart city builders when formulating smart city construction plans and plans, and provide reference for pre evaluation of construction effectiveness for smart city construction decision-makers.*

Keywords: *Smart city; Input and output analysis; Key element analysis; canonical correlation analysis*

From the development process of smart cities, it can be seen that the development of new generation information technology, cloud computing, and the Internet of Things Exhibition is the technological foundation and necessary condition for building a smart city. The construction of smart cities not only promotes the widespread use of information technology, but also puts forward higher requirements for information and communication technology, which in turn promotes the rapid development of information technology and is expected to contribute to the next technological revolution. [1]

Against the backdrop of resource and environmental constraints, with the development of smart city construction, the interpretation of smart cities by the government and residents has also changed. The government and residents have a deeper understanding of smart cities, and the ultimate goal of building smart cities has gradually evolved from early informatization to achieving coordinated and sustainable development of economy, society, and environment. The construction of smart cities therefore requires extensive participation from various industries and all residents, which is a fundamental transformation involving production and lifestyle, urban management, and operation modes. The construction of smart cities not only involves disciplines such as information and communication technology, architecture, and urban planning, but also requires analysis. The impact of smart city construction also requires the comprehensive use of theories and methods from multiple disciplines such as macroeconomics, welfare economics, public economics, urban economics, regional economics, development economics, and industrial economics.[2]

This study focuses on elucidating the interactive relationship between investment in smart city construction and output of construction achievements from the perspective of economic analysis, providing effective basis for pre evaluating the implementation effectiveness of smart city construction.

1. Introduction

Smart cities are an open and complex giant system engineering[3], and there are also many uncertainties in the correlation between investment, construction, and output. The current industry is more concerned about how to improve the efficiency of smart city investment. The starting point and foothold of this article is to extract effective parts from the current practice of smart city construction, identify key core elements, and find key directions for investment in smart cities in new urban areas. In order to study the relationship between input and output of smart cities as shown in Figure 1, a "input-output" prediction model is established by establishing smart city input indicators and post

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evaluation indicators of smart city output. The interactive relationship between smart city construction input and construction outcome output is elaborated, providing an effective basis for pre evaluating the implementation effectiveness of smart city construction.

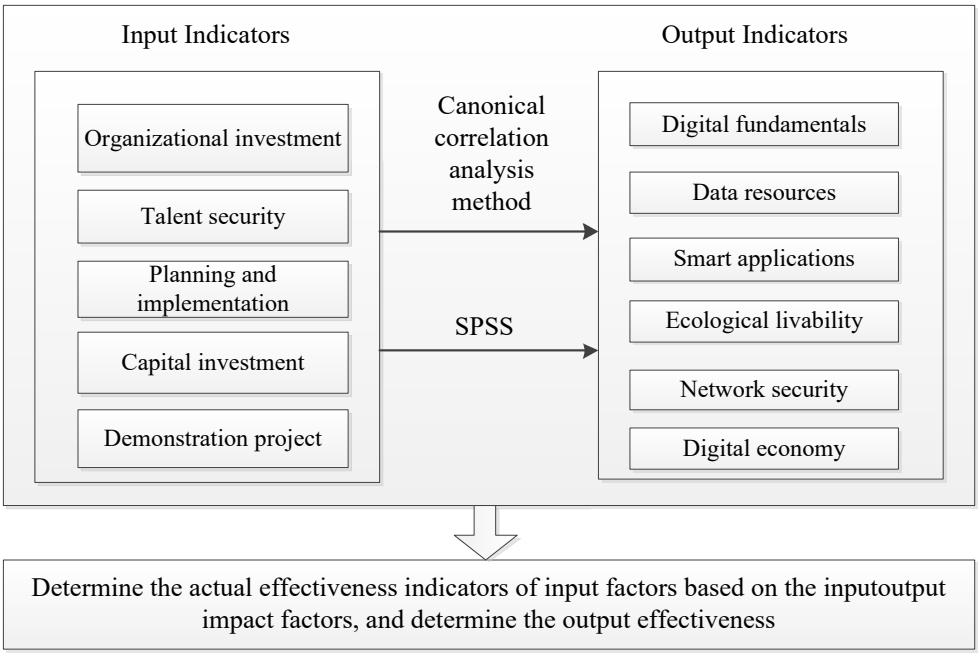

Figure 1: Architecture of the Input and Output Analysis Model for Smart Cities

2. Typical correlation analysis methods

Canonical correlation analysis is an application of the cross covariance matrix.[4] This article uses SPSSPRO data science analysis software. According to the description of typical correlation analysis by this software, its function is to study multiple variables and the linear correlation between multiple variables, which can reveal the internal relationship between two sets of variables.

Firstly, we find the linear combination of variables in each group, so that there is the maximum correlation coefficient between the two sets of linear combinations. Then, we select a linear combination that is not related to the initially selected pair of linear combinations and pair them until the correlation between the two sets of variables is extracted. Let X (1), …,X (n) is a sample taken from a normal population. Each sample measures two sets of indicators, which are more than two quantitative variables or ordered categorical variables, which marked as $X=(X_1,..., X_p)$"; $Y=(Y_1,..., Y_q)$" respectively. They are two or more quantitative variables or ordered categorical variables.

The original data matrix is:

$$\begin{bmatrix} x_{11} & x_{12}\cdots x_{1p} & y_{11} & y_{12}\cdots y_{1q} \\ x_{21} & x_{22}\cdots x_{2p} & y_{21} & y_{22}\cdots y_{2q} \\ \vdots & \vdots \quad \vdots & \vdots & \vdots \quad \vdots \\ x_{n1} & x_{22}\cdots x_{2p} & y_{21} & y_{22}\cdots y_{nq} \end{bmatrix}_{n\times(p+q)} \tag{1}$$

Test the correlation coefficient of the first pair of typical variables, that is, the correlation of paired typical variables, and the explanatory ratio of typical variables to the research variable.

$$H_0{:}\lambda_1 = 0, H_1{:}\lambda_1 \neq 0 \tag{2}$$

Its likelihood ratio statistic is:

$$\Lambda^2 = \left(1-\widehat{\lambda_1^2}\right)\left(1-\widehat{\lambda_2^2}\right)\cdots\left(1-\widehat{\lambda_p^2}\right) = \prod_{i=1}^{p}\left(1-\widehat{\lambda_i^2}\right) \tag{3}$$

The statistic is:

$$\mathrm{Q}_1 = -\left[n-2-\frac{1}{2}(p+q+1)\right]\ln\Lambda_1 \tag{4}$$

Through the above process, two goals are achieved. Firstly, data simplification is achieved, using a

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small number of linear combinations to explain the correlation between two sets of variables. Secondly, data interpretation is used to search for eigenvalues.

3. Typical correlation analysis results

By collecting variable data and importing it into the SPSS PRO analysis software, the correlation between input and output factors is obtained. As shown in Table 1, it can be seen that investment is still the most important influencing factor, which is also determined by the essence of intelligent urban housing in project-based investment. Therefore, the focus of this input-output typical correlation analysis is on the factors that are second only to capital investment and have relatively high correlation.

Table 1: Input-output relationship matrix

Index	Digital fundamentals	Data resources	Smart applications	Ecological livability	Network security	Digital economy
Organizational investment	0.625	0.362	0.362	0.297	0.157	0.507
Talent security	0.456	0.241	0.236	0.175	0.184	0.356
Planning and implementation	0.581	0.511	0.271	0.352	0.235	0.461
Capital investment	0.783	0.508	0.499	0.608	0.431	0.491
Demonstration project	0.523	0.449	0.221	0.292	0.173	0.434

A new area is located at the easternmost point of the Guangdong Hong Kong Macao Greater Bay Area in China. With obvious geographical advantages and convenient external transportation, it is an important strategic growth pole radiating from the Guangdong Hong Kong Macao Greater Bay Area to the eastern coastal economic zone of Guangdong. The construction of a smart city in a certain new area is an important investment, and the funding investment has a significant guarantee. However, the construction of a smart city in this new area also requires other important success factors. Therefore, the topic focuses more on the second and third important factors, second only to capital investment.

3.1 Digital Basic Analysis

Strengthen organizational investment (0.625): Create an efficient collaborative body for the construction of smart new areas. The structure of an organization determines its functions. The digital base of a certain new area during its current construction phase includes information infrastructure, public infrastructure, and spatiotemporal information platforms. These are the top priorities for the current construction of a smart new area. As a newly developed area in the city, a team of urban managers has gradually arrived in a certain new area. Among them, urban decision-makers, functional departments, and members of the management team need to closely focus on the management committee of the new area to strengthen overall leadership, collaboration between functional departments, team building, and organizational evaluation. They also need to maintain coordination and consistency in construction concepts, ideas, management methods, and methods. Otherwise, it can easily lead to an "entropy increase" in the construction of the entire smart new area, resulting in waste of resources and investment

Planning and Implementation (0.581): Explore "original innovation" and build a globally leading digital Li Sheng city with the characteristics of the new area. The concept of smart cities has been put into practice for less than 15 years, and its ontology, epistemology, and methodology are still being explored in theoretical research and project practice, and are still not mature enough. Therefore, so far there is no mature sample city that can be copied and copied for the reference of this new area. From this perspective, the cost of trial and error is high and 'slow is fast'. However, overall, the basic laws of the digital economy have gradually emerged. From the construction experience and direction of smart cities, cities need to improve the top-level design and construction of a complete digital twin city operating system. At present, the new area has built and used a multidimensional spatial geographic information platform visualization system, with the aim of strengthening the coordination between infrastructure construction at the current stage, especially the urgent need for construction collaboration between underground pipelines. At present, there is no mature model of a digital Li Sheng city in the world. If the top-level design, planning, and implementation of the digital Li Sheng city can be centered, a smart city construction model with the characteristics of the new area will be formed. This

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will achieve the "five unifications" of the development of the new area based on the digital Li Sheng platform of the new area, namely unified planning, unified standards, unified construction, unified operation, and unified management.

3.2 Data resource analysis

Planning and Implementation (0.511): Cultivate "data element productivity" and form data assets based on digital twins. Data has become a new factor of production, and data governance requires integrating digital resources, developing sharing mechanisms, and planning the scope of data resource use. Part of the data requires cooperation between government and enterprises, leveraging the power of social enterprises to fully leverage the value of data resources. The construction of smart cities is a systematic project, and the interconnectivity between data resources, big data mining, and use will greatly promote the value realization of data production factors, forming data factor productivity.

Standard specifications for spatiotemporal data management, includes standards for spatiotemporal data management, updates, and the use of common layers. The construction of a spatiotemporal database includes the construction of a spatiotemporal data center to achieve integrated management of spatiotemporal data. In terms of application system construction, the construction of basic and demonstration application systems is relatively dispersed, and there is still a need for standardized management ideas to normalize various lines into a set of digital twin based urban operating systems, and plan and implement them on this overall platform

Demonstration project (0.523): Grasp the "construction timeline" and form a closed-loop mechanism of demand scenario pilot demonstration summary improvement. The development and sharing of data resources in the smart region requires a rigorous construction timeline. The key is not to rely on the investment of people, finance, and materials accumulated through project by project investment, but to carry out pilot demonstrations based on medium and long-term needs. Pilot demonstrations should be carried out in industries with sufficient data and mature conditions, copying each mature one, and gradually expanding the scope, boundaries, and types of data resource sharing and use.

3.3 Smart application analysis

In terms of the correlation ratio of the five major input-output factors, the output indicator of smart applications is lower than that of digital bases and data resources, which also reflects the strong market participation behavior of smart applications. However, the premise is to strengthen government organization and guidance, and form a smart application market ecosystem with government guidance, merchant competition, technology comparison, and market revitalization.

Organizational investment (0.362): Strengthen "policy guidance", reduce market intervention, and enrich smart application scenarios. At present, the industry technologies corresponding to various smart applications are basically mature, and there are a large number of solutions in the industry. Smart applications can directly introduce relevant mature technologies and enterprises to participate in construction. It is necessary to organize and strengthen investment attraction, and to enhance the scientific and targeted nature of policy formulation,

By adopting various modes such as BOT, PPP, direct procurement and operation services, and opening up the market to liven up, the government has opened up data interfaces, and both state-owned and private enterprises can carry out market-oriented competition under the unified organization of the digital Li Sheng region's planning. Through competition, technology research and development, technology application, cost reduction, and active various smart application markets can be driven.

Planning and Implementation (0.271): Accumulate smart urban data assets in the region around unified planning. All types of smart applications can be divided into three major parts: application scenario front end, data middle end, and urban data back end. These aspects between smart application scenarios are the relationship between system data calls, and data precipitation needs to be formed around the smart city operating system, accumulating urban data through continuous iteration.

3.4 Ecological livability analysis

Planning and Implementation (0.352): Environmental friendliness provides guarantees for investment attraction and also attracts talents and enterprises to settle in. Ecological investment is

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mainly focused on government public budgets, with capital investment being the key. The key focus of investment is to strengthen environmental monitoring, supervision, and auditing within the framework of existing environmental laws and regulations. In addition to capital investment, it is also necessary to build a smart and environmentally friendly IoT sensing platform, as well as a linkage between urban environmental monitoring and governance.

Organizational investment (0.297): Ecological construction is a highly external public project, but the short-term benefits are poor, and the medium to long-term benefits are often good. Therefore, it is necessary for the region to strengthen organizational investment. In the process of planning, construction, and operation and maintenance in the smart region, strong organizational concepts and environmental law enforcement should be implemented to ensure the progress of ecological civilization in the region.

3.5 Network security analysis

Planning and Implementation (0.235): Network security is the foundation for the steady development of smart cities and one of the goals of smart city development.[5] Network security guarantee has high requirements for network reliability and network attack prevention coding, and is an investment intensive field. At the same time, it is also necessary to strengthen network security planning, develop network security mechanisms and emergency measures in advance, and unify the planning of network and data security areas, security levels, and security standards.

Talent guarantee (0.186): Establish a "security team" to form a network security guarantee team with high technical literacy. With the deepening of new infrastructure construction, urban infrastructure and networks have become tightly integrated. Network and information security incidents are often attacks initiated by hackers, which is a strength competition between network technology teams and technical teams. During the construction process of a new district, it is necessary to have a stable and high-level network security guarantee team.

3.6 Digital Economy analysis

Organizational investment (0.507): Revitalize the "digital industry" and cultivate international competitiveness in the era of smart digital economy in the region. The digital economy is divided into five categories: digital product manufacturing, digital product service, digital technology application, digital factor driven, and digital efficiency improvement. The first four categories are the development of new digital industries, and the fifth category is the upgrading of traditional industries. These fields are based on enterprises as the main body of innovation, and need to strengthen guidance, organizational investment, policy guidance, financial support, and identify unique positioning.

Planning and Implementation (0.461): It is necessary to pay attention to government guidance for investment promotion, mobilize organizational forces to carry out investment promotion activities, and include them in organizational indicators. Investment in guiding funds will drive local characteristic industries to form leading industrial clusters through different types of core enterprises, forming location effects.

4. Conclusions

Smart cities open up complex giant systems, and we must adhere to the system theory. Essentially, the above construction elements are not completely linear. Typical correlation analysis is of great significance for the sustainability of investment in smart cities. In order to simplify the calculation, this article conducted a typical correlation analysis by collecting data. The benefits obtained by investing in different industrial sectors vary, and the driving effects on other sectors are also different, except for direct driving. In addition to directly driving the economy, the infrastructure construction of smart cities can also have a driving effect on other industries, and the value-added driving effect of different industrial sectors on other industrial sectors also varies. Therefore, choosing different industrial sectors to invest in the construction of smart city projects will result in different output efficiency.

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