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A Comprehensive Evaluation on the Performances of China's Information Technology Characteristic Towns Utilizing the Advantage-Oriented Competitive Evaluation (ACE) Method

Shitong Huang [1,*], Kai Yang [2,*], Ping Wang [1], Qing Yang [1] and Luyun Li [1]

[1] International Business School, Hainan University, Haikou 570228, China
[2] School of Business, Nanjing University of Information Science & Technology, Nanjing 211544, China
* Correspondence: shitonghuang@hainanu.edu.cn (S.H.); 003153@nuist.edu.cn (K.Y.)

Abstract: The characteristic town (CT, or Te Se Xiao Zhen in Chinese) program is among the most important drivers of China's new urbanization. However, the program aroused countrywide concerns about its rapid elevation, excessive real estate construction, high investment risk, and severe construction homogenization. Despite the policy's rapid dissemination, there needs to be a theoretical basis and practical guidance for the local government to evaluate CT candidates to ensure the feasibility and sustainability of this novel urbanization practice. Moreover, simply employing traditional evaluation techniques, such as TOPSIS or analytical hierarchical process, may overwhelmingly stress inherited advantages of existing towns and easily overlook the potential candidates in the policy's early implementation. Thus, the current study employs a novel advantage-oriented competitive evaluation (ACE) approach, which values the comparative advantages of the evaluated objects, to rate the performance of fifteen information technology characteristic towns (ITCTs) comprehensively. The presented work constructs a three-level performance index system based on public statistics, comprehensively evaluates the ITCTs' performance, and reveals each CT's unique advantages. The analysis and discussion disclose the evaluated ITCTs' development status, highlighting the blooming development against public concerns and the ITCTs' clustering based on unique comparative advantages. The evaluation results also verify that the ACE is an excellent comprehensive evaluation approach that can reveal an object's comparative advantages from varying facets and depths. Finally, this work briefly concludes the emerging issues of ITCTs' construction, the limitations of ACE evaluation, and suggestions for future research.

Keywords: characteristic town (Te Se Xiao Zhen); advantage-oriented (Jingyou) competitive evaluation; information technology characteristic towns; comprehensive evaluation

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1. Introduction

The fast increase in China's urbanization rate over the past four decades depicts its significant modernization progress [1,2]. In contrast, several issues emerged during this tremendous socio-economical transformation, such as uneven development and significant income differences between urban and rural areas [3], over-concentration of human resources and capitals in eastern coastal cities [4,5], deteriorating environmental conditions and intense global competition on coastal city clusters [4], the disparity between resided population and residents in urban areas (54.7% vs. 36% in 2014) [4], or even urbanization shrinkage [6]. In witnessing the massive resource consumption and intensive labor input, the government and academics considered the past development pattern to be the bottleneck retarding China's GDP growth and urbanization process [7,8]. Therefore, China urgently requires a transformation from resource-oriented and labor-oriented economic development [9] to ecological-friendly development [1]. The report of China's 19th National Congress pointed out that China's economic growth has shifted from high-speed growth to high-quality development, of which the core module is technological innovation.

As a new core model aiding high-quality development, the characteristic town program is essential to crack the bottleneck of spatial resources, promote the construction of new urbanization, upgrade the coordinated development of urban and rural areas, and accelerate industrial structure transformation. The characteristic town (CT, or Te Se Xiao Zhen in Chinese, or Featured Town [10] or a town with distinct characteristics [11]) is not a traditional administrative township [11] but a suburban production space with distinct features and industries. A CT packages production, living, and ecology components in a territory area (usually less than three square kilometers) [8] with new design styles and preferential policies. Aiming to attract talents and foster industrial upgrading [10], CTs function as new platforms that integrate industries, residence, tourism, and culture [7]. The Central People's Government of the People's Republic of China issued the Proposals for the Fourteenth Five-Year Plan and Vision 2035 in March 2021, which explicitly stated that the spatial layout of urban areas should be improved by developing small towns and promoting the standardized and healthy development of characteristic towns according to their geographic locations, resource endowment, and foundation [12]. In response to promoting the construction of science and technology CTs of Zhejiang Province, the General Office of the People's Government of Zhejiang Province, the CT program's origin, issued the "Guiding Opinions on Continuously Promoting the High-Quality Development of Characteristic Towns" on 9 December 2022, which explicitly puts forward developing science and technology innovation bases; promotes the close collaboration between universities, R&D institutions, and characteristic towns; and establishes the "institute-platform-enterprise" linkage. The "institutes-platforms-enterprises" linkage aims to promote scientific and technological innovation platforms, develop the construction of provincial-level enterprise R&D institutions, and guide the aggregation of innovation factors and resources. The CT program was quickly promoted to a national policy in 2016 [5,8,10] and inspired China's central government to invest in 1000 CTs countrywide covering tourism, trading, modern manufacturing, education, high-tech, and culture by 2020. Since its announcement, the CT program has become the most crucial driver of China's industrialization and urbanization [7,10,13] among multiple central government policies, such as "Mass Entrepreneurship and Innovation", "Supply-side Reform", and "New-type Urbanization" [11].

However, several concerns emerged as the policy disseminated, including early warning signals of house affordability [14], excessive development in real estate [10], irrational or excessive construction, severe homogenization [1], and its speculative nature with high-risk [10]. Among these concerns, the most outstanding worry was the significant gap between the investment for CT constructions and the limited resources available [3]. The local administrations urgently require a comprehensive evaluation approach to select projects with solid foundations and prevent resource waste caused by blind constructions [5]. Conversely, few studies revealed how local governments evaluate and choose CT projects for construction [5], resulting in unsound assessment systems [1] and potential risks hindering the feasibility and sustainability of CT development.

Several academics proposed CT performance evaluation studies to bootstrap their construction from various perspectives [3,15–19]. Hu [20] developed a comprehensive evaluation system to identify the critical factors for the sustainable development of agriculture-oriented CTs (AOCTs), with which the comparison between the AOCTs located in China's four major regions exhibited their respective comparative advantages and suggested the adoption of a development strategy according to the local resource advantages. In Guangzhou University Town, Guo [21] employed the analytic hierarchy process (AHP) approach to filter the candidate sites for science tourism from a geographical perspective, of which the results suggested the west region as the most suitable location for popular science tourism, owing to its prevailing advantages. He [22] employed the gradient difference method against remote sensing data to measure the spatial spillover scope of 84 characteristic towns in Zhejiang province between 2014 and 2020, aiming to provide a reference for CT policy adjustment and optimization. Miao's anatomy is the source of the concept 'Characteristic Town' [10] in terms of its origin and elevation in Chinese national policy. The same author [14] presented a preliminary assessment that revealed the concerns related to CT policy, such as lack of implementation guidelines, overlooking the four critical supporting elements in CTs' construction, and early warnings such as excessive development in real estate. Li [15] employed AHP and the fuzzy comprehensive evaluation method to evaluate the tourism function of Qinling characteristic towns and proposed suggestions for developing the studied tourism CTs, such as improving the accommodation environment and upgrading the traffic in the scenic areas. Aligning with the rural revitalization strategy, Fan [16] established an evaluation index towards the high-quality development of agricultural characteristic towns from six dimensions, with which they combined entropy-based information and TOPSIS to rate the agricultural characteristic towns in Han Dan City in Hebei Province. Chen [3,19] explored the influence of multiple stakeholders on the private partners to participate in the construction of sport and leisure CTs.

Due to the CT policy's unique characteristics, similar international experiences in small towns and rural areas [10,23,24] might provide limited guidance for CT development. As the assumed origin that stimulated the CT policy, the "garden city" policy, a most internationally famous idea associated with the low-density suburban format's development, now seemed problematic in new planning orthodoxies for China or other countries' suburbanization worldwide [10]. Though the technoburbia of the USA inspired the first CT construction in Hangzhou, the two closely related and similar practices diverge in terms of the experimental contradictions, the economic and social contradictions and their drivers [14]. The feasibility issue roots in the different ideological and financial support from the administrations of the two countries, indicating the planned nature of China's urbanization development [14]. The cause applies to the feasibility issue of other urbanization practices outside China, such as Heritage Europe, the European Council for the Village and Small Town, Cittaslow International Network of small towns [24], and small town development in India [23].

An in-depth review of the above literature highlights several potential directions for future CT evaluation studies. First, the existing studies' focus was limited on evaluating the information technology characteristics towns (ITCTs). Despite their relatively tiny portion among the entire CT cases, the ITCTs match well with the national CT development strategy [25] due to their high-speed development. Next, the evaluation strategy employed by the published studies usually treats the to-be-evaluated CTs as independent, isolated individuals and could overlook a CT's development history and comparative advantage. The evaluation methods used in the past studies, such as the subjective evaluation method represented by AHP [15,21] and the objective method represented by TOPSIS [16], adopt uniform standard evaluation criteria and lack the revelation and refinement of CTs' comparative advantages. Therefore, the current paper conducts a comprehensive ITCT performance evaluation to disclose their development status by employing the advantage-oriented competitive evaluation (ACE) method [26–29] that accounts for an individual's comparative advantages. In short, the contributions of the current study include a comprehensive evaluation of 15 ITCTs' performance under a carefully established performance index system, the ACE-based evaluation result that reflects each ITCT's comparative advantages, and validation of the ACE approach as an innovation to comprehensive evaluation practice.

The organization of this paper is as follows: Section one briefly reviews the literature related to CT evaluation and the ACE method. Section two presents the ITCTs' universal and distinct features to demonstrate why the current study selects ITCTs as the research objects. Section three states the ACE's principles and its representative application scenarios, followed by applying the ACE method to ITCT evaluation in section four. Section five lists the current study's essential findings and in-depth discussions, from which section six draws the conclusion and suggests future research directions.

2. Information Technology Characteristic Towns

2.1. ITCTs' Distinctive Features

China's ITCTs feature location advantages, primary dependent industries, unique government-enterprise cooperation patterns, and special consideration for the local ecological environment (Figure 1), as seen in the following:

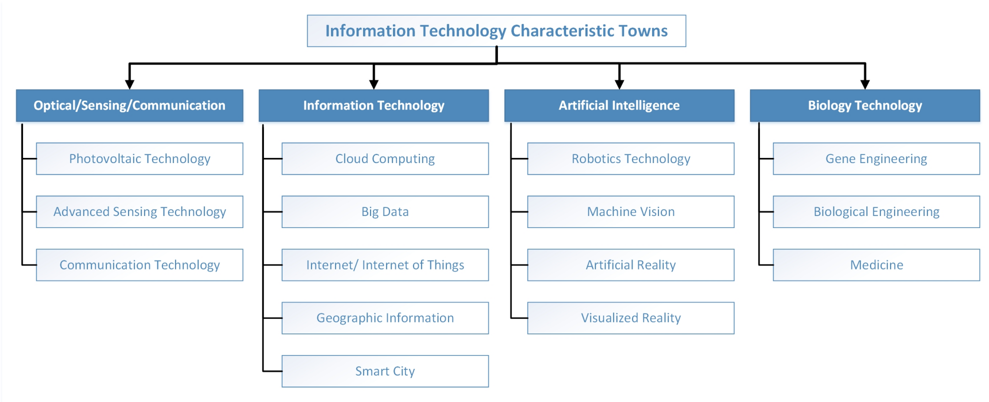

Figure 1. ITCTs' classification based on their primary dependent industries.

Distinctive location advantages. Most ITCTs are located in economically developed areas where high-tech industries concentrate [30]. This overlap between ITCTs' locations and China's high-tech industries denotes the ITCTs' prominent location characteristics among all CT types.

New urbanization community integrating industry, town, and population. The ITCTs' dependent industries primarily aggregate on the emerging high-end technology industries, such as new-generation information technology, cloud computing, big data, the Internet, the Internet of Things, artificial intelligence, and gene technology. As platforms aiding incubation, innovation, and entrepreneurship, the ITCTs aim to attract high-end scientific and technological talents—the vital elements of the technology industry.

Government-enterprise cooperation pattern. The developed countries usually adopted a *'construction and development without government's guidance'* pattern in their urbanization practice, e.g., the development of Western Silicon Valley, USA matches the pattern well. Unlike this pattern, the ITCTs in China follow the *'government-led, social-capital-based'* pattern. In this pattern, the government first establishes policies covering various perspectives such as town planning, financial support, and supporting facilities. Meanwhile, social capital functions as the main construction body and jointly works with governments promoting ITCTs. This novel pattern first exhibits its advantage in the ITCT construction of Zhejiang, the CT program's origin.

Integration with the ecological and cultural advantages. Most ITCTs' plannings consider the *'science and technology featured cultural tourism'* essential component, aiming to balance the local ecological environment and the scientific and technological elements and save spaces for science and technology landscapes, such as science- and technology-related theme parks, culture expos, and theme hotels.

2.2. ITCT Case Selection

This study filters the ITCTs from those CTs listed in Huang's report [31] for further study (Figure 2). Notably, the keyword-based filtering might overlook ITCTs since the typical naming convention, such as the technology-based characteristic town, the technology featured town, and technology innovation characteristic town, are misleading in illustrating the ITCTs' primary dependent industry. For example, Jiaxing Haining Sunshine Science and Technology Town is a manufacturing town other than an ITCT, despite its name including the keyword *'science and technology'*, since it features smart manufacturing belonging to the green energy industry. Therefore, a manual investigation is carried out carefully and locates fifteen ITCTs , as listed in Table 1.

(**a**)

(**b**)

(**c**)

(**d**)

Figure 2. ITCTs' on-site view: (**a**) Weifang Fangzi *Phoenix Geo-Info CT* [32]; (**b**,**c**) Hangzhou *Xihu Yunqi CT* [33,34]; (**d**) Nanjing Jiangning, *Life Science and Technology CT* [35].

Table 1. Information concerning the selected ITCTs.

ID	Name	City	Province	Area (km^2)	Population (10^3 pl)
S_1	Fenggang *Artificial Intelligence CT*	Dongguan	Guangdong	2460	8261.4
S_2	Gulou Jinniu Internet + CT	Fuzhou	Fujian	12,675	7570
S_3	Binjiang *Internet CT*	Hangzhou	Zhejiang	16,596	9188
S_4	Binjiang *Internet of Things CT*	Hangzhou	Zhejiang	16,596	9188
S_5	Xihu *Yunqi CT*	Hangzhou	Zhejiang	16,596	9188
S_6	Xiaoshan *Information Bay CT*	Hangzhou	Zhejiang	16,596	9188
S_7	Yuhang *Artificial Intelligence CT*	Hangzhou	Zhejiang	16,596	9188
S_8	Deqing *Geographic Information CT*	Huzhou	Zhejiang	5820	2648
S_9	Tonghu *Science and Technology CT*	Huizhou	Guangdong	11,346	4775
S_{10}	Wuzhen *Internet CT*	Jiaxing	Zhejiang	4223	4614
S_{11}	Jiangning *Life Science and Technology CT*	Nanjing	Jiangsu	6587	8270
S_{12}	Nanjing *Future Network CT*	Nanjing	Jiangsu	6587	8270
S_{13}	Shangrao High-speed Railway Economic Pilot Zone *Digital Economy CT*	Shangrao	Jiangxi	22,791	6752
S_{14}	Fangzi Phoenix *Geo-Info CT*	Weifang	Shandong	16,143	9357
S_{15}	Yancheng *Digital Dream CT*	Yancheng	Jiangsu	16,931	7235

3. ACE Methodology

3.1. The Principal Idea of the ACE

Noticing the importance of an individual’s comparative advantages, Zhao and his colleagues proposed a novel evaluation method named *‘Advantage-oriented Competitive Evaluation’* (ACE) [26] to evaluate object performance by cross-referencing. ACE’s principal idea is that an individual, as an organizational member, will intentionally or unintentionally realize his value and fulfil self-promotion by exploring and utilizing the laws of things. Meanwhile, various individuals have distinct advantages due to endogenous differences. Acknowledging the cognition limitations and differences in individuals’ skill endowments, an organization should guide, evaluate, and encourage its members by rewarding an individual’s relative advantages instead of his absolute advantages.

The primary distinction differentiating ACE from other evaluation approaches lies in its accounting for collaboration and competition within the organization. Instead of using a uniform global weight structure, the ACE comprehensively evaluates all objects’ performance under a group of object-specific weight structures, under which each to-be-evaluated object produces an advantageous weight structure substantially beneficial to itself the most. Therefore, an object’s overall performance, composed of credits evaluated by every object’s most beneficial weight structure, can objectively reflect the object’s performance from all objects’ perspectives. Therefore, ACE is proper for individual performance evaluation that involves teamwork and collaboration, e.g., the comprehensive ranking for the employee of high-tech industries [27,36,37] or R&D organizations [28]. Moreover, ACE enables complex evaluation involving a multi-level index system [38], which helps ACE be successfully applied in several scenarios, such as high-tech talent evaluation [27–29] and city creativity evaluation [38,39]. However, the method was rarely internationally cited for socio-economic purposes in the English-language literature.

3.2. The ACE Evaluation Procedure

A typical ACE evaluation procedure consists of four steps: index construction, data normalization, individual advantageous pattern recognition, and ACE comprehensive evaluation. The last two steps distinguish the ACE method from other evaluation methods.

3.2.1. The Evaluation Index Construction

ACE is independent of the index system employed. Therefore, any typical index construction technique is applicable for ACE, which includes preliminary index selection [8,24], index reduction [3,19,24], consistency, and coverage check [3,5].

3.2.2. Feature Data Normalization

ACE employs data normalization to map the original performance data into range [0, 1], aiming to balance the contribution of scale-varied performance indicators. A commonly utilized normalization approach is the min–max normalization, as is illustrated in Section 4.2.

3.2.3. Recognition of Individuals' Advantageous Patterns

Recognizing the individual advantageous pattern is a core module of ACE evaluation. For a set of N objects ($\vec{o} = [o_1, \ldots, o_N]^T$), each object o_i featuring for an M-dimension performance vector $\vec{f}_i = [f_{i,1}, \ldots, f_{i,M}]^T$ has a weight structure $\vec{w}_i = [w_{i,1}, \ldots, w_{i,M}]^T$ that produces its personal best for a given positive objective function $P(\vec{f}, \vec{w})$, such as

$$\begin{aligned} &\min P(\vec{f}_i, \vec{w}_i) \\ &\text{s.t.} \sum_{j=1}^{M} w_{i,j} = 1 \end{aligned} \tag{1}$$

where the vector $\vec{w}_i$ is referred to as the individual advantageous pattern (IAP) for object o_i.

A common choice of objective function $P(\vec{f}_i, \vec{w}_i)$ is o_i's Euclidean distance from a reference object, such as:

$$P(\vec{f}_i, \vec{w}_i) = \sum_{j=1}^{M} d_j^2(f_{i,j}, f_j^*) = \sum_{j=1}^{M} w_{i,j}^2 (f_{i,j} - f_j^*)^2 \tag{2}$$

where $\vec{f}^*$ denotes the feature vector of the reference object, which is usually a synthesized ideal object that has a feature vector consisting of the maxima (or minima) in the M-dimension feature space, i.e., $\forall f_j^* = 1(\text{or } 0),$ for $j = 1, \ldots, M$.

3.2.4. ACE Performance Evaluation

Since an IAP corresponds to an object's personal best performance, ACE iteratively evaluates an object's performance under all objects' IAPs to calculate the object's relative advantages, i.e., for object $o_k, j = 1, \ldots, M$, ACE successively selects each object's IAP $\vec{w}_j, j = 1, \ldots, N$ as a proxy and calculates o_k's performance under the proxy IAP $\vec{w}_j$, such as

$$p_{k,j} = P(\vec{f}_k, \vec{w}_j) \quad \text{for } k, j = 1, \ldots, N \tag{3}$$

Therefore, all $p_{k,j}$ form an $N \times N$ performance matrix $\mathbf{P}$. In $\mathbf{P}$, the $j-$th column contains all objects' performance under the j-th proxy IAP $\vec{w}_j$, which is supposed to be most beneficial to object o_j, and o_j is supposed to be the first in this column. Furthermore, the $k-$th row reflects the object o_k's performance under all objects' IAPs.

Next, ACE rates an object o_j's performance by checking if its rank in column j matches the expectation, such as

- The one that shows the *most significant* advantage if its performance ranks first in the column;
- The one that shows *NO* advantage if its performance ranks the last in the column;
- Otherwise, the one that shows ordinary performance or no significant advantage.

To implement a single-value evaluation, ACE can employ a comprehensive evaluation manner that accounts for an object's average or total performance, i.e., the average of row i, $\bar{p}_i = \frac{1}{N} \sum_{j=1}^{N} p_{i,j}$ or the sum of row i, $s_i = \sum_{j=1}^{N} p_{i,j}$. An object o_i is considered "under excellent performance" if its average performance $\bar{p}_i$ or total performance s_i ranks in the top 3 among all objects, since it comprehensively performs well under all objects' IAPs.

For those evaluation cases involving multi-level indexes, ACE employs a bottom-up manner to calculate an object's performance, where t lower level indexes $X_{j,1}^{(l-1)}, \ldots, X_{j,t}^{(l-1)}$ contribute to an upper level l feature $X_j^{(l)}$, and object o_i's performance on the upper level $X_j^{(l)}$ is

$$f_{i,j}^{(l)} = \sum_{k=1}^{t} f_{i,j,k}^{(l-1)} w_{i,j,k}^{(l-1)} \tag{4}$$

where $f_{i,j}^{(l)}$ denotes object o_i's performance at feature $X_j^{(l)}$, $\vec{w}_{i,j}^{(l-1)} = [w_{i,j,1}^{(l-1)}, \ldots, w_{i,j,t}^{(l-1)}]^T$ is o_i's IAP on t low-level features.

4. ACE-Based ITCTs Evaluation

4.1. The ITCTs Evaluation Index Construction

The current study selects the initial evaluation indexes via the literature review [3,8,24,40] and policy documents analysis [3,13], which phases out indexes or factors with no available statistics. Next, the expert survey, fieldwork, and questionnaire are performed to subjectively weigh the initial indexes, followed by a correlation-based index reduction that removes non-essential indexes. Finally, the current study checks the index system's full coverage and internal contradictions through consistency analysis and coverage validation [3,5,40], as listed in Table 2. In addition to the meanings of every performance index, Table 2 also lists their data source and quantification methods for non-numerical indicators, such as interval-valued quantification(IVQ) and expert grading method(EGM).

4.2. Data Normalization

The data normalization maps the original performance data into range $[0, 1]$ via the "min-max normalization" method. Among all the indexes in the three-level index system (Table 2), two are cost indexes (*City spatial location* X_{221} and *High-speed railway transportation* X_{223}) and the rest are benefit indexes. Therefore, the current study normalizes object o_i's j-th original performance data $a_{i,j}$ as

For a cost index preferring smaller values,

$$f_{ij} = \begin{cases} \dfrac{a_{ij} - a_j^-}{a_j^+ - a_j^-} & \text{for } a_j^+ \neq a_j^- \\ 1 & \text{for } a_j^+ = a_j^- \end{cases} \tag{5}$$

and for a benefit index preferring larger values,

$$f_{ij} = \begin{cases} \dfrac{a_j^+ - a_{i,j}}{a_j^+ - a_j^-} & \text{for } a_j^+ \neq a_j^- \\ 1 & \text{for } a_j^+ = a_j^- \end{cases} \tag{6}$$

where a_j^+, a_j^- denotes the maximum and minimum value of the $j-$th feature. The original performance data of the selected ITCTs are listed in (Table 3).

Table 2. The ITCT Evaluation Index System.

Variable	Description	Data Source	Quantification
Distinctive Industry Development (X_1)			
Industry aggregation level (X_{11})			
X_{111}	*Location Quotient (LQ)* of a local region measures an industry's spatially relative concentration such as $LQ_{i,j} = \frac{q_{i,j}/q_i}{q_j/q}$, where $q_{i,j}, q_j$ denote the j-th industry's regional and national value of a particular statistical index, e.g., for product output, q_i and q denote the regional and national statistics such as GDP.	China City Statistical Yearbook (2021) [41], China Statistical Yearbook (2022) [42]	
Development level (X_{12})			
X_{121}	*Industrial labor productivity* is the industrial output per capita of the industry or the secondary industry sector, which reflects the overall productivity of the regional industry sector.	China City Statistical Yearbook (2021) [41], China Statistical Yearbook 2022 [42]	
X_{122}	*Density of Market Entities* (DMEs) is the ratio of active market subjects to the area of the local administrative area.	China City Statistical Yearbook (2021) [41]	IVQ
X_{123}	*Scale economies effect index* of above-scale industrial enterprises (ASIEs) is the ratio of the overall business income of ASIEs to the number of ASIEs. The ASIEs, which are defined as the industrial enterprises with annual revenue of more than 20 million RMB, can significantly reflect the industry's overall competitiveness.	China City Statistical Yearbook (2021) [41]	
Development prospect (X_{13})			
2 X_{132}	*Sustainable development* of regional industries (mainly in the industrial sector) is quantified by the emissions of three primary pollutants per 10,000 RMB of industrial output value of the ASIEs.	China City Statistical Yearbook (2021) [41]	

Table 2. *Cont.*

Variable	Description	Data Source	Quantification
Development Foundation (X_2)			
Regional Capability (X_{21})			
X_{211}	*Township Capability* is the rank of a CT's belonging town in the national ranking named "one-thousand national comprehensive powerful towns of China".	Annual Report on Development of Small- and Medium-sized Cities in China (2022) [43]	IVQ
Regional Transportation (X_{22})			
X_{221}	*City spatial location* is the distance from a CT's center to the center of its belonging town/city	The Transport Yearbook of China (2022) [44], Baidu Map [45]	
X_{222}	*Air Transportation* is the annual passenger of the civil airports in the CT's belonging town.	The Transport Yearbook of China (2022) [44]	IVQ
X_{223}	*High-speed Railway Transportation* is the linear spatial distance between a CT and its nearest high-speed railway station.	The Transport Yearbook of China (2022) [44]	
Capital Elements (X_{23})			
X_{231}	*Strength of Local Financial Institutions* uses the balance of RMB (in 100 million) loans of all financial institutions (city-wide) at year-end.	China City Statistical Yearbook (2021) [41]	
X_{232}	*Strength of the Leading Development Body* is a CT's credit rating of primary development and construction entities in the open financial market.	China City Statistical Yearbook (2021) [41]	EGM
Human Capital Elements (X_{24})			
X_{241}	*Labor Density* is quantified by the average distribution of the labor force, i.e., the ratio of the employed persons in urban entities at the year-end to the area of the local administrative region.	The Transport Yearbook of China (2022) [44]	
X_{242}	*Education Level of the Population* is the ratio of the local population with tertiary education or above to the resident population in the sixth census in 2010.	Tabulation on the 2010 Population Census of the People's Republic of China [46]	

Table 2. *Cont.*

Variable	Description	Data Source	Quantification
Urban Environment (X_3)			
Urban Construction Foundation (X_{31})			
X_{311}	*Construction Investment Intensity* is calculated as the total fixed asset investment in five years to the increase in the built-up area of the CT's belonging city over the same period.	China City Statistical Yearbook (2017) [47], China City Statistical Yearbook (2021) [41]	IVQ
Infrastructure (X_{32})			
X_{321}	The *Highway Network Density* is the ratio of a CT's year-end road mileage to the area of the city's administrative region.	China City Statistical Yearbook (2021) [41], The Transport Yearbook of China (2022) [44]	
X_{322}	The *Health care level* of a CT is evaluated by its belonging city's average number of hospitals and health centers per 100 km^2.	China City Statistical Yearbook (2021) [41]	
Exclusive Resource (X_{33})			
X_{331}	The *Cultural Heritage* of a CT is quantified by the number of intangible cultural heritage sites, the acquisition of prestigious and influential titles such as the UN Habitat City.	China City Statistical Yearbook (2021) [41], questionnaire.	EGM
Ecology (X_{34})			
X_{341}	*Urban Greening Coverage* is the percentage of greening coverage area in a CT's built-up area.	China City Statistical Yearbook (2021) [41]	
X_{342}	*Air Quality*, or a CT's *Annual Average Ambient Air Quality Composite Index* in the "Annual White Paper on China's Environment".	Bulletin of Marine Ecology and Environment Status of China in 2021 [48]	IVQ
X_{343}	*Water Quality* is evaluated by the clean water resources available per person in the CT's region.	Bulletin of Marine Ecology and Environment Status of China in 2021 [48]	

Table 2. *Cont.*

Variable	Description	Data Source	Quantification
Investment Environment (X_4)			
Business Development Environment (X_{41})			
X_{411}	*Business City Rankings* is the ranking of a CT's belonging city in the "Best Business Cities in China" published by the Forbes magazine.	Forbes China's Best 100 Cities For Business List (Full Ranking) [49]	IVQ
X_{412}	*Achievements of Supported Entrepreneurship* is quantified by the variation rate of urban self-employed private workers in five years.	China City Statistical Yearbook (2017) [47], China City Statistical Yearbook (2021) [41]	IVQ
Administrative Environment (X_{42})			
X_{421}	*Regional Development Strategy* of a CT is rated according to if the CT's belonging city is entitled with any of following titles: National New District, National Comprehensive Reform Pilot Zone, Free Trade Pilot Zone Area, National Demonstration Zone of Industry–City Integration, National Demonstration Zone of Independent Innovation, Guangdong–Hong Kong–Macao Bay Area, National Poverty-stricken County, Provincial Poverty-stricken County, and Expanded Power County.	China City Statistical Yearbook (2021) [41]	EGM
X_{422}	*Local Financial Support* is calculated as the local level financial self-sufficiency rate = annual local fiscal expenditure/annual local fiscal revenue $\times$ 100%	China City Statistical Yearbook (2021) [41]	
X_{423}	*Administration Level* of the rank of a CT's belonging city in the "Annual Report on Rule of Law in China 2022".	Annual Report on Rule of Law in China (2022) [50]	IVQ

Table 3. The ITCT Performance Statistics.

	X_1						X_2							
	X_{11}	X_{12}			X_{13}		X_{21}	X_{22}			X_{23}		X_{24}	
ID	X_{111}	X_{121}	X_{122}	X_{123}	X_{131}	X_{132}	X_{211}	X_{221}	X_{222}	X_{223}	X_{231}	X_{232}	X_{241}	X_{242}
S_1	0.699	33.854	187.148	25,034.010	0.125	35.957	36	−48.7	6	−14.8	6402.48	75	939.995	0.071
S_2	1.408	47.599	13.879	37,926.335	0.239	54.731	1000	−3.6	26	−6.9	12,124.69	80	123.730	0.125
S_3	5.179	47.448	20.767	21,852.496	0.182	49.245	439.21	−8.3	10	−18	25,464.83	80	174.822	0.189
S_4	1.391	47.448	20.767	21,852.496	0.233	49.245	439.21	−8.3	10	−5.3	25,464.83	80	174.822	0.189
S_5	5.179	47.448	20.767	21,852.496	0.182	49.245	155	−17.1	10	−15.6	25,464.83	100	174.822	0.189
S_6	5.179	47.448	20.767	21852.496	0.182	49.245	477.38	−10.8	10	−7.6	25,464.83	80	174.822	0.189
S_7	1.391	47.448	20.767	21,852.496	0.233	49.245	371	−19	10	−21.1	25,464.83	85	174.822	0.189
S_8	0.450	48.120	10.820	16,415.006	0.182	78.481	534.33	−30.2	10	−2.5	2740.35	80	86.298	0.066
S_9	0.678	26.075	17.299	35,595.057	0.125	32.710	431	−25.3	76	−29.7	3155.13	85	84.692	0.058
S_{10}	0.414	43.114	30.905	15,606.693	0.182	49.532	1000	−24.8	7	−7.4	5185.23	20	190.731	0.077
S_{11}	1.161	86.938	57.109	48,647.200	0.231	51.767	608.67	−19.2	12	−10	21,681.28	80	311.508	0.261
S_{12}	1.161	86.938	57.109	48,647.200	0.286	51.767	608.67	−23.1	12	−11.2	21,681.28	100	311.508	0.261
S_{13}	0.190	22.038	3.028	27,989.631	0.309	95.803	1000	−9.6	76	−1.5	1742.12	20	19.035	0.038
S_{14}	0.578	90.181	15.548	35,010.120	0.336	61.367	1000	−10.9	76	−10.3	4797.91	75	53.118	0.079
S_{15}	0.294	57.452	11.751	28,825.243	0.231	49.281	514	−29.6	66	−5.3	3699.32	85	51.639	0.063

Table 3. *Cont.*

	X_3							X_4				
	X_{31}	X_{32}		X_{33}		X_{34}		X_{41}		X_{42}		
ID	X_{311}	X_{321}	X_{322}	X_{331}	X_{332}	X_{333}	X_{334}	X_{411}	X_{412}	X_{421}	X_{422}	X_{423}
S_1	10.051	2.141	3.618	10	47.67	4.09	412.279	43	0.258	50	0.909	70.573
S_2	478.128	0.900	1.815	18	43.92	3.35	2291.546	34	0.147	40	0.722	79.830
S_3	187.240	0.983	2.199	64	40.73	5.24	2319.330	10	0.014	25	0.999	82.060
S_4	187.240	0.983	2.199	64	40.73	5.24	2319.330	10	0.014	25	0.999	82.060
S_5	187.240	0.983	2.199	64	40.73	5.24	2319.330	10	0.014	25	0.999	82.060
S_6	187.240	0. 983	2.199	64	40.73	5.24	2319.330	10	0.014	25	0.999	82.060
S_7	187.240	0.983	2.199	64	40.73	5.24	2319.330	10	0.014	25	0.999	82.060
S_8	154.398	1.327	2.509	18	48.35	5.02	3175.880	55	0.087	15	0.732	71.373
S_9		1.193	1.269	10	42.94	3.25	3793.298	80	0.010	50	0.710	70.573
S_{10}	214.108	1.922	3.410	22	45.11	4.85	880.147	33	0.160	25	0.877	71.373
S_{11}	227.819	1.702	3.416	67	44.74	5.58	831.802	4	0.207	40	0.973	77.010
S_{12}	227.819	1.702	3.416	67	44.74	5.58	831.802	4	0.207	25	0.973	77.010
S_{13}	64.102	0.893	1.764	7	34.19	4.7	4685.871	100	-0.038	15	0.459	49.974
S_{14}	204.923	1.665	1.951	15	41.99	6.29	149.407	44	0.280	37	0.818	69.550
S_{15}	102.352	1.156	1.689	3	41.78	4.53	1175.259	78	0.053	27	0.568	66.754

4.3. IAP Recognition Results of the Fifteen ITCTs

Applying the hierarchical evaluation strategy presented in Section 3.2.3, the current study identifies the IAP of each ITCT based on its features of the three-level index system (Table 2). The IAPs of fifteen objects on the primary are listed in Table 4, and their secondary and tertiary indicators are listed in Appendix A.

Table 4. The Individual Advantageous Patterns (IAPs) of the fifteen ITCTs on the Primary Performance Indicators.

	$\mathbf{X_1}$	$\mathbf{X_2}$	$\mathbf{X_3}$	$\mathbf{X_4}$		$\mathbf{X_1}$	$\mathbf{X_2}$	$\mathbf{X_3}$	$\mathbf{X_4}$
$\mathbf{S_1}$	0.009	0.108	0.0313	0.8517	$\mathbf{S_9}$	0	1	0	0
$\mathbf{S_2}$	0	1	0	0	$\mathbf{S_{10}}$	0	1	0	0
$\mathbf{S_3}$	0.0076	0.688	0.1179	0.1866	$\mathbf{S_{11}}$	0	1	0	0
$\mathbf{S_4}$	0.0056	0.7856	0.0809	0.1279	$\mathbf{S_{12}}$	0	1	0	0
$\mathbf{S_5}$	0	1	0	0	$\mathbf{S_{13}}$	0	0.5	0	0.5
$\mathbf{S_6}$	0.0084	0.6555	0.1302	0.206	$\mathbf{S_{14}}$	0	0.5	0	0.5
$\mathbf{S_7}$	0.0167	0.3552	0.2432	0.3849	$\mathbf{S_{15}}$	0.0136	0.9248	0.0185	0.0431
$\mathbf{S_8}$	0.0028	0.9751	0.0122	0.0098	**Avg.**	0.0043	0.7661	0.0423	0.1873

4.4. Proxy ACE Results of the ITCTs

After obtaining the entire group of IAPs, ACE performs a unique procedure to evaluate all the ITCTs' relative advantages and rank them through a proxy-based strategy (Section 3). Table 5 lists the ITCTs ranking under primary indicator as a demonstration, leaving the rest of the ranking results in Appendix B.

Table 5. ACE Proxy Evaluation at Primary Indicators.

Ranking	**Proxy Characteristic Town**														
	$\mathbf{S_1}$	$\mathbf{S_2}$	$\mathbf{S_3}$	$\mathbf{S_4}$	$\mathbf{S_5}$	$\mathbf{S_6}$	$\mathbf{S_7}$	$\mathbf{S_8}$	$\mathbf{S_9}$	$\mathbf{S_{10}}$	$\mathbf{S_{11}}$	$\mathbf{S_{12}}$	$\mathbf{S_{13}}$	$\mathbf{S_{14}}$	$\mathbf{S_{15}}$
1	$\mathbf{S_{14}}$	●	$\mathbf{S_4}$	●	●	$\mathbf{S_4}$	$\mathbf{S_4}$	$\mathbf{S_{13}}$	●	●	●	●	●	●	●
2	❍	$\underline{S_{10}}$	❍	S_6	S_{12}	❍	S_5	❍	$\underline{S_{13}}$	$\underline{S_2}$	$\underline{S_{12}}$	S_{11}	S_{15}	S_2	S_{13}
3	S_{11}	$\underline{S_{13}}$	S_6	S_{11}	S_7	S_3	S_6	S_4	$\underline{S_{14}}$	$\underline{S_{13}}$	S_3	S_5	S_9	S_{15}	S_8
4	S_{12}	$\underline{S_{14}}$	S_5	S_3	S_9	S_{11}	S_3	S_{15}	S_{15}	$\underline{S_{14}}$	S_4	S_7	S_{14}	S_{11}	S_2
5	S_{10}	S_{11}	S_7	S_5	S_{15}	S_5	❍	S_2	S_2	S_{11}	S_5	S_3	S_8	S_{12}	S_{14}
6	S_2	S_{12}	S_{11}	S_{12}	S_2	S_{12}	S_{12}	S_{10}	S_{11}	S_{12}	S_6	S_4	S_2	S_{10}	S_4
7	S_8	S_8	S_{12}	S_2	S_3	S_7	S_{11}	S_6	S_{12}	S_8	S_7	S_6	S_{10}	S_9	S_6
8	S_{15}	S_{15}	S_2	S_7	S_4	S_{10}	S_{10}	S_{11}	S_3	S_{15}	S_2	S_2	S_1	S_{13}	S_{11}
9	S_4	S_6	S_{14}	S_{14}	S_6	S_2	S_2	S_{14}	S_4	S_6	S_{10}	S_{14}	S_6	S_8	S_{10}
10	S_6	S_3	S_{10}	S_{10}	S_8	S_{14}	S_{14}	S_{12}	S_5	S_3	S_{14}	S_8	S_3	S_1	S_{12}
11	S_5	S_4	S_9	S_8	S_{11}	S_8	S_8	S_1	S_6	S_4	S_1	S_1	S_4	S_6	S_1
12	S_3	S_9	S_8	S_{13}	S_1	S_9	S_1	S_5	S_7	S_9	S_8	S_9	S_7	S_3	S_5
13	S_7	S_7	S_{13}	S_{15}	S_{14}	S_1	S_9	S_3	S_8	S_7	S_9	S_{15}	S_{11}	S_4	S_3
14	S_9	S_5	S_{15}	S_9	S_{10}	S_{15}	S_{15}	S_7	S_{10}	S_5	S_{15}	S_{10}	S_{12}	S_7	S_7
15	S_{13}	S_1	S_1	S_1	S_{13}	S_{13}	S_{13}	S_9	S_1	S_1	S_{13}	S_{13}	S_5	S_5	S_9

'●' denotes a CT is the first under its own IAP; '❍' denotes a CT's ranking when it is not the first under its own IAP; '_' denotes those tied for first under the other CT's IAP.

5. Discussions

5.1. The ITCTs' Universal Well Developments

This paper combines a heatmap and a bar chart to illustrate the ACE evaluation results. In a combined plot such as Figure 3, the heatmap on the left side presents the whole picture of all objects' evaluation results at a particular performance indicator, i.e., the cell (i, j) with a row index i and a column index j in the heatmap denotes the ranking of object S_i under object S_j's IAP P_j, where the cell's number, as well the cell's hue, is the ranking of the evaluated object S_i under IAP P_j. The bar chart on the right depicts the total credits of all objects S_i under the entire group of IAPs, where the highest ranking and lowest ranking correspond to credit 15 and 1, respectively. Therefore, an object winning a top ranking obtains the highest credit, and consequently, its total credit reaches a higher position if it performs well under multiple objects' IAPs. The annotation on a bar in Figure 3 displays an ITCT's ranking at the current indicator, its total credits and the name for informative purposes.

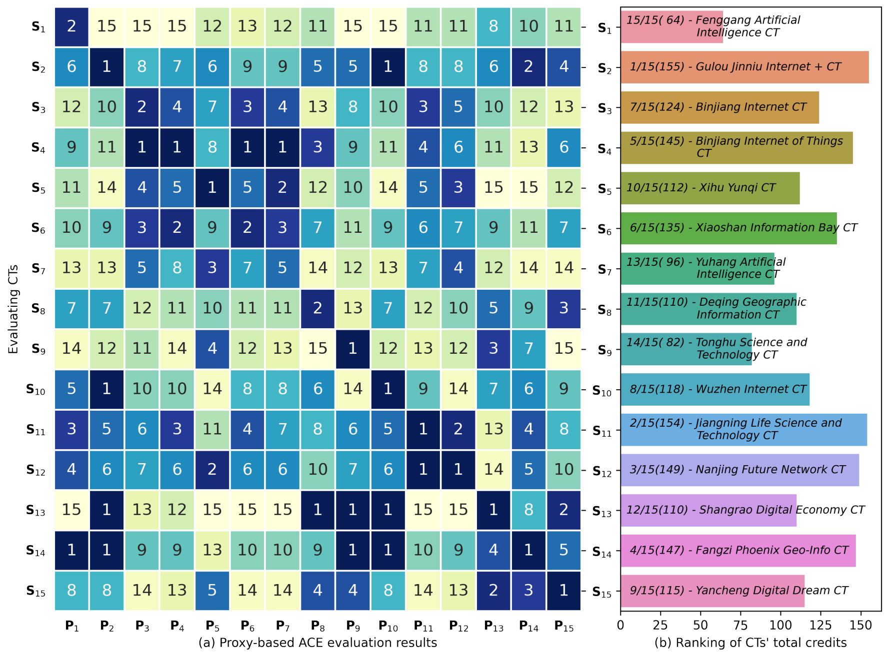

Figure 3. ACE evaluation on the fifteen ITCTs' performance at the primary indicator.

According to their performance at the primary indicator, all ITCTs, except for S_1-*Fenggang Artificial Intelligence CT* and S_9-*Tonghu Science and Technology CT*, present universal sound developments and show no apparent disadvantages, i.e., the total credits of most ITCTs are approximately equal. Most ITCTs rank themselves the first under their IAPs, i.e., fourteen of the fifteen diagonal cells in Figure 3 equal one or two. This parallel "blossoming" trend shows the *non-homogeneous* characteristics of the ITCTs, depicting a trend against the increasing concerns in the unbalanced development of China's CTs construction [1]. As is presented in the next section (Section 5.2), the distinct features of ITCTs are the outcomes of their distinctive dependent industries, such as IT technologies, life-science industries, and artificial intelligence (Table 4).

Significantly, winning several first places under multiple IAPs does not necessarily guarantee an ITCT the most significant total credit at the primary indicator. For example, among the fifteen evaluated ITCTs, the S_1-*Weifang Fangzi Phoenix Geo-Info CT* outperforms other CTs by winning the first place five times (including being tied for first). However, this CT's total credit ranks fourth place in Figure 3 and is eight points lower than that of the top one, S_2-*Gulou Jinniu Internet+ CT*. This result is due to the diverged rankings that a particular CT might receive under varying IAPs. For the S_{11}-*Weifang Fangzi Phoenix Geo-Info CT*, its lowest ranking is 13th place, plus one 10th place and three 9th places. An extreme case is the S_{13}-*Shangrao Digital Economic CT*, whose credit ranks the first place five times and the last six times and is placed twelfth in the ITCT's total credit ranks.

The above two points exhibit the ACE's favor in an evaluated object's balancing and global well development. As illustrated in the heatmap of Figure 3, a cross-reference comparison does not hide but highlight all ITCTs' unique comparative advantages from multiple facets, i.e., it shows an ITCT's performance from varying perspectives or the weight structures that are theoretically most beneficial to each ITCTs itself, respectively. Moreover, the weighted summation of an ITCT's performance credits do not attenuate an ITCT's unique advantages. On the contrary, an ITCT has to achieve a balanced development and obtain significant advantages under multiple IAPs to win the top position comprehensively. An ITCT, such as S_{13}-*Shangrao Digital Economic CT*, may fall behind in the total ranking due to its poor evaluation credits received from several IAPs.

5.2. Five Outperformed ITCTs at the Distinctive Industry Development Indicator

As its name implies, the secondary indicator *Distinctive Industry Development* can uniformly measure an ITCT's development level. In the heatmap of Figure 4, the distribution of all ITCTs' rankings share a similar pattern, which is similar to that of total credit rankings in the bar chart on the right, e.g., S_{12}- *Nanjing Future Network CT* consistently ranks top two under all IAPs (first place for nine times and second place for six times) and the top one in the total credit ranking. The statement applies to other ITCTs also, from the second highest one, S_{14}-*Fangzi Phoenix Geo-Info CT*, to the poorest one, S_{10}-*Wuzhen Internet CT*. The similarity between the evaluation results under all IAPs and their total ranking makes five ITCTs significantly outperform the rest of the ITCTs. In Figure 4, the top two ITCTs, S_{12}-*Nanjing Future Network CT* and S_{14}-*Weifang Phoenix Geo-info CT*, outperform other ITCTs by winning the first place nine times and six times, respectively. In addition to the above two top ones, S_{11}-*Jiangning Life Science and Technology CT*, S_2-*Gulou Jinniu Internet+ CT*, and S_{15}-*Yancheng Digital Dream CT* also demonstrate excellent performance with several top-three rankings at the current indicator.

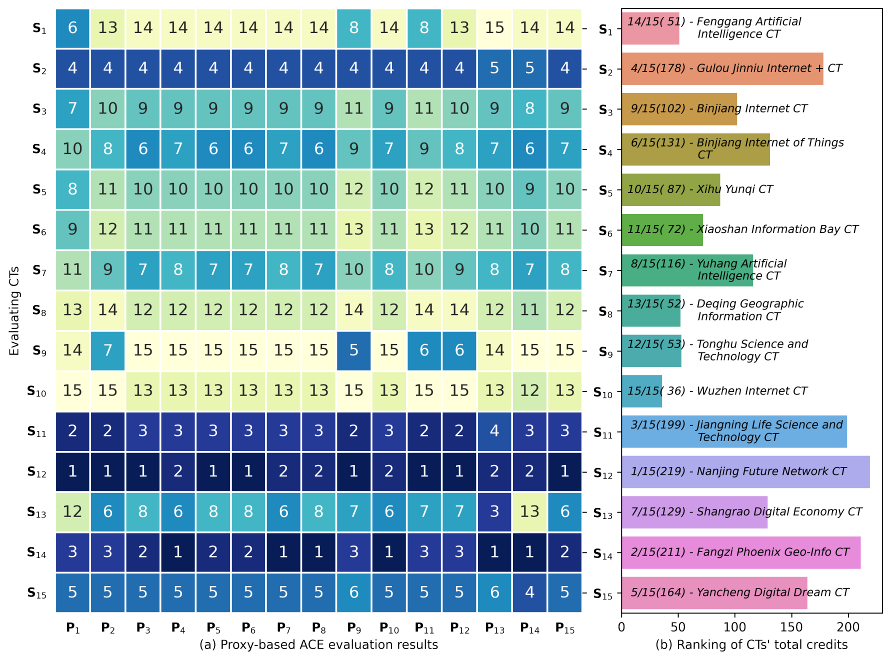

Figure 4. ACE evaluation on the fifteen ITCTs' performance at the *Distinctive Industry Development* indicator.

Moreover, the current secondary indicator includes three tertiary indicators, such as *Industry aggregation level*, *Development Level*, and *Development Prospect*. The larger two weights of all the IAPs' global average (Table A1), $[0.0938, 0.5271, 0.3791]^T$, indicate that the fifteen ITCTs show comparative advantages in the corresponding indicators, *Development Level* and *Development Prospect*.

5.3. Prevailing Advantages of the ITCTs at the Development Foundation Indicator

The secondary indicator *Development Foundation* consists of four tertiary indicators, such as *Regional Capability*, *Regional Transportation*, *Capital Elements*, and *Human Capital Elements*. This indicator primarily quantifies an ITCT's advantages in location and its relation to the surrounding economic center and available resources of capital and intelligence. As mentioned in Section 2, this work selects ITCTs as the research objectives since they feature a more solid development foundation than other types of CTs. As expected, the selected fifteen ITCTs perform well under the indicator *Development Foundation* (Figure 5), where nine out of fifteen ITCTs rank themselves the best, revealing ITCTs' prevailing advantages from the perspective of the development foundation. The top five ITCTs, including S_2-*Gulou Jinniu Internet+ CT*, S_{14}-*Fangzi Phoenix Geo-Info CT*, S_4-*Binjiang Internet of Things CT*, S_{13}-*Shangrao Economic Digital CT*, and S_{11}-*Jiangning Life Science and Technology CT*, demonstrate their unique advantages at the current indicator and balancing development under the majority of IAPs. As a comparison, three of the nine ITCTs that consider themselves the best fall into the worst five of the total-credit-based ranking, including S_5-*Xihu Yunqi CT* (10th), S_{10}-*Wuzhen Internet CT,* (12th) and S_9-*Tonhu Science and Technology CT* (13th) (Figure 5). These three ITCTs, though valuing themselves the best, receive inconsistent credits under other ITCTs' IAPs. Again, the differential ranking of the above nine ITCTs confirms that the ACE method weighs more on balancing development.

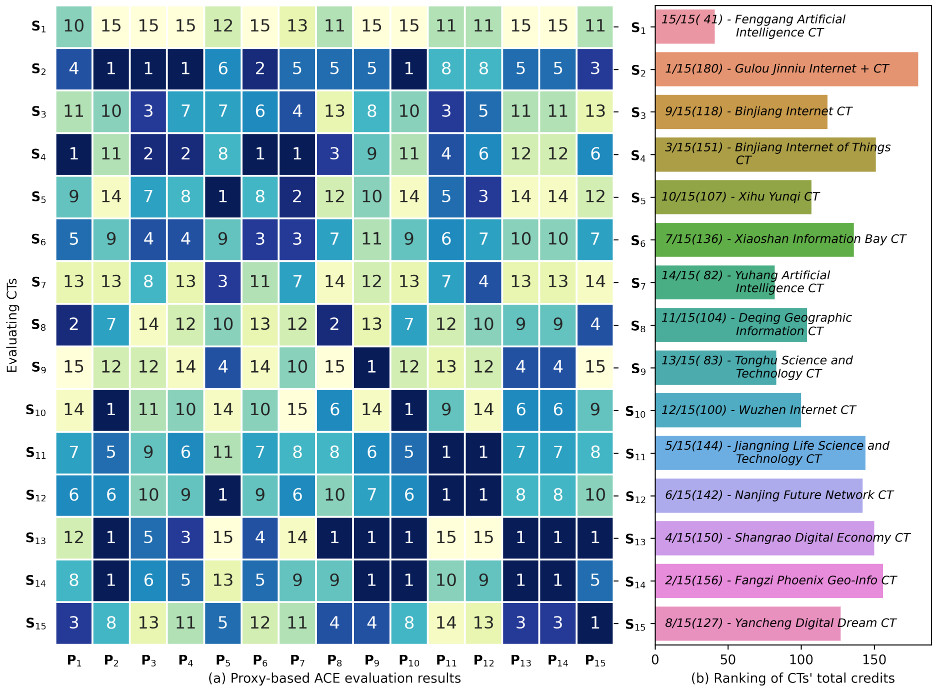

Figure 5. ACE evaluation on ITCTs' performance at the *Development Foundation* indicator.

Another note-worthy fact lies in the conflicts between the total credits of several Zhejiang ITCTs and our traditional understanding of them. As the origin of the CT program, Zhejiang province holds unique advantages and remarkable achievements in economic strength, human resources, administration performance, and fundamental infrastructure. Therefore, the authors expected them to receive good credits under most IAPs and win top rankings. However, some of these Zhejiang ITCTs, i.e., S_5-*Wuzhen Yunqi CT*, S_8-*Deqing Geographic Information CT*, S_{10}-*Wuzhen Internet CT*, and S_7-*Yuhang Artificial Intelligence CT*, rank in the last third of fifteen ITCTs.Their rankings are distributed from 10th place to 14th place in the final ranking based on total credits. This finding confirms that the ACE method, as a cross-referencing approach, can help identify the weakness of ITCTs, especially against those who claim to stand at leading positions or feature prevailing advantages.

Finally, the global averaged IAP $[0.203, 0.549, 0.140, 0.109]^T$ (Table A1) exposes the fifteen ITCTs' weak points in the *Capital Elements* and *Human Capital Elements*, which matches ITCTs' construction objective, a platform integrating capital, talents, and high-tech industries.

5.4. Two Regional ITCT Clusters at the Indicator Urban Environment

An ITCT's comprehensive performance under this indicator, *Urban Environment*, comes from four aspects: *Urban Construction Foundation*, *Infrastructure*, *Exclusive Resources*, and *Ecology*. However, the heatmap in Figure 6 illustrates an apparent aggregation phenomenon of ITCTs that come from the same region, i.e., ITCTs fall into two clusters, namely, the *Nanjing cluster* and the *Zhejiang cluster*. The former includes two ITCTs in Nanjing city, such as S_{11}-*Nanjing Jiangning Life Tech CT* and S_{12}-*Nanjing Future Network CT*. The latter consists of seven ITCTs located in Zhejiang province, including S_3-*Hangzhou Binjiang Internet CT*, S_4-*Hangzhou Binjiang Internet of Things CT*, S_5-*Xihu Yunqi CT*, S_6-*Xiaoshan Information Bay CT*, S_7-*Hangzhou Yuhang Artificial Intelligence CT*, S_8-*Deqing Geographic Information CT*, and S_{10}-*Hangzhou Wuzhen Internet CT*. In Figure 6, ITCTs belonging to the same cluster show equivalent evaluation results under all IAPs in the heatmap on the left and rank closely in the bar chart on the right. The clustering of ITCTs since the current indicator, *Town Environment*, consists of tertiary indicators closely correlated to an ITCT's geographic location. Notably, the similar names of ITCTs in the same cluster confirm this elaboration. Moreover, the *instinctively tied* rankings of ITCTs in the same cluster (Figure 6) manifest the comparative advantages of eastern provinces in their urban environment and also depicts the indicator's weakness in differentiating CTs from the same regions, even if the ITCTs may show varying advantages from other perspectives.

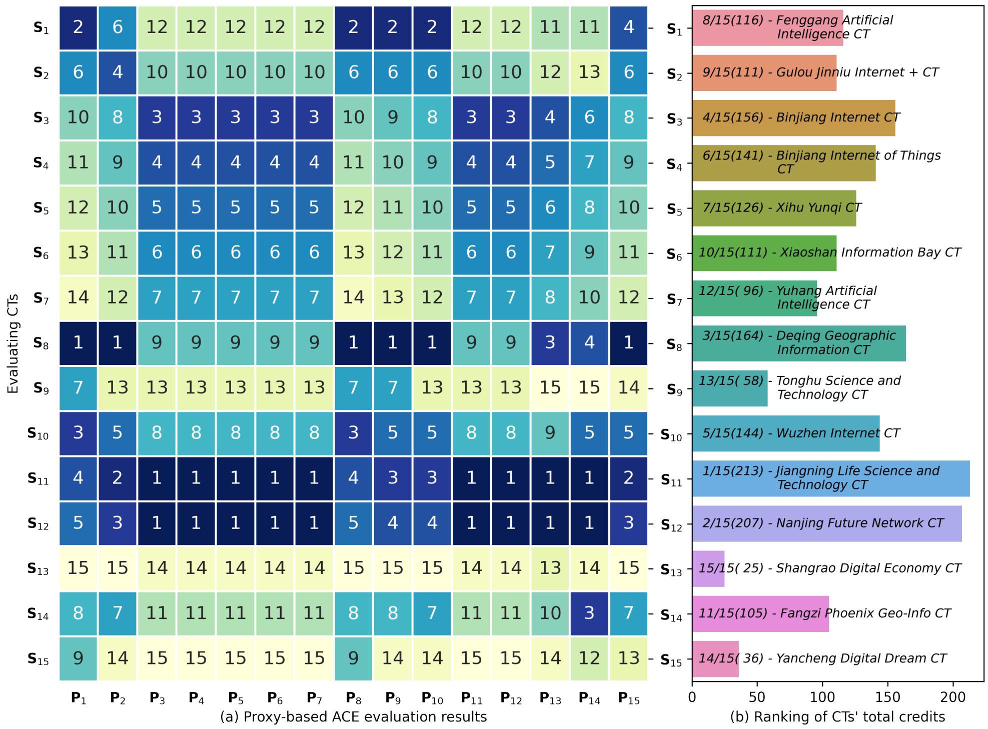

Figure 6. ACE evaluation on ITCTs' performance at the *Town Environment* indicator.

5.5. ITCTs' Diverged Performance in Investment Environment

The *Investment Environment*, including *Business development environment* and *Administrative Environment* as its sub-indicators, reflects the impacts of local capital and administration upon the ITCTs' development. The global average IAP $[0.4172, 0.5828]^T$ in Table A1 demonstrates ITCTs' relatively balanced foundation in the investment environment and local administration.

As seen in the heatmap of Figure 7, significant divergence emerges between several ITCTs' self-evaluation and mutual evaluation. Most ITCTs, ten out of fifteen, rank themselves first under their IAPs in Figure 7. However, the seven ITCTs from the *Zhejiang cluster* mutually rank each other tied first but receive diverged credits from ITCTs outside the cluster. Similarly, two ITCTs in the *Nanjing Cluster* (S_{11}-*Jiangning Life Science and Technology CT* and S_{12}-*Nanjing network CT*), plus S_{14}-*Weifang Fangzi Phoenix Geo-Info CT*, S_{13}-*Shangrao Digital Economy CT*, S_9-*Tonghu Science and Technology CT*, confront the similar situation that they receive poor credits from ITCTs other than themselves. This situation reflects the over-confidence of most ITCTs at the secondary indicator, *Investment Environment*. In contrast, the ACE approach helps mutually reveal the subjective performance of the evaluated ITCTs.

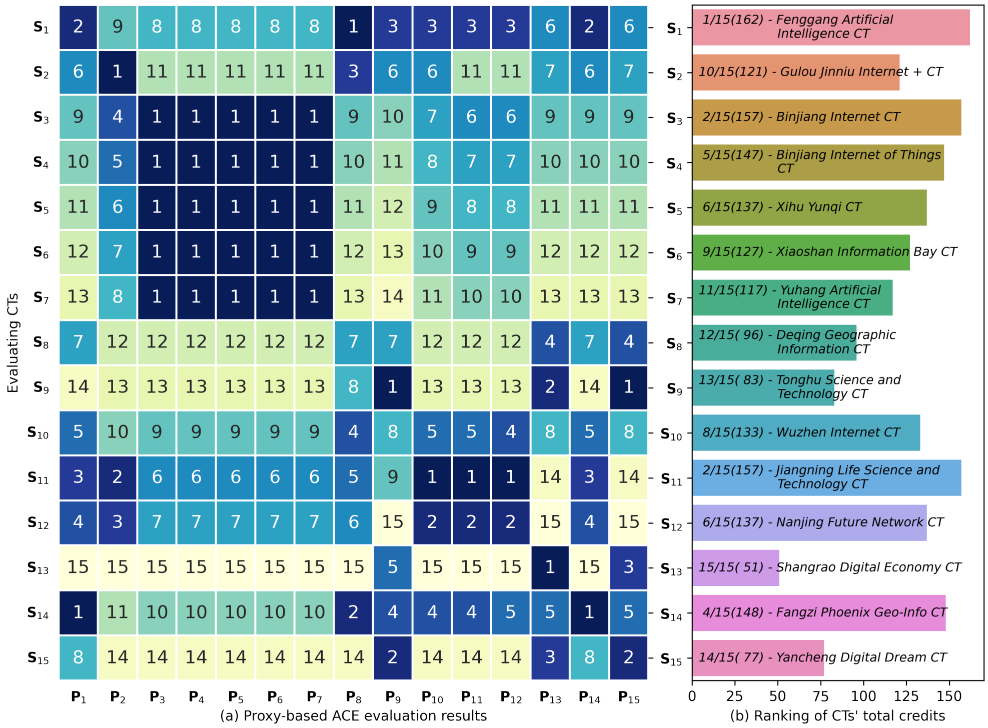

Figure 7. ACE evaluation on ITCTs' performance at the *Investment Environment* indicator.

Notably, the comprehensive ranking spots S_1-*Fenggang Artificial Intelligence CT* as a particular case. Under the most beneficial IAP to itself, the Fenggang ITCT gives up its first place to S_{14}-*Fangzi Phoenix Geo-Info CT* at Weifang city, an ITCT that considers itself the top one under its own IAP. Even after losing the first under its IAP, the Fenggang ITCT still ranks the best according to the total credits(the bar chart in Figure 7) due to the high credits it is given by S_8-*Deqing Geo-Information CT* (1st place) and $S_1$4-*Fangzi Phoenix Geo-Info CT* (2nd place). The difference between an ITCT's self-evaluation and the final ranking of total credits indicates the ACE's favor in the global comparative advantages, not the absolute advantages evaluated under a single standard.

6. Conclusions

The rapid dissemination of China's characteristic towns program in recent years aroused countrywide concerns about the program's risks, such as excessive real estate construction and severe development homogenization. A theoretical basis and practical guidance are necessary for local administrations to phase out high-risk CT construction proposals. Aiming to address this issue, we select fifteen information technology characteristic towns as the representatives for a comprehensive evaluation study on CT construction. As a first attempt, the current work selects a novel evaluation technique, advantage-oriented evaluation, to compare and spot the unique comparative advantages of selected ITCTs, of which the primary findings include:

1. All fifteen ITCTs, except for *Fenggang Artificial Intelligence CT* and *Tonghu Science and Technology CT* at Guangdong province, presented universal sound developments and no apparent disadvantages at the top-level indicator. A parallel "blossoming" trend shows the non-homogeneous characteristics of the ITCTs and varies from the increasing concerns in the unbalanced development of China's CT construction.
2. The ITCTs' mutual evaluation results show varying distribution patterns at the four second-level indicators, which include *Distinctive Industry Development*, *Development Foundation*, *Urban Environment*, and *Investment Environment*. For example, the indicator *Distinctive Industry Development* can uniformly measure an ITCT's construction performance; however, the indicator *Urban Environment* fails to distinguish ITCTs in the same geographical regions regarding the indicator's close correlation with local advantages. Moreover, the fifteen ITCTs' prevailing advantages at the indicator *Development Foundation* confirms the soundness of the current work in selecting ITCTs as the research objects for the CT evaluation study.
3. The significant divergence in ITCTs' self-evaluation, mutual evaluation, and final ranking indicates the ACE's favor in the global comparative advantages, not the absolute advantages obtained under a single standard. For instance, most ITCTs rank themselves the best under their IAP at the secondary indicator *Investment Environment* but need better evaluation results from other provinces. For the same indicator, the *Fenggang Artificial Intelligence CT* can even win the best in the final ranking based on total credits, even after losing the first at its most beneficial IAP. The comprehensive evaluation results of other secondary indicators also confirm this statement. By revealing their distinctive advantages, the presented work verifies the ACE approach's value in evaluating CT performance and highlighting their comparative advantages.

However, the current study is a preliminary attempt to evaluate the ITCTs' construction performance regarding the complexity of the CT program, which is still in its early development. Since the term "characteristics" in the CT program stands for both "specialty" and "novelty", strengthening and enhancing the CT program will be a time-varying challenge that should match the pace of China's development. Meanwhile, the ACE approach's drawbacks also lie in its advantages, manifesting as the difficulty in concluding a simple and universal statement—the difficulty increases when utilizing the ACE method to address over-complex, large-scale evaluation tasks. Furthermore, the limited reports on evaluating ITCTs' performance make it difficult for the authors to compare this work with other published CT evaluation results. In contrast, detailed and similar comparisons between ACE evaluation and other techniques can be found in the previously published Chinese literature, such as [26,36].

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Abbreviations

The following abbreviations are used in this manuscript:

ACE	Advantage-oriented competitive evaluation method
AHP	Analytical hierarchical process
AOCT	Agricultural-oriented characteristic town
ASIEs	Above-scale industrial enterprises
CT	Characteristic town
DMEs	Density of market entities
EGM	Experts grading method
ITCT	Information technology characteristic town
IVQ	Interval-valued quantification
LQ	Location quotient
UN	United Nations

Appendix A. The Individual Advantageous Patterns of Fifteen ITCTs at Secondary and Tertiary Indicators

Table A1. The IAPs of the fifteen ITCTs on the Secondary Performance Indicators.

	X_1			X_2				X_3				X_4	
	X_{11}	X_{12}	X_{13}	X_{21}	X_{22}	X_{23}	X_{24}	X_{31}	X_{32}	X_{33}	X_{34}	X_{41}	X_{42}
S_1	0.105	0.593	0.302	0.009	0.805	0.149	0.038	0.030	0.141	0.040	0.789	0.942	0.059
S_2	0.081	0.546	0.373	1.000	0.000	0.000	0.000	0.157	0.120	0.086	0.637	0.303	0.697
S_3	0.137	0.480	0.383	0.004	0.939	0.043	0.015	0.010	0.019	0.899	0.073	0.025	0.975
S_4	0.103	0.449	0.449	0.002	0.963	0.026	0.009	0.010	0.019	0.899	0.073	0.025	0.975
S_5	0.137	0.480	0.383	0.000	0.000	1.000	0.000	0.010	0.019	0.899	0.073	0.025	0.975
S_6	0.137	0.480	0.383	0.005	0.929	0.050	0.017	0.010	0.019	0.899	0.073	0.025	0.975
S_7	0.103	0.449	0.449	0.011	0.671	0.259	0.058	0.010	0.019	0.899	0.073	0.025	0.975
S_8	0.110	0.468	0.422	0.001	0.990	0.008	0.001	0.035	0.078	0.046	0.841	0.444	0.556
S_9	0.105	0.595	0.300	0.000	1.000	0.000	0.000	0.060	0.135	0.081	0.725	0.477	0.523
S_{10}	0.114	0.466	0.420	1.000	0.000	0.000	0.000	0.063	0.173	0.085	0.680	0.444	0.556
S_{11}	0.039	0.787	0.174	0.000	0.000	0.000	1.000	0.003	0.008	0.959	0.031	0.411	0.590
S_{12}	0.036	0.732	0.232	0.000	0.000	0.500	0.500	0.003	0.008	0.959	0.031	0.418	0.583
S_{13}	0.074	0.323	0.602	0.500	0.500	0.000	0.000	0.091	0.203	0.100	0.606	1.000	0.000
S_{14}	0.041	0.547	0.412	0.500	0.500	0.000	0.000	0.074	0.128	0.078	0.720	1.000	0.000
S_{15}	0.087	0.511	0.402	0.005	0.934	0.058	0.003	0.078	0.158	0.069	0.695	0.697	0.303
Avg.	0.094	0.527	0.379	0.203	0.549	0.140	0.109	0.043	0.083	0.466	0.408	0.417	0.583

Table A2. The IAPs of the fifteen ITCTs on the Tertiary Performance Indicators.

	X_{11}	X_{12}			X_{13}		X_{21}	X_{22}			X_{23}		X_{24}		X_{31}	X_{32}		X_{33}	X_{34}			X_{41}		X_{42}		
	X_{111}	X_{121}	X_{122}	X_{123}	X_{131}	X_{132}	X_{211}	X_{221}	X_{222}	X_{223}	X_{231}	X_{232}	X_{241}	X_{242}	X_{311}	X_{321}	X_{322}	X_{331}	X_{341}	X_{342}	X_{343}	X_{411}	X_{412}	X_{421}	X_{422}	X_{423}
S_1	1	0.250	0.428	0.322	0.615	0.385	1	0.153	0.012	0.835	0.084	0.916	0.643	0.357	1	0.215	0.785	1	0.896	0.065	0.039	0.003	0.997	0.283	0.545	0.172
S_2	1	0.276	0.145	0.579	0.750	0.250	1	0.967	0.000	0.033	0.084	0.916	0.275	0.726	1	0.397	0.603	1	0.801	0.097	0.102	0.093	0.907	0.087	0.118	0.795
S_3	1	0.426	0.232	0.342	0.676	0.324	1	0.934	0.002	0.064	0.340	0.660	0.090	0.910	1	0.360	0.641	1	0.599	0.276	0.125	0.192	0.808	0.007	0.661	0.332
S_4	1	0.426	0.232	0.342	0.742	0.258	1	0.547	0.001	0.452	0.340	0.660	0.090	0.910	1	0.360	0.641	1	0.599	0.276	0.125	0.192	0.808	0.007	0.661	0.332
S_5	1	0.426	0.232	0.342	0.676	0.324	1	0.655	0.006	0.339	0.000	1	0.090	0.910	1	0.360	0.641	1	0.599	0.276	0.125	0.192	0.808	0.007	0.661	0.332
S_6	1	0.426	0.232	0.342	0.676	0.324	1	0.566	0.002	0.432	0.340	0.660	0.090	0.910	1	0.360	0.641	1	0.599	0.276	0.125	0.192	0.808	0.007	0.661	0.332
S_7	1	0.426	0.232	0.342	0.742	0.258	1	0.732	0.008	0.260	0.225	0.776	0.090	0.910	1	0.360	0.641	1	0.599	0.276	0.125	0.192	0.808	0.007	0.661	0.332
S_8	1	0.469	0.241	0.290	0.647	0.353	1	0.013	0.000	0.987	0.044	0.956	0.402	0.598	1	0.329	0.671	1	0.871	0.081	0.048	0.321	0.679	0.056	0.368	0.575
S_9	1	0.212	0.183	0.605	0.618	0.382	1	0.000	1	0.000	0.026	0.974	0.427	0.573	1	0.449	0.552	1	0.752	0.104	0.144	0.828	0.172	0.503	0.192	0.306
S_{10}	1	0.433	0.273	0.293	0.676	0.324	1	0.157	0.003	0.840	0.463	0.537	0.400	0.600	1	0.237	0.763	1	0.789	0.145	0.065	0.078	0.922	0.049	0.639	0.312
S_{11}	1	0.365	0.060	0.575	0.740	0.261	1	0.376	0.005	0.620	0.210	0.790	0.000	1	1	0.235	0.765	1	0.723	0.214	0.064	0.014	0.986	0.044	0.732	0.224
S_{12}	1	0.365	0.060	0.575	0.819	0.181	1	0.335	0.006	0.659	0.000	1	0.000	1	1	0.235	0.765	1	0.723	0.214	0.064	0.014	0.986	0.016	0.753	0.231
S_{13}	1	0.264	0.232	0.505	0.816	0.184	1	0.000	1	0.000	0.410	0.590	0.459	0.541	1	0.402	0.598	1	0.419	0.307	0.275	1	0.000	0.200	0.406	0.394
S_{14}	1	0.673	0.078	0.249	0.876	0.124	1	0.000	1	0.000	0.076	0.924	0.370	0.630	1	0.387	0.613	1	0.528	0.405	0.068	0.000	1	0.148	0.505	0.347
S_{15}	1	0.437	0.176	0.387	0.742	0.258	1	0.056	0.072	0.871	0.027	0.973	0.420	0.580	1	0.410	0.590	1	0.700	0.194	0.106	0.743	0.257	0.162	0.272	0.566
Avg.	1	0.392	0.202	0.406	0.721	0.279	1	0.366	0.208	0.426	0.178	0.822	0.256	0.744	1	0.340	0.661	1	0.680	0.214	0.107	0.270	0.730	0.106	0.522	0.372

Appendix B. Rankings of the Fifteen ITCTs at Secondary Indicators

Table A3. ACE Proxy Evaluation at Distinct Industry Development.

Ranking	Proxy Characteristic Town														
	$\mathbf{S_1}$	$\mathbf{S_2}$	$\mathbf{S_3}$	$\mathbf{S_4}$	$\mathbf{S_5}$	$\mathbf{S_6}$	$\mathbf{S_7}$	$\mathbf{S_8}$	$\mathbf{S_9}$	$\mathbf{S_{10}}$	$\mathbf{S_{11}}$	$\mathbf{S_{12}}$	$\mathbf{S_{13}}$	$\mathbf{S_{14}}$	$\mathbf{S_{15}}$
1	$\mathbf{S_{12}}$	$\mathbf{S_{12}}$	$\mathbf{S_{12}}$	$\mathbf{S_{14}}$	$\mathbf{S_{12}}$	$\mathbf{S_{12}}$	$\mathbf{S_{14}}$	$\mathbf{S_{14}}$	$\mathbf{S_{12}}$	$\mathbf{S_{14}}$	$\mathbf{S_{12}}$	●	$\mathbf{S_{14}}$	●	$\mathbf{S_{12}}$
2	S_{11}	S_{11}	S_{14}	S_{12}	S_{14}	S_{14}	S_{12}	S_{12}	S_{11}	S_{12}	○	S_{11}	S_{12}	S_{12}	S_{14}
3	S_{14}	S_{14}	S_{11}	S_{11}	S_{11}	S_{11}	S_{11}	S_{11}	S_{14}	S_{11}	S_{14}	S_{14}	○	S_{11}	S_{11}
4	S_2	○	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_{11}	S_{15}	S_2
5	S_{15}	S_{15}	S_{15}	S_{15}	S_{15}	S_{15}	S_{15}	S_{15}	○	S_{15}	S_{15}	S_{15}	S_2	S_2	○
6	○	S_{13}	S_4	S_{13}	S_4	S_4	S_{13}	S_4	S_{15}	S_{13}	S_9	S_9	S_{15}	S_4	S_{13}
7	S_3	S_9	S_7	○	S_7	S_7	S_4	S_7	S_{13}	S_4	S_{13}	S_{13}	S_4	S_7	S_4
8	S_5	S_4	S_{13}	S_7	S_{13}	S_{13}	○	S_{13}	S_1	S_7	S_1	S_4	S_7	S_3	S_7
9	S_6	S_7	○	S_3	S_3	S_3	S_3	S_3	S_4	S_3	S_4	S_7	S_3	S_5	S_3
10	S_4	S_3	S_5	S_5	○	S_5	S_5	S_5	S_7	S_5	S_7	S_3	S_5	S_6	S_5
11	S_7	S_5	S_6	S_6	S_6	○	S_6	S_6	S_3	S_6	S_3	S_5	S_6	S_8	S_6
12	S_{13}	S_6	S_8	S_8	S_8	S_8	S_8	○	S_5	S_8	S_5	S_6	S_8	S_{10}	S_8
13	S_8	S_1	S_{10}	S_{10}	S_{10}	S_{10}	S_{10}	S_{10}	S_6	○	S_6	S_1	S_{10}	S_{13}	S_{10}
14	S_9	S_8	S_1	S_1	S_1	S_1	S_1	S_1	S_8	S_1	S_8	S_8	S_9	S_1	S_1
15	S_{10}	S_{10}	S_9	S_9	S_9	S_9	S_9	S_9	S_{10}	S_9	S_{10}	S_{10}	S_1	S_9	S_9

'●' denotes a CT is the first under its own IAP; '○' denotes a CT's ranking when it is not the first under its own IAP.

Table A4. ACE Proxy Evaluation at Development Foundation.

Ranking	Proxy Characteristic Town														
	$\mathbf{S_1}$	$\mathbf{S_2}$	$\mathbf{S_3}$	$\mathbf{S_4}$	$\mathbf{S_5}$	$\mathbf{S_6}$	$\mathbf{S_7}$	$\mathbf{S_8}$	$\mathbf{S_9}$	$\mathbf{S_{10}}$	$\mathbf{S_{11}}$	$\mathbf{S_{12}}$	$\mathbf{S_{13}}$	$\mathbf{S_{14}}$	$\mathbf{S_{15}}$
1	$\mathbf{S_4}$	●	$\mathbf{S_2}$	$\mathbf{S_2}$	●	$\mathbf{S_4}$	$\mathbf{S_4}$	$\mathbf{S_{13}}$	●	●	●	●	●	●	●
2	S_8	$\underline{S_{10}}$	S_4	○	$\underline{S_{12}}$	S_2	S_5	○	$\underline{S_{13}}$	$\underline{S_2}$	$\underline{S_{12}}$	$\underline{S_{11}}$	$\underline{S_{14}}$	$\underline{S_{13}}$	$\underline{S_{13}}$
3	S_{15}	$\underline{S_{13}}$	○	S_{13}	S_7	○	S_6	S_4	$\underline{S_{14}}$	$\underline{S_{13}}$	S_3	S_5	S_{15}	S_{15}	S_2
4	S_2	$\underline{S_{14}}$	S_6	S_6	S_9	S_{13}	S_3	S_{15}	S_{15}	$\underline{S_{14}}$	S_4	S_7	S_9	S_9	S_8
5	S_6	S_{11}	S_{13}	S_{14}	S_{15}	S_{14}	S_2	S_2	S_2	S_{11}	S_5	S_3	S_2	S_2	S_{14}
6	S_{12}	S_{12}	S_{14}	S_{11}	S_2	S_3	S_{12}	S_{10}	S_{11}	S_{12}	S_6	S_4	S_{10}	S_{10}	S_4
7	S_{11}	S_8	S_5	S_3	S_3	S_{11}	○	S_6	S_{12}	S_8	S_7	S_6	S_{11}	S_{11}	S_6
8	S_{14}	S_{15}	S_7	S_5	S_4	S_5	S_{11}	S_{11}	S_3	S_{15}	S_2	S_2	S_{12}	S_{12}	S_{11}
9	S_5	S_6	S_{11}	S_{12}	S_6	S_{12}	S_{14}	S_{14}	S_4	S_6	S_{10}	S_{14}	S_8	S_8	S_{10}
10	○	S_3	S_{12}	S_{10}	S_8	S_{10}	S_9	S_{12}	S_5	S_3	S_{14}	S_8	S_6	S_6	S_{12}
11	S_3	S_4	S_{10}	S_{15}	S_{11}	S_7	S_{15}	S_1	S_6	S_4	S_1	S_1	S_3	S_3	S_1
12	S_{13}	S_9	S_9	S_8	S_1	S_{15}	S_8	S_5	S_7	S_9	S_8	S_9	S_4	S_4	S_5
13	S_7	S_7	S_{15}	S_7	S_{14}	S_8	S_1	S_3	S_8	S_7	S_9	S_{15}	S_7	S_7	S_3
14	S_{10}	S_5	S_8	S_9	S_{10}	S_9	S_{13}	S_7	S_{10}	S_5	S_{15}	S_{10}	S_5	S_5	S_7
15	S_9	S_1	S_1	S_1	S_{13}	S_1	S_{10}	S_9	S_1	S_1	S_{13}	S_{13}	S_1	S_1	S_9

'●' denotes a CT is the first under its own IAP; '○' denotes a CT's ranking when it is not the first under its own IAP; '_' denotes thy are tied for first under the other CT's IAP.

Table A5. ACE Proxy Evaluation at Town Environment.

Ranking	Proxy Characteristic Town														
	$\mathbf{S_{1}}$	$\mathbf{S_{2}}$	$\mathbf{S_{3}}$	$\mathbf{S_{4}}$	$\mathbf{S_{5}}$	$\mathbf{S_{6}}$	$\mathbf{S_{7}}$	$\mathbf{S_{8}}$	$\mathbf{S_{9}}$	$\mathbf{S_{10}}$	$\mathbf{S_{11}}$	$\mathbf{S_{12}}$	$\mathbf{S_{13}}$	$\mathbf{S_{14}}$	$\mathbf{S_{15}}$
1	$\mathbf{S_{8}}$	$\mathbf{S_{8}}$	$\mathbf{S_{11}}$	$\mathbf{S_{11}}$	$\mathbf{S_{11}}$	$\mathbf{S_{11}}$	$\mathbf{S_{11}}$	●	$\mathbf{S_{8}}$	$\mathbf{S_{8}}$	●	●	$\mathbf{S_{11}}$	$\mathbf{S_{11}}$	$\mathbf{S_{8}}$
2	○	S_{11}	$\underline{S_{12}}$	$\underline{S_{12}}$	$\underline{S_{12}}$	$\underline{S_{12}}$	$\underline{S_{12}}$	S_{1}	S_{1}	S_{1}	$\underline{S_{12}}$	$\underline{S_{11}}$	$\underline{S_{12}}$	$\underline{S_{12}}$	S_{11}
3	S_{10}	S_{12}	○	S_{3}	S_{3}	S_{3}	S_{3}	S_{10}	S_{11}	S_{11}	S_{3}	S_{3}	S_{8}	○	S_{12}
4	S_{11}	○	S_{4}	○	S_{4}	S_{4}	S_{4}	S_{11}	S_{12}	S_{12}	S_{4}	S_{4}	S_{3}	S_{8}	S_{1}
5	S_{12}	S_{10}	S_{5}	S_{5}	○	S_{5}	S_{5}	S_{12}	S_{10}	○	S_{5}	S_{5}	S_{4}	S_{10}	S_{10}
6	S_{2}	S_{1}	S_{6}	S_{6}	S_{6}	○	S_{6}	S_{2}	S_{2}	S_{2}	S_{6}	S_{6}	S_{5}	S_{3}	S_{2}
7	S_{9}	S_{14}	S_{7}	S_{7}	S_{7}	S_{7}	○	S_{9}	○	S_{14}	S_{7}	S_{7}	S_{6}	S_{4}	S_{14}
8	S_{14}	S_{3}	S_{10}	S_{10}	S_{10}	S_{10}	S_{10}	S_{14}	S_{14}	S_{3}	S_{10}	S_{10}	S_{7}	S_{5}	S_{3}
9	S_{15}	S_{4}	S_{8}	S_{8}	S_{8}	S_{8}	S_{8}	S_{15}	S_{3}	S_{4}	S_{8}	S_{8}	S_{10}	S_{6}	S_{4}
10	S_{3}	S_{5}	S_{2}	S_{2}	S_{2}	S_{2}	S_{2}	S_{3}	S_{4}	S_{5}	S_{2}	S_{2}	S_{14}	S_{7}	S_{5}
11	S_{4}	S_{6}	S_{14}	S_{14}	S_{14}	S_{14}	S_{14}	S_{4}	S_{5}	S_{6}	S_{14}	S_{14}	S_{1}	S_{1}	S_{6}
12	S_{5}	S_{7}	S_{1}	S_{1}	S_{1}	S_{1}	S_{1}	S_{5}	S_{6}	S_{7}	S_{1}	S_{1}	S_{2}	S_{15}	S_{7}
13	S_{6}	S_{9}	S_{9}	S_{9}	S_{9}	S_{9}	S_{9}	S_{6}	S_{7}	S_{9}	S_{9}	S_{9}	○	S_{2}	○
14	S_{7}	S_{15}	S_{13}	S_{13}	S_{13}	S_{13}	S_{13}	S_{7}	S_{15}	S_{15}	S_{13}	S_{13}	S_{15}	S_{13}	S_{9}
15	S_{13}	S_{13}	S_{15}	S_{15}	S_{15}	S_{15}	S_{15}	S_{13}	S_{13}	S_{13}	S_{15}	S_{15}	S_{9}	S_{9}	S_{13}

'●' denotes a CT is the first under its own IAP; '○' denotes a CT's ranking when it is not the first under its own IAP; '_' denotes they are tied for first under the other CT's IAP.

Table A6. ACE Proxy Evaluation at Investment Environment.

Ranking	Proxy Characteristic Town														
	$\mathbf{S_{1}}$	$\mathbf{S_{2}}$	$\mathbf{S_{3}}$	$\mathbf{S_{4}}$	$\mathbf{S_{5}}$	$\mathbf{S_{6}}$	$\mathbf{S_{7}}$	$\mathbf{S_{8}}$	$\mathbf{S_{9}}$	$\mathbf{S_{10}}$	$\mathbf{S_{11}}$	$\mathbf{S_{12}}$	$\mathbf{S_{13}}$	$\mathbf{S_{14}}$	$\mathbf{S_{15}}$
1	$\mathbf{S_{14}}$	●	●	●	●	●	●	$\mathbf{S_{1}}$	●	$\mathbf{S_{11}}$	●	$\mathbf{S_{11}}$	●	●	$\mathbf{S_{9}}$
2	○	S_{11}	$\underline{S_{4}}$	$\underline{S_{3}}$	$\underline{S_{3}}$	$\underline{S_{3}}$	$\underline{S_{3}}$	S_{14}	S_{15}	S_{12}	S_{12}	○	S_{9}	S_{1}	○
3	S_{11}	S_{12}	$\underline{S_{5}}$	$\underline{S_{5}}$	$\underline{S_{4}}$	$\underline{S_{4}}$	$\underline{S_{4}}$	S_{2}	S_{1}	S_{1}	S_{1}	S_{1}	S_{15}	S_{11}	S_{13}
4	S_{12}	S_{3}	$\underline{S_{6}}$	$\underline{S_{6}}$	$\underline{S_{6}}$	$\underline{S_{5}}$	$\underline{S_{5}}$	S_{10}	S_{14}	S_{14}	S_{14}	S_{10}	S_{8}	S_{12}	S_{8}
5	S_{10}	S_{4}	$\underline{S_{7}}$	$\underline{S_{7}}$	$\underline{S_{7}}$	$\underline{S_{7}}$	$\underline{S_{6}}$	S_{11}	S_{13}	○	S_{10}	S_{14}	S_{14}	S_{10}	S_{14}
6	S_{2}	S_{5}	S_{11}	S_{11}	S_{11}	S_{11}	S_{11}	S_{12}	S_{2}	S_{2}	S_{3}	S_{3}	S_{1}	S_{2}	S_{1}
7	S_{8}	S_{6}	S_{12}	S_{12}	S_{12}	S_{12}	S_{12}	○	S_{8}	S_{3}	S_{4}	S_{4}	S_{2}	S_{8}	S_{2}
8	S_{15}	S_{7}	S_{1}	S_{1}	S_{1}	S_{1}	S_{1}	S_{9}	S_{10}	S_{4}	S_{5}	S_{5}	S_{10}	S_{15}	S_{10}
9	S_{3}	S_{1}	S_{10}	S_{10}	S_{10}	S_{10}	S_{10}	S_{3}	S_{11}	S_{5}	S_{6}	S_{6}	S_{3}	S_{3}	S_{3}
10	S_{4}	S_{10}	S_{14}	S_{14}	S_{14}	S_{14}	S_{14}	S_{4}	S_{3}	S_{6}	S_{7}	S_{7}	S_{4}	S_{4}	S_{4}
11	S_{5}	S_{14}	S_{2}	S_{2}	S_{2}	S_{2}	S_{2}	S_{5}	S_{4}	S_{7}	S_{2}	S_{2}	S_{5}	S_{5}	S_{5}
12	S_{6}	S_{8}	S_{8}	S_{8}	S_{8}	S_{8}	S_{8}	S_{6}	S_{5}	S_{8}	S_{8}	S_{8}	S_{6}	S_{6}	S_{6}
13	S_{7}	S_{9}	S_{9}	S_{9}	S_{9}	S_{9}	S_{9}	S_{7}	S_{6}	S_{9}	S_{9}	S_{9}	S_{7}	S_{7}	S_{7}
14	S_{9}	S_{15}	S_{15}	S_{15}	S_{15}	S_{15}	S_{15}	S_{15}	S_{7}	S_{15}	S_{15}	S_{15}	S_{11}	S_{9}	S_{11}
15	S_{13}	S_{13}	S_{13}	S_{13}	S_{13}	S_{13}	S_{13}	S_{13}	S_{12}	S_{13}	S_{13}	S_{13}	S_{12}	S_{13}	S_{12}

'●' denotes a CT is the first under its own IAP; '○' denotes a CT's ranking when it is not the first under its own IAP; '_' denotes they are tied for first under the other CT's IAP.

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