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Chinese Non-Equivalent Words from the Old Tea House of *Old Tales and Photos of Kunming in Reminiscence* and Their Ways of Translation into English

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Ways of translation;

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Old tea house of old tales and photos of kunming in reminiscence;

ABSTRACT

This article puts concentration on the Chinese non-equivalent words in the Old Tea House part from the book *Old Tales and Photos of Kunming* in Reminiscence and the methods adopted in translating these non-equivalent words into English. By using the theoretical analysis, induction and deduction, this article displays many tables to give a classification of the non-equivalent words and the translation strategies, meanwhile, with the statistic ways, the article specifically shows the proportions of the non-equivalent words and the translation methods, so as to spread Chinese culture abroad and smoothly carry on cross cultural communication.

INTRODUCTION

The notion of equivalence is the conceptual basis of translation and, to quote Catford, “the central problem of translation practice is that of finding TL (target language) equivalents. A central task of translation theory is therefore that of defining the nature and conditions of translation equivalence [1].” Although in different kinds of culture and literature exist different non-equivalent words, Chinese expert Feng Yulv suggested that due attention must be given to the analysis and comparison of the cultural connotations of words in four areas: non-equivalence, conceptual grouping, cultural background and association-derivation [2]. From above-mentioned, it shows that translation of non-equivalent words is meaningful to know different kinds of culture.

Each language is the conveyor of a certain culture. Since words are the smallest unit of a language, they are closely related to the culture. Therefore, the meaning of non-equivalent words varies from person to person who lives in different culture. This article puts concentration on the Chinese non-equivalent words in the Old Tea House part from the book *Old Tales and Photos of Kunming* in Reminiscence and their strategies adopted into English translation. As a result, this article tries to break through the traditional translating methods and apply the systematic translation theory to the translation practice. It discusses the translation from a new angle, which not only provides people with a fresh perspective to look at the issue of translation, but also, more importantly, makes up for the existing translation theories and practice of how to translate the non-equivalent words.

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By using the theoretical analysis, induction and deduction, this article displays a concrete analysis about the non-equivalent words form the Old Tea House part of the book *Old Tales and Photos of Kunming* in Reminiscence and their methods of translation into English. At the same time, the article cites many examples from the above-mentioned book to showcase the author’s viewpoints. In the article, the author displays many tables to give a classification of the non-equivalent words and the translation strategies, meanwhile, with the statistic ways, the article specifically shows the proportions of the non-equivalent words and the translation methods, so as to spread Chinese

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culture abroad and smoothly carry on cross cultural communication.

1.The Related Research on Non-Equivalent Words Translation

Generally, almost all translation scholars emphasize the role of equivalence in the process or product of translation directly or indirectly. Therefore, it is in the center of the translation studies. It must be said that much ink has been devoted to the problem of non-equivalence in translation which shed light on many studies. As a consequence, the nature of non-equivalence, its strategies tackling non-equivalence at a new level, they will be clearly clarified in this article.

1.1.The Definition of Non-Equivalent Words

Non-equivalent words are very special words in different culture from different countries. At the same time, some experts definite them as culture-loaded words or culturally traditional words, however, the article shows the definition of non-equivalent words from various scholars' perspectives.

In Mona Baker's expressions, "the source-language word may express a concept which is totally unknown in the target culture. The concept in question may be abstract or concrete: it may relate to a religious belief, a social custom, or a type of food. Such concepts are often referred to as 'culture-specific' [3]." Louis B. Salomon, considers the non-equivalent words as "vocabulary blanks" and "semantic un-fact" and some other scholars define them as "key words (to society and culture)", "culturally bound or culture-specific, culturally conditioned words [4]. "

Mr. Wang Huan, a distinguished scholar, thinks that, "every language has the so-called culture-bound terms which are closely related to the cultural background of those speaking that language, and which represent the concepts of those things produced from that peculiar culture. There are no equivalent words or expressions since such things do not exist in another culture [5]." Another Chinese scholar Mr. Hu Wenzhong, believes that, "Non-equivalent words load with specific national culture information and indicate deep national culture. They are the direct or indirect reflections of national culture at the structure of lexemes [6]."

Nevertheless, no matter how differently non-equivalent words are defined, they share the following three main characteristics: (1). they are peculiar to one culture; (2). they are rich in cultural connotation or associative reflection; (3). it is difficult or impossible to find their equivalences in other culture. Therefore, only when enough attention is paid to their translation can the culture be transferred to other countries effectively.

1.2.The Related Theory on Non-Equivalent Words Translation in Western Countries

In Western countries, non-equivalent words translation takes a popular position. The term "equivalence" in translation first appeared in J. R. Firth's writing (1957) when he stated that "the so-called translation equivalence between two languages are never really equivalent (Snell-Hornby, 1988) [7]. "

Briefly, J. R. Firth, Nida, Catford, Baker, Newmark and Wilss, all of these theorists have endeavored to interpret the notion of equivalence, approached equivalence from different angles and perspectives and all have contributed much to this area of research. Particularly, Wilss states that "the concept of translation equivalence has been all essential issue not only in translation theory over the last 2000 years, but also in modem translation studies. Nevertheless or maybe as a result of prolonged reflection about translation equivalence — mere is hardly any other concept in translation theory which has produces as many contradictory statements and has set off many attempts at an adequate, comprehensive definition as the concept of translation equivalence between source language text and target language text (Wilss, 2002) [8]." In his definition, "translation is a transfer process which aims at the transformation of a written source language text in to an optimally equivalent target language text and which requires the syntactic, the semantic and the pragmatic understanding and analytical processing of the source language text (Wilss,1982) [9]."

1.3.The Popularity of Non-Equivalent Words Research in China

Equivalence studies in China in the past times was not very popular, however, nowadays some scholars put their concentrations on the terms. At the end of the 19th century, Yan Fu, put forth the three principle of translation — faithfulness, expressiveness and elegance. Faithfulness means equivalence, mainly concerning the content.

Expressiveness refers to the relationship between the message and the receptors. Elegance relates to style. In a word, Yan Fu made great contributions to the development of translation of China. Afterwards, there is a great number of translators and translation theorist such as Lu Xun, Qu Qiubai and Ji Xianlin, etc. They also put forward a lot of translation theories similar to equivalence theory in the western countries. All of them have contributed to the development of equivalence theory.

1.4.The Introduction on *Old Tales and Photos of Kunming* in Reminiscence

Old Tales and Photos of Kunming in Reminiscences was Published by Yunnan Fine Arts Publishing House, and it is a monumental six-volume cultural history series that stands as the most comprehensive visual and textual archive of Kunming's urban heritage. Compiled over five years by Zhu Jingyu, a research fellow at Kunming Municipal Institute of Cultural History and distinguished local historian, this collection was first released in June 2021, with a revised edition following in July 2024.

Spanning 1,900 pages with over two million Chinese characters and 2,000 carefully curated historical photographs, the series comprises 1,260 short essays organized into six thematic volumes. Each volume explores a distinct dimension of old Kunming: Those Scenes (urban landscapes and architecture), Those Trades (commerce and industry), Those Local Customs (geography and feng shui traditions), Those Curiosities (extraordinary people and mysterious events), Those Folkways (customs and dialects), and Those City Walls (urban formation and evolution).

The series distinguishes itself through rigorous historical scholarship and unprecedented visual documentation. Drawing upon diverse sources including official histories, local gazetteers, archaeological records, folklore, and oral histories, Zhu Jingyu corrects longstanding historical misconceptions. Notable achievements include debunking the myth of Kunming's "turtle-shaped" city walls through contextual evidence, and tracing the origins of the famous "Eighteen Oddities of Yunnan" to a Ming Dynasty text discovered in overseas archives, rectifying century-old textual errors.

A particularly valuable contribution is the inclusion of rare photographs by Auguste François, the French consul in Kunming during the late Qing Dynasty, whose copyright was secured through substantial investment by the publisher. These images, alongside ancient and modern maps, many published for the first time, provide irreplaceable visual testimony to the city's transformation.

The series employs a unique narrative structure: each self-contained essay of 1,000-2,000 characters presents a vivid micro-story, while collectively forming coherent chapters and volumes that interweave to create a multidimensional portrait of Kunming's social history. This approach has earned the work praise for being "readable, viewable, understandable, usable, and enjoyable" — the "five excellences" celebrated by readers.

Beyond academic circles, the series has achieved remarkable public impact. Kunming Daily serialized over 100 installments under the title "Kunming's Urban Pulse," while the municipal government has utilized its materials for official cultural promotion. The collection received prominent placement at the National Reading Conference, and three volumes have been translated into English for international distribution, sharing Kunming's stories with global audiences.

Zhu Jingyu, born in Kunming with Hunan ancestry, brings diverse life experience—from sent-down youth and factory worker to journalist and editor — to this magnum opus created in his seventies. His previous works on Yunnan's cultural mysteries and the Ancient Tea Horse Road established his reputation; this series represents his definitive contribution to preserving Kunming's historical memory.

More than a local history, *Old Tales and Photos of Kunming* in Reminiscences serves as an essential reference for understanding modern China's frontier development, ethnic integration, and urban modernization. It transforms scattered archival fragments into an accessible, engaging narrative that honors the city's complex past while illuminating its contemporary identity.

2.The Classification of Chinese Non-Equivalent Words from the Old Tea House Part of *Old Tales and Photos of Kunming* in Reminiscences

2.1.Non-equivalent Words on Idioms, Colloquial Phrases, Folk Adage and Vulgar Expressions

Looking through the Chinese history, there are many phrases

and words were created in the process of the development of our society. In Chinese language, the four-word idioms play an outstanding role in the language systems; they are frequently used in the communications. Meanwhile, from *Old Tales and Photos of Kunming* in Reminiscences the author also used a large number of four-word idioms to depict some situations that are displayed in the following tables. While the article also picked up some widely used Chinese colloquial phrases, folk adages and not very rude vulgar expressions from the above-mentioned book like the followings.

No.	Chinese Non-Equivalent words	English Translation
1	*弥久如故*	a refreshing aroma
2	*指手画脚*	gesturing and drooling
3	*蛊惑人心*	deceiving people
4	*"张家长、李家短"*	"the daily life of every family around them"
5	*捕风捉影*	spreading uncertain news
6	*"三只手"*	"three hands" (thief)

Table.1. Non-Equivalent Words on Idioms, Colloquial Phrases, Folk Adages and Vulgar Expressions

2.2.Non-equivalent Words on Chinese Sayings, Proverbs, and Classical Allusions

Chinese sayings, proverbs and classical allusions are the magnificent treasure in Chinese culture treasury. It is the accumulation and sublimation of various experiences in human's long-term livelihood and social practice. Particularly, the classical allusions are summarized from some preeminent historical events by Chinese people in the ancient times or in the modern periods. Therefore, having a good command of using them helps people understand the thinking methods as well as the customs and habits of a nation. Part of these non-equivalent words are displayed in table 2.

No.	Chinese Non-Equivalent words	English Translation
1	*不亦乐乎*	Extremely enjoyable
2	*善者则称诒不置，恶者则贬斥有加*	Those who are kind will praise these, and those who are evil will criticize and add more negative details.
3	*而今人长大，心事乱麻*	When I grow up today, my mind is in turmoil.
4	*更上一层楼*	Strive for further improvement
5	*如痴如醉，不能自已*	Intoxicated and unable to do it on one's own
6	*要知后事如何，且听下回分解*	You need to know what will happen next, and listen to the next chapter to break it down.

Table.2. Non-Equivalent Words on Chinese Sayings, Proverbs, and Classical Allusions

2.3.Non-equivalent Words on Addressing of People and Characters

In China, people prudently deal with the relationships with others, especially the addressing of people. In the relationship scale, Chinese obey the traditional address of people, such as, in Chinese culture, everyone should choose the appropriate address to call a person, because the inappropriate title or name will cause misunderstanding and even discrimination. Some of these non-equivalents words are showed in table 3.

No.	Chinese Non-Equivalent words	English Translation
1	*阿娘*	aunt
2	*乡亲父老*	fellow villagers
3	*娇妻美妾*	beautiful wife and concubine
4	*大儒*	a great Confucian scholar
5	*江湖郎中*	quacks
6	*地下党员*	an underground party member

Table.3. Non-Equivalent Words on Addressing of People and Characters

2.4.Non-equivalent Words on Chinese Historical Periods

China is an old country with a long history. In every dynasty, it has its own short and unique name about the era. Therefore, they are also the Chinese non-equivalent words which are selected from *Old Tales and Photos of Kunming* in Reminiscences and are put in the table below.

No.	Chinese Non-Equivalent words	English Translation
1	*晚清*	the late Qing Dynasty

2	*民国时期*	the Republic of China Era
3	*抗日战争时期*	the War of Resistance against Japanese Aggression
4	*清乾隆年*	the Qianlong reign of the Qing Dynasty
5	*清光绪年间*	the reign of Emperor Guangxu in the Qing Dynasty
6	*明代*	the Ming Dynasty

Table.4. Non-Equivalent Words on Chinese Historical Periods

2.5.Non-equivalent Words on Materials and Objects

There are various different kinds of materials and things exist in every country with different cultures, although they naturally came into being or are created by people, they are also the symbols of different cultures. The article drew attention to some special Chinese things which do not exist in Western countries from the composition as non-equivalent words to show the uniqueness in the following table.

No.	Chinese Non-Equivalent words	English Translation
1	*乌龙茶*	Oolong tea
2	*长嘴铜壶*	a long mouthed copper pot
3	*八仙桌*	Eight Immortals Tables
4	*水烟筒*	hookah pipes with Yunnan style
5	*芙蓉糕*	lotus cake
6	*草鞋*	straw sandals
7	*文房四宝*	the Four Treasures of Study
8	*米线*	rice noodles

Table.5. Non-Equivalent Words on Materials and Objects

2.6.Non-equivalent Words on Customs or Traditional Activities

Customs and traditional activities as the necessary parts of culture, they contribute a large share to human culture. Looking back to the historical development, each nation has had its own belief and formed its own special custom and traditional activities. In most of the Western countries, Christianity imposes great influences on the social culture; while in China, Buddhism, Taoism and Confucianism take a dominant position in the civilization. From these different customs, people also use different words to depict them. The article selects some custom non-equivalent words on Chinese culture which the author describe some traditional aspects in *Old Tales and Photos of Kunming* in Reminiscences (see table 6).

No.	Chinese Non-Equivalent words	English Translation
1	*“打围鼓”*	“Weigu (playing drum)”
2	*听花灯*	listening to the Huadeng opera
3	*评书*	storytelling
4	*搓麻将*	playing mahjong
5	*提笼斗雀*	carrying a cage sparrow
6	*看手相*	the service of palmistry checking
7	*斗蟋蟀*	cricket fighting

Table.6. Non-Equivalent Words on Custom and Traditional Activities

2.7.Non-equivalent Words on Nature and Ecology

Putting the concentration on the nature and ecology, distinctive living surroundings lead to the fact that people hold different attitude toward nature. This kind of non-equivalent words are the reflections of the climate, and the characteristics of the natural environment of a certain language community. Thus, the non-equivalent words are related with nature and ecology serve as a unique group for people to do cultural communication. They are reflected in the table 7.

No.	Chinese Non-Equivalent words	English Translation
1	*风花雪月*	enjoying the leisure and beauty of life
2	*绿意葱茏*	lush
3	*五湖四海*	from all corners of the world
4	*过河拆桥*	cross the river and demolish the bridge (drop one’s benefactor as soon as his help is not required)
5	*天经地义*	a natural thing
6	*风雨无阻*	regardless of wind or rain

Table.7. Non-Equivalent Words on Nature and Ecology

2.8.Geographical non-equivalent Words

From the geographical perspective, every country locates in the different zones in the whole word, and they are famous for some places, such cities, cultural relics, towns, rivers, lakes, roads and so on. In China, it really exists thousands of famous places, such as the cultural relics. These famous places are also as non-equivalent words distinguished from other countries, and parts of these non-equivalent words are showed in the table 8.

No.	Chinese Non-Equivalent words	English Translation
1.	*昆明市*	Kunming City (the capital of Yunnan province in China)
2.	*广东*	Guangdong
3.	*四川*	Sichuan
4.	*滇越铁路*	the Yunnan-Vietnam Railway
5.	*巡津街*	Xunjin Street
6.	*翠湖*	The Green Lake

Table.8. Geographical Non-Equivalent Words

2.9.Linguistic and Literary Non-Equivalent Words

With the eye of linguistics, this article chose some linguistic words that are created by Chinese nations. This article also shows some literary compositions and masterpieces of Chinese writers. They are also non-equivalent words which carry the essence of Chinese culture to the world (see table 9).

No.	Chinese Non-Equivalent words	English Translation
1	*《本草纲目》*	(Li Shizhen's) *Compendium of Materia Medica*
2	*《云南掌故》*	*Anecdotes of Yunnan*
3	*《老昆明风情录》*	*Record of Old Kunming Style*
4	*《昆明市志》*	*The Kunming City Chronicle*
5	*《三国演义》*	*The Romance of the Three Kingdoms*
6	*《水浒传》*	*Heroes of the Marshes*
7	*《红楼梦》*	*The Dream of Red Mansion*

Table.9. Linguistic and literary Non-Equivalent WordsNon-Equivalent Words on Nature and Ecology

To um up, in all above-mentioned Chinese non-equivalent words, they not only represent the uniqueness and characteristics in the Old Tea House part from the book *Old Tales and Photos of Kunming* in Reminiscence, but also could be looked upon as the crystallization of Chinese language and culture. Therefore, it is necessary to translate them into English or other languages for people from all over the world to appreciate the Chinese literature and culture. Raised for translation, in the third part, this article will show the techniques adopted in translating the Chinese non-equivalent words into English.

3.Strategies Adopted to Translate the Chinese Non-Equivalent Words into English and Case Analysis in the Old Tea House Part of *Old Tales and Photos of Kunming* in Reminiscences

3.1.Strategies Adopted to Translate the Chinese Non-Equivalent Words into English

In this part, the article will give a detailed explanation of the strategies adopted in the non-equivalent words translation; meanwhile, it also selects many examples from the the Old Tea House Part of *Old Tales and Photos of Kunming* in Reminiscences to give analysis of how to translate the Chinese non-equivalent words into English. This paper gives a statistics about ten ways of translation. They are displayed in table 10.

No.	The names of the strategies of translation
1	Transcription
2	Transliteration
3	Calques or Half-calques
4	Word-by-word translation (Literal translation)
5	Free translation
6	Conversion
7	Implication
8	Omission or Reduction
9	Compensation
10	Explanatory

Table.10. Ten Ways of Translation

3.2.Case Analysis about the Non-Equivalent words and Their Ways of Translation into English in the Old Tea House Part of *Old Tales and Photos of Kunming* in Reminiscences

In A practical transcription is an inter-linguistic operation as

it deals with two languages: the sounds of the source language word are rendered by the letters of the target language. Through this way of translation, there are many non-equivalent words are translated in the Old Tea House part of *Old Tales and Photos of Kunming* in Reminiscences, such as *乌龙茶* "Oolong tea" is translated into English in this way.

The notion of transliteration is based on representing written characters of one language by the characters of another language.Transliteration and transcription often compete, so that sometimes it is difficult to state how to render a word (especially a personal or place name) in the other language. But transliteration is preferred to transcription in bibliographical citations found in publications, such as the non-equivalents *昆明* "Kunming" related to places can be translated in this way. And Calques, also called blueprint translation, are the translation of a word or a phrase by parts. Some linguists (V. Komissarov, for one) consider calques (blueprint) translation as mechanical copying [10]. Calque is translation by parts, they may take place half-calques in cases where half of the word is borrowed through transcription or transliteration and the other half is translated [11], the Chinese non-equivalent word about the places such as 巡津街"Xunjing Street" is a prototype of this translation way.

Literal translation is sometimes called word-by-word translation referred to as formal, or grammar translation, though it is not the same [12]. In the Old Tea House part, this is one of the popular or frequent ways to translate the Chinese non-equivalent words. This article picks up some example and display in the example 1:

最让听众吊胃口的是,在听到最精彩的部分时, 随着"啪"一声惊堂木响:"要知后事如何, 且听下回分解." (1a) The most tantalizing thing for the audience is when they hear the most exciting part, accompanied by a deafening "bang": "You need to know what will happen next, and listen to the next chapter to break it down."

Free translation is the translation method switches the source form and content in a loose way. This concept means adding extra elements of information or losing some essential ones [13]. This translation method can can be used to translate the Chinese non-equivalent words in the example 2.

当然, 交易双方知道其中必有差价, 而这个差价理所当然归掮客所有, 这是天经地义的事, 只是他们不知道具体数额而已。(2a) Of course, both parties to the transaction know that there must be a price difference, and this price difference naturally belongs to the brokers. This is a natural thing, but they do not know the specific amount.

Conversion is just like the transformation; translators will use some special expressions or sentence structures to change the meaning, the grammar of the source language, nut it will not deviate from the primitive meaning [14].

茶铺里的"自娱自乐"多了, 有些茶馆老板又更上一层楼, 走"专业"路线扩展营业。(3a) There are more "self entertainment" activities in tea shops, and some tea house owners have striven for further improvement and taken a "professional" approach to expand their business.

Implication is a kind of technique that translators use something is inferred to translate the specific words or expressions, or maybe the translator wants switch the meaning that is not expressly stated but can be inferred [15]. This method is rarely used in the translations, but it always plays an important role in translating some euphemism, periphrases or some vulgar expressions.

学生的话题大多是时局、学习和娱乐; 农民则更多的谈论"张家长、李家短。" (3a) Students mostly talk about the current situation, learning, and entertainment; farmers talk more about "the daily life of every family around them."

Omission or reduction is giving up redundant and communicatively irrelevant words. The reduction is a must if a source language expresses the notion by a phrase and the target language compresses the idea in one word [16].

那是一个污浊而混乱的时代, 学生生活又穷困得近乎潦倒, 但是很多人却能自许清高, 鄙视庸俗, 并能保持绿意葱茏的幽默感, ...。 (5a) It was a polluted and chaotic era, where student life was almost impoverished and destitute. However, many people could consider themselves lofty, despise vulgarity, and maintain a lush sense of humor ....

Compensation is a deliberate introduction of some additional element in the target text to make up for the loss of a similar element in the source text. The main reason for this transformation is a vocabulary deficiency in the target language.

有看相人穿行其间, 绕来绕去, 嘴里念说着"送看手相不要钱"。(6a) A physiognomy walked through it, circling back and forth, muttering, "You don't need to pay for the service of palmistry checking."

Explanatory translation, which is the way rewording the meaning into another structure so that the receptor will have a better understanding of the phrase. Sometimes this transformation is named as explicit, defined as the technique

of making explicit in the target text information that is implicit in the source text [17].

作者是明代的大儒陈白沙。(7a) The author is Chen Baisha, a great Confucian scholar from the Ming Dynasty.

From the above-mentioned typical cases analysis and the classifications of non-equivalent words to know, the proportion of the translation methods used to translate the Chinese non-equivalent words into English in the Old Tea House part from the book *Old Tales and Photos of Kunming* in Reminiscence can be showed in the statistical figure 1. The most frequent used translation method is literal translation for the Chinese non-equivalent, and it takes nearly 50%. While the rest of the other nine ways of translation take an average proportion among them.

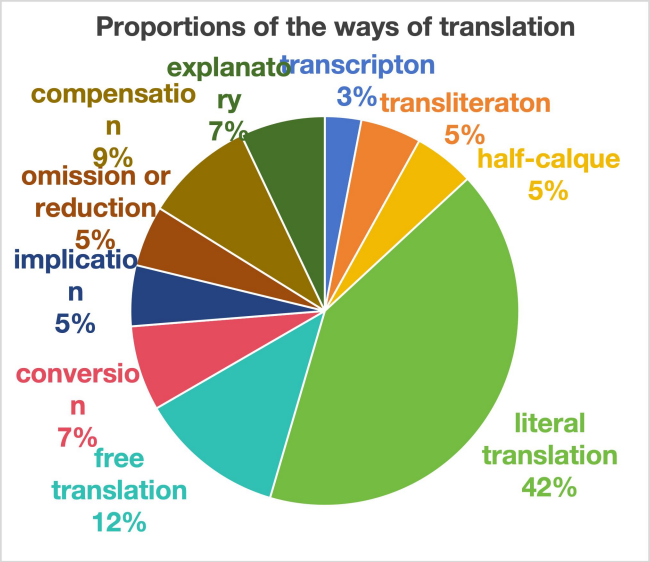

Fig.1. Proportions of the Ways of Translation

Conclusion

This article makes a systematic study about the Chinese non-equivalent words from the Old Tea House part of *Old Tales and Photos of Kunming* in Reminiscences and the strategies adopted to translate them into English.

As a result, this paper also searched translation techniques such as half-calques, implication, omission or reduction, conversion, explanatory, compensation. Especially literal translation, transcription and transliteration, the former one is the main strategy while the latter two methods are the supplementary. The proper combination of all these translation methods can help keep the unique Chinese culture in the translated version and make the westerners better perceive its profound meaning.

The study apparently cannot offer detailed and comprehensive comments on the strength and weaknesses of various strategies up to the expectation. The use of translation strategies applied in different context as well as more researches on Chinese and English case is critically needed. Generally speaking, non-equivalent words and their translation strategies in literary translation keep the presuppositional information and help preserve the traditional culture so that target-language readers can appreciate the foreign culture through the translation. Also they help increase the readability of the target-language text and ease the cultural conflict by altering the presuppositional information.

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How Social Practice Experiences Shape College Students ' Employability: Evidence from a Case Study in Chongqing, China

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KEYWORDS

Graduate employability;

Social practice;

Higher education management;

Social capital;

Chongqing Case Study;

ABSTRACT

This study examines how social practice experience shapes the employability of college students through a qualitative case study conducted in Chongqing, China. Although practical education has been widely promoted, existing research often indicates whether practice is beneficial rather than explaining how it helps improve employability. This study proposes a three mechanism framework consisting of human capital development, identity and psychological resource formation, and social capital accumulation, guided by the perspectives of experiential learning and graduate capital. The interview evidence explained in conjunction with publicly available employment indicators suggests that when students engage in real tasks, receive feedback, reflect on career expectations, and gain access to employment related networks, their employability becomes apparent. The research findings indicate that practice serves as both a learning environment and an opportunity interface, linking higher education with labor market access. This study contributes to the study of employability by providing mechanism oriented explanations based on non coastal Chinese backgrounds, and provides insights for higher education management, including structured reflection, employment quality assurance, and practice design based on partnershipss.

INTRODUCTION

The employability of graduates has become a core focus of global higher education, as people increasingly expect universities to not only provide subject knowledge, but also transferable skills and workplace preparation to help students adapt to the rapidly changing labor market. The commonly accepted definition of employability in higher education describes it as a series of achievements - skills, understanding, and personal attributes - that increase the likelihood of graduates finding employment and succeeding in their chosen careers. Importantly, employability is not a single skill, but a multidimensional ability that includes human capital (such as skills and knowledge), psychosocial resources (such as adaptability and self-efficacy), and the ability to navigate opportunities. This complexity explains why many institutions are shifting towards learning designs that go beyond classroom teaching, immersing students in real-world environments where they can practice, reflect, and transform learning into job-related abilities。

Among these methods, 'social practice experience' (such as internships, volunteer service, community engagement, field research, and practice based projects) is often seen as a practical pathway for developing employability. These experiences connect students with practical tasks, social networks, and workplace norms. In a broader international literature, Work Integrated Learning (WIL) is often linked to the development of employability skills, although challenges and quality gaps in implementation remain widespread. There is evidence to suggest that well-designed internships can enhance communication, teamwork, problem-solving, and professional awareness - skills that employers typically expect graduates to possess. Similarly, research has found that service learning and community experience have a positive impact on students' personal development and social abilities, which are closely related to employment outcomes such as self insight, social understanding, and interpersonal communication skills. However, the empirical question is

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not just whether these practices are "effective", but how they operate - through what development mechanisms and under what conditions.

In theory, experiential learning provides a powerful perspective for understanding how social practice shapes employability. The experiential learning theory emphasizes that learning is generated through the transformation of experience, typically involving concrete experiences, reflective observations, conceptualization, and active experimentation, rather than just passive acceptance of knowledge. When students participate in real social practice, they test classroom ideas, receive feedback from real stakeholders, and have a more realistic understanding of work and society. At the same time, research on employability conceptualizes employability as a psychological, social, and adaptive structure: an individual's ability to respond to changes in the labor market, mobilize resources, and align with opportunities. From this perspective, social practice not only influences employability by improving "hard" and "soft" skills, but also shapes identity, confidence, and networks related to professions。

Despite these advances, there are still several gaps in existing research that are particularly relevant to academic education management. Firstly, many studies rely on surveys or short-term evaluations that can demonstrate associations but often provide limited insights into the process, such as what students actually do in practice, what they learn from key events, and the role of reflection and institutional support. Secondly, although WIL and internship research are growing, the quality and outcomes of these practices vary depending on the environment, curriculum design, and local labor market conditions. Thirdly, most of the evidence regarding employability comes from Western higher education backgrounds, and the transferability of these models to other systems (especially large-scale policy driven systems) requires more context sensitive research.

This study addresses these gaps through a qualitative case study of Chongqing, China, a region with a large population of higher education and a continuously developing regional economy. Chongqing provides a meaningful case for educational management research, as it represents a non coastal development background where universities, local industries, and public sector organizations jointly shape students' practical opportunities and employment transformation. By focusing on students' life experiences and development trajectories, this case study aims to go beyond "computational participation" and provide a mechanism centered explanation for the formation of employability。

This study is guided by the following questions and aims to provide practical insights for universities seeking to design higher quality social practice projects by providing rich background evidence from China, contributing to the international debate on employability:

What types of social practice experiences do Chongqing students engage in, and how are these experiences organized and supported?

2. Through which learning processes (such as skill acquisition, reflection, feedback, and identity formation) do these experiences affect abilities related to employability?

3. What background factors (such as institutional design, internet access, and perceived labor market constraints) promote or limit the development of employability in social practice?

By answering these questions, this study aims to enrich the evidence base on employability in the Chinese context and contribute to the ongoing global discussion on the design of employability in higher education.

1.Literature review and theoretical framework

1.1.Graduates' employability: a multidimensional perspective

Graduate employability has been widely discussed in higher education research, but it remains a controversial concept. Scholars no longer equate employability solely with the outcome of obtaining a job, but increasingly conceptualize it as a set of abilities that enable graduates to obtain, maintain, and develop employment in a constantly changing labor market environment[1]. This viewpoint emphasizes that employability is a result of the development of higher education.

In addition to the definition based on skills, employability is also understood as a psychological and social structure. [Fugate, Kinicki, and Ashforth conceptualized employability as including professional identity, personal adaptability, and social and human capital, emphasizing the ability of graduates to navigate career transitions. Similarly, Tomlinson proposed the "Graduate Capital" framework, which views employability as the accumulation and

mobilization of various forms of capital - human, social, cultural, identity, and psychological. This approach is particularly valuable for context sensitive research as it acknowledges that employability is not only influenced by individual attributes, but also by institutional structures and local opportunity patterns.

Therefore, in this study, employability is understood as a multidimensional skill that includes knowledge and technical skills, adaptability and confidence, career identity, and social networks related to employment.

1.2.Social Practice Experience and Employment Ability Development

\Social practice experience, such as internships, community participation, volunteer work, and practice based projects, is widely regarded as an important way to cultivate employability. International research on Work Integrated Learning (WIL) suggests that these practical experiences can enhance skills related to employability, although their outcomes largely depend on factors such as curriculum design, supervision, and opportunities for reflection (Jackson, 2015). Empirical research on higher education in China also emphasizes how institutional arrangements and support structures affect the learning outcomes of students who participate in internships and practical activities (Li, Clotey,&McCombs, 2020).

Service learning and community practice are also related to positive employment outcomes. Meta analysis suggests that these experiences have beneficial effects on students' personal, social, and cognitive development, which are closely related to employability (Yorio&Ye, 2012; Celio et al., 2011). Recent research on Chinese university students further suggests that community service learning can enhance career adaptability and social responsibility (Pong et al., 2023).

Despite these findings, most literature focuses on whether social practice is beneficial and has limited understanding of how these experiences can be transformed into employability. Specifically, the mechanisms for promoting skill development, identity formation, and access to job-related resources through practice have not been fully explored, especially in the context of China.

1.3.Theoretical Framework

To address these gaps, this study combines experiential learning theory [Kolb, 1984] with a capital based perspective on employability. The experiential learning theory explains how specific experiences can be combined with reflection and application to promote learning and skill development. From a capital based perspective, it is further believed that employability is caused by the accumulation of human, psychological, identity, and social capital[2].

Based on these theoretical foundations, this study proposes that social practice experience shapes employability through three interrelated mechanisms:Skill and knowledge development;Professional identity and psychological resource formation;Accumulate social capital through network expansion.

This framework guides the design and analysis of case studies in Chongqing.

2.Method

2.1.Research design

This study adopts a qualitative case study design to explore how social practice experience shapes the employability of college students. The case study method is suitable for this study as it focuses on answering the questions of "how" and "why" and attempts to provide a deep, context sensitive understanding of complex social and educational processes, rather than aiming to obtain statistically universal findings. This case study is essentially exploratory and explanatory, aimed at investigating students' life experiences in social practice and how these experiences contribute to the development of employability related abilities[3].

2.2.Case selection: Chongqing, China

There are three main reasons why Chongqing was chosen as the research site. Firstly, as a major city in western China, Chongqing represents a non coastal higher education background and is underrepresented in international employment capacity research. Secondly, Chongqing has numerous higher education institutions closely related to manufacturing, service, and public sector organizations, providing students with various social practice opportunities. Thirdly, the region is facing enormous employment pressure and policy driven practical education, which provides an ideal background for studying the role of social practice in the development of employment capacity.

2.3.Participants and Sampling

Participants are selected through purposive sampling, which is a common technique in qualitative research for identifying informative cases. The sample includes undergraduate and graduate students who have participated in structured social practice activities, as well as a small number of university staff who have participated in organizing or supervising such activities.

The criteria for selecting student participants are as follows:

-Participate in at least one form of structured social practice (such as internships, community service, or practice based projects).

-I am studying at a university in Chongqing.

-Willing to reflect on one's own learning and career development experiences.

2.4.Data Collection: Semi structured Interviews

The data is mainly collected through semi-structured interviews, which allows participants to elaborate on their experiences and enables researchers to explore key themes related to employability development. The interview questions mainly focus on:

-The nature and organization of social practice activities.

-Perceived learning outcomes and challenges.

-Reflection on skill development, professional identity, and professional consciousness.

-Interaction with supervisors, colleagues, and external stakeholders.

Each interview lasts about 40-60 minutes and is conducted with informed consent. The interview was recorded and transcribed word for word for analysis.

3.5 Ethical considerations and integrity

According to institutional requirements, the study has obtained ethical approval. Participants were informed of the purpose of the study, their voluntary participation, and the confidentiality of their responses. Using pseudonyms to protect the identity of participants.

To enhance credibility, the study employed strategies such as carefully recording and analyzing decisions, and using direct citations to support explanations[4].

3.Method

Test items	Sub-Themes (Child Nodes)	Description / Indicators
Human Capital Development	Skill acquisition	Communication, teamwork, problem-solving, technical skills
	Work-related knowledge	Understanding workplace norms, organisational processes
	Learning through feedback	Supervisor comments, performance evaluation
Identity & Psychological Development	Professional identity	Career clarity, sense of professional role
	Self-efficacy & confidence	Increased confidence in work tasks and job search
	Adaptability	Coping with uncertainty, adjusting to new environments
Social Capital Accumulation	Network expansion	Contacts with supervisors, colleagues, community members
	Access to information	Career advice, job-related information
	Opportunity linkage	Internships, recommendations, employment leads

Table.1. Coding Framework for Employability Development Mechanisms

Source: The coding is directly sourced from the literature [Fugate et al., 2004; Tomlinson, 2017; Kolb, 1984]

4.Survey results: Chongqing cultivates employability through social practice

4.1.Background: The Supply Pressure of Graduate Students and the Expansion of Higher Education in Chongqing

The continuously expanding participation in higher education and the growing output of graduates in Chongqing have created a structural environment, and employability has become a prominent issue. According to the Chongqing Statistical Bulletin (2023), there are 72 higher education institutions in the city with 299400 undergraduate/university

graduates and 27700 graduate students. These numbers reflect a steady increase in the number of graduates entering the labor market.

The following year, the Chongqing Statistical Bulletin (2024) reported on 73 higher education institutions, with the number of undergraduate/university graduates increasing to 317000 and the number of graduate students increasing to 30100. These numbers highlight the continuous expansion of graduation production, which may intensify competition for entry-level positions and emphasize the increasing importance of practice based employability development.

The labor market indicators for 2024 indicate that although the overall employment environment remains stable, it still faces enormous pressure. Official statistics show that the urban survey unemployment rate is 5.3%, with 719000 new urban job opportunities added in 2024. In addition, the Chongqing Municipal Government emphasizes targeted support for graduates and youth employment, including measures to promote graduates' employment and entrepreneurship throughout the city.

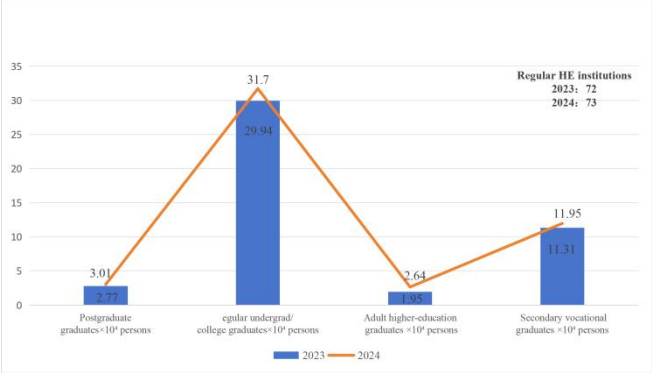

Fig.1. Chongqing Education Output (2023–2024, official statistics)

4.2.Institutional Evidence of Chongqing Graduates' Employment Quality Report (Triangle Dataset)

To supplement urban level statistical data, institutional level evidence can provide valuable insights into how graduates evaluate their employment outcomes and readiness in practice oriented higher education. The latest "2024 Annual Report on Graduate Employment Quality" from Chongqing University of Economics and Business provides a specific dataset for triangulation, including survey indicators for graduates and employers, as well as job search challenges.

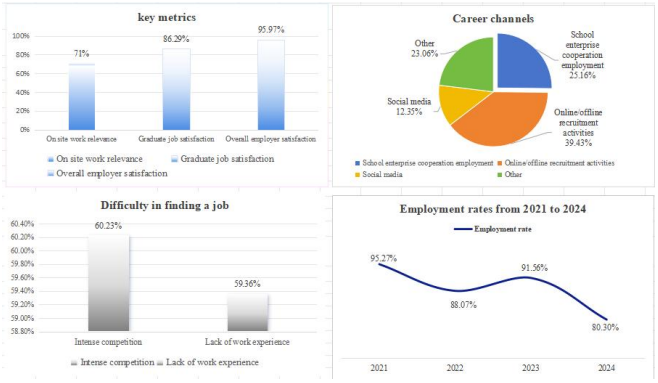

Fig.2. Report on the Employment Quality of Graduates in Chongqing

The report shows a significant decline in employment rates in 2024, indicating fluctuations and challenges in the employment outcomes of graduates from the institution.

4.3.Mechanism based Discovery Consistent with Theoretical Framework

Participants described how social practices such as internships, volunteer services, and community projects expose them to real-world tasks and performance expectations[5]. Through repeated practice and feedback, students reported progress in communication, coordination, problem-solving, and task execution skills, which are often considered crucial for employability. This approach conforms to the logic of experiential learning: when students reflect on task outcomes and adjust their behavior, specific experiences and feedback become learning resources. Evidence from NVivo code, such as skill acquisition, job norm awareness, and feedback driven learning, suggests that students often mention improvements in job-related skills, such as communication and problem-solving. For example, a participant stated, "I coordinated a community project, received feedback from my supervisor on my time management, and improved my task execution ability in the next stage." However, there were some exceptions where participants described low-quality internship experiences, repetitive tasks, and a lack of meaningful feedback, resulting in minimal learning outcomes. This highlights the importance of high-quality, structured social practice in cultivating employability. Based on the current situation in Chongqing, the data on "lack of work experience" in institutional reports (59.36%) is consistent with students' understanding that experience is the main obstacle to obtaining a job, emphasizing the importance of practical

skills development in this socio-economic context. Participating in structured social practice can help students bridge the gap between academic knowledge and real-world employment skills, making this pathway systemically relevant.

Students often describe social practice as a 'reality check', helping them clarify their career preferences, understand role expectations, and build confidence in unfamiliar environments. Some participants reported that practice reduced occupational ambiguity and improved self-efficacy, while others experienced a discrepancy between expectations and reality and needed to adjust their strategies to adapt. Evidence from NVivo code, such as clarity of professional identity, self-efficacy/confidence, and adaptability under constraints, indicates that many students reported clearer career goals after social practice experiences. A participant shared, "During my internship, I realized that I enjoy marketing, which I had never considered before. After receiving positive feedback from my supervisor, I feel more confident about working in this field." In contrast, some students found their experiences frustrating. One participant mentioned, 'I thought I would like accounting, but these tasks are repetitive and I don't see how they relate to my future career,' which illustrates how practice can clarify career paths or lead to career reassessment. The triangulation of public data such as graduate job satisfaction (86.29%) and main job relevance (71%) shows that in Chongqing's practice oriented environment, career fit and satisfaction are measurable and significant, further confirming that practice based experience contributes to career clarity and confidence.

Social practice also expands students' weak connections and bridge networks, involving supervisors, colleagues, and community stakeholders, providing avenues for obtaining career information, recommendations, and visibility of opportunities. Many participants reported that mentors provided advice on the recruitment process, or their internship environment became a gateway for interviews and job opportunities. Evidence of NVivo code, such as network extensions, access to job information, and opportunity links/recommendations, suggests that students have established valuable professional networks in social practice. Recruitment activities (39.43%) and campus enterprise cooperation (25.16%) indicate that institutional and organizational interfaces are key entry points for employment opportunities[6]. This supports the concept of social capital, where interpersonal and mentor relationships can promote career opportunities. Although the data suggests that these channels have influence, qualitative interviews help explain the underlying mechanisms driving these connections.

4.4.Discussion

The research results should first be understood from the structural conditions of the rapidly increasing supply of graduates in Chongqing, which intensifies early career competition and enhances the perceived value of practice based ability development. Official statistics show an increase in higher education institutions and the number of graduates, while institutional evidence suggests that lack of experience and competition are the main barriers to employment. In this environment, social practice not only becomes an educational activity, but also a transitional mechanism connecting education and work.

Only when practice provides real tasks and structured feedback can human capital gains be achieved, and the results show that participation alone does not generate employability; On the contrary, skill development occurs when students participate in meaningful tasks and receive evaluation feedback that allows for iterative improvement. This supports the explanation of the learning process of practice: skills related to employability are developed through performance correction and internalization of work norms rather than exposure. The actual meaning is that despite formal participation, poorly structured resettlement may result in minimal development returns.

Social practice helps to improve employability, enabling students to test their expectations based on real career environments and build clearer career self understanding. Through reflection on success, difficulties, and mismatches, students develop confidence, adaptability, and career clarity. These psychological resources help explain why subjective job fit and satisfaction remain the core of employment outcomes in practice oriented systems[7].

Overall, these findings support a comprehensive explanation: human capital promotes performance, psychological capital maintains career agency, and social capital promotes opportunity acquisition. The weaknesses of any approach will limit the improvement of employability, which means that effective practice design must simultaneously coordinate task structure, reflection, and external

participation.

Conclusion

This study suggests that social practice shapes the employability of college students through a multi mechanism process rather than a single skill effect. In the context of Chongqing, employment ability is developed through the following ways: (1) forming ability through real task participation, (2) forming identity and confidence through reflective experience, and (3) obtaining opportunities through network expansion. Therefore, this study redefines social practice as a structured transitional process that links higher education participation with labor market entry.

6.2.Impact on Higher Education Management

The research findings indicate that universities should prioritize the quality of practice over the quantity of participation by defining competency goals, embedding feedback cycles, and formalizing reflective learning. In addition, institutions should manage practice as a coordinated system involving supervisors, students, and external organizations, ensuring that internships bring both learning and opportunities[8]. Finally, a fair distribution mechanism is necessary so that employment benefits are not limited to students with previous advantages.

6.3.Policy implications

At the policy level, the employment plan for graduates should go beyond the number of employed individuals and include quality indicators such as mentor intensity and learning outcomes. Regional coordination between universities and employers can stabilize practical channels, while youth employment policies should combine ability development with recruitment channels to address barriers related to experience.

Limitations and Future Research

This study provides an analytical summary explanation, but still relates to the institutional and labor market environment in Chongqing. The dependence on participants' perceptions introduces subjectivity, and triangulated institutional data contextualizes causal relationships rather than verifying them. Therefore, the research results explain the mechanism, but cannot estimate the size of the effect or the strength of causality.

Future research should compare regions with different opportunity structures, use mixed methods to quantify mechanism relationships, and develop measurable quality indicators for practice. Vertical design will further elucidate how employability capital accumulates in multiple practical experiences and early stages of career development.

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Stochastic Process in the Concentrating System of a Solar Power Plant for Greenhouse Agriculture

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KEYWORDS

Greenhouse farming;
Photovoltaic system;
Stochastic processes;
MATLAB simulation;

ABSTRACT

Agricultural greenhouses are usually located in the suburbs or remote areas away from towns, and generally speaking, the cost of transmission and power supply is high, and some remote areas do not even have electricity supply. However, traditional greenhouses contain many different electrical equipment and facilities, and a stable power supply is essential for the normal, economical and efficient operation of the greenhouse. Modern agricultural greenhouses also need to be equipped with complete lighting systems, temperature and humidity control systems, ventilation systems, carbon dioxide concentration control systems, irrigation sprinkler systems, etc., which are difficult for traditional greenhouses to achieve smoothly. Traditional greenhouses are usually covered with plastic film, which usually needs to be replaced every year, and the discarded plastic film does not meet the requirements of energy conservation and environmental protection. The problem of "thermal insulation" in greenhouses has also been plaguing greenhouse growers. From the perspective of planting cycle, traditional greenhouses are generally only planted twice a year, and the economic benefits are limited.

1.Solar Power Systems: Background and Significance

1.1.Background of solar power generation system

Energy has always been the driving force and source of the survival and development of human society. With the continuous development and progress of society, fossil energy reserves are also increasingly depleted. According to official statistics, China imported 150 million tons of crude oil last year alone. At the current rate of consumption, China's existing energy reserves can only last for 50 years at most. Fortunately, with the continuous advancement of science and technology, mankind has discovered a variety of new energy sources such as nuclear energy, geothermal energy, tidal energy, wind energy, and solar energy. Under the limitations of fossil energy and the pressure of environmental protection, countries around the world have stepped up their efforts to support the development and utilization of these green renewable energy sources.

Under the limitations of fossil energy and the pressure of environmental protection, most countries in the world have increased their support for the development of green new and renewable energy. Especially since the beginning of the 21st century, the demand for energy in countries around the world has been growing. The installed capacity of renewable energy power generation in Germany, Denmark and other countries has reached a high level. In order to promote the development of renewable energy, countries not only continue to increase investment in the research and development of renewable energy technology, but also take measures at the legislative and policy levels to support the development and utilization of renewable energy and accelerate its development, making it an important alternative energy source for energy diversification, climate change and sustainable development.

Considering many factors such as energy supply, solar energy is undoubtedly an ideal green energy source for sustainable development. At the same time, solar energy is about to become one of the most important energy sources in the 21st century. Solar energy is the energy radiated by the sun into space, which is the energy produced by continuous

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nuclear fusion reactions inside the sun. The solar energy that reaches the Earth's surface is about 82×100,000 kilowatts, and the energy density is about 1 kilowatt/square meter. Solar power generation is mainly divided into thermal power generation and photovoltaic power generation. Due to its wide distribution, inexhaustible availability, safety and cleanliness, solar energy has gradually become an ideal new generation of renewable energy for mankind, and it is the energy that humans can ultimately rely on [1].

1.2.Importance of solar power generation system

Solar power generation is one of the important forms of solar energy utilization, which directly converts solar energy into electricity. Among the various power generation methods, photovoltaic power generation is the mainstream. Photovoltaic power generation converts the light energy that hits the solar cells directly into electrical energy output.

In order to encourage the development and utilization of solar technology, governments around the world have actively formulated various preferential policies to promote the development of solar photovoltaic power generation. In 1996, with the support of the U.S. Department of Energy, the U.S. government launched the "Photovoltaic Building Program" with an investment of $2 billion. In 1997, the U.S. government took the lead in announcing the launch of the "Million Solar Roof Program". In 2002, the total production capacity of photovoltaic cells in the United States reached 112.9 megawatts. The plan aims to reduce the cost of electricity generation to 7.7 cents per kWh by 2010, reduce CO2 emissions by 3.511 million tons per year and create 71,500 new jobs. The program is currently approved by the California Department of Implementation[2]. The Japanese government announced the "Sunshine Plan" as early as 1974 and proposed the "New Sunshine Plan" in 1993, aiming to promote the comprehensive and long-term development of solar energy research programs. Japan has successively issued a series of regulations on incentives for the research and application of renewable green energy such as solar energy, which has greatly promoted the development and application of Japan's photovoltaic industry. In 2002, Japan's total photovoltaic cell production reached 254 megawatts, ranking first in the world with a growth rate of 48.6%. It is planned that by 2010, more than half of the new residential roofs will be equipped with photovoltaic solar systems. The German government is one of the first and most active countries in the world to advocate and encourage photovoltaic applications [3]. In 1990, the German government took the lead in launching the "Thousand Roof Solar Program". In 1993, Germany took the lead in implementing the "Thousand Roofs Plan" supported by government investment and approved by power companies, and expanded to the "Rooftop Photovoltaic Plan" in 2001. In 1998, the German government further proposed the "100,000 PV Roof Plan" and developed dedicated PV modules integrated with buildings. The "100,000 solar roofs plan" was implemented in January 1999. The Renewable Energy Act promulgated by the German government came into force on April 1, 2000. In addition, Italy, India, Switzerland, France, the Netherlands, and Spain have similar programs and are investing heavily in technology research and development and accelerated industrialization [4].

From a global perspective, photovoltaic power generation has completed the initial research and development and large-scale application demonstration stage, and is currently developing in the direction of mass production and large-scale application. It has evolved from a small power supply to today's grid-connected power generation to serve the public power system. Its range of applications also covers almost all areas of electricity consumption. In addition, photovoltaic centralized power generation and photovoltaic buildings have developed rapidly and gradually become the main force in the market.

1.3. Overview of solar power generation system

Solar power generation systems are a new type of power generation system that uses the photovoltaic effect of semiconductor materials to directly convert solar radiation energy into electricity. The so-called photovoltaic effect refers to the phenomenon that after an object absorbs light energy, the distribution state and concentration of non-conductive carriers inside it change, resulting in current and electromotive force.

A key component of this technology is the solar cell. Solar cells can be encapsulated and protected in series to form a large area of solar cell modules. Combined with power controllers and other components, photovoltaic power generation devices can be formed. The advantage of photovoltaic power generation is that it is less geographically restricted because the sun shines on the earth;

Photovoltaic systems also have the advantages of safety and reliability, no noise, low pollution, no fuel consumption, no need to erect transmission lines, local power generation, and short construction period.

Light energy conversion equipment, or photovoltaic cells, is a device that uses the photovoltaic effect to convert light energy into electricity. At present, the photovoltaic conversion devices widely used in photovoltaic power generation projects are mainly silicon photovoltaic cells, including monocrystalline silicon, polycrystalline silicon and amorphous silicon cells. The production technology of monocrystalline silicon photovoltaic cells has matured and has entered the stage of large-scale industrial production. Now we use crystalline silicon as an example to describe the photovoltaic power generation process. As shown in Fig. 1, N-type silicon is obtained after phosphorus doping of P-type crystalline silicon to form PN junctions. When the light hits the surface of the photovoltaic cell, some photons are absorbed by the silicon material. The energy of the photons is transferred to the silicon atoms, causing electrons to transition into free electrons, which collect on either side of the PN junction, creating a potential difference. When the external circuit is turned on, under the action of this external voltage, the current will flow through the external circuit to produce a certain output power.

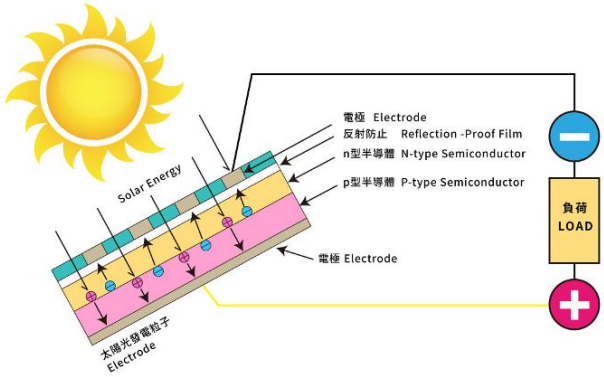

Fig.1. Principle of the photovoltaic effect

2.Modeling and simulation of solar power generation systems

2.1.Solar array modeling

The basic characteristics of solar cells can be expressed in terms of the relationship between current and voltage. The relationship between current and voltage also depends on a range of other parameters, especially those related to the intensity of sunlight on the solar cell surface and the temperature of the cells.Figure 2 shows the equivalent circuit of an ideal photovoltaic cell.

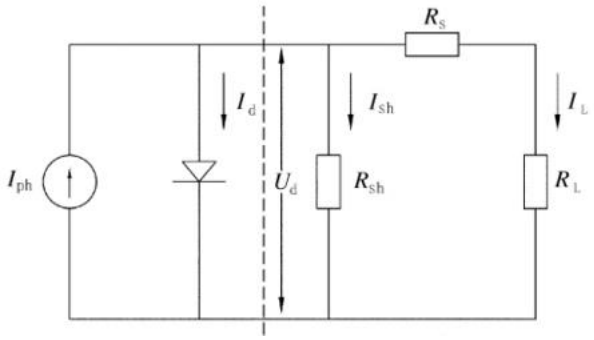

Fig.2. Photovoltaic cell equivalent circuit

It consists of series and parallel resistors, diodes, and photo generated current sources. I _{ph} is the photogenerated current. When the light intensity is constant, it can be equivalent to a constant current source because the photogenerated current does not change with the working state of the photovoltaic cell. When the two ends of the photovoltaic cell are connected to the load, the voltage at the load side acts on the PN junction, generating a current I_L opposite to the direction of the photogenerated current. The series equivalent resistor R_s represents the obstruction of current flow in the battery, and its value depends on the PN junction depth, semiconductor material purity, and contact resistance [5]. The larger the series resistance, the greater the line loss, and the lower the output efficiency of the photovoltaic cell. The bypass resistor R_{sh} is inversely proportional to the battery's floor leakage current. The relationship between the output voltage and current of the photovoltaic array is as follows:

$$I = I_{ph} - I_D\left(e^{\frac{q(U+IR_S)}{AkT}} - 1\right) - \frac{U+IR_S}{R_{sh}}$$

In the formula, A is the ideal coefficient of the diode, the Boltzmann constant k=1.38×10⁻²³J/K, q=1.6×10⁻¹⁹ C is the electron charge; θ is the temperature, R _{sh} and R_s are the parallel and series resistances, respectively. Since the photogenerated current I_{*ph} *is proportional to the instantaneous light intensity of the photovoltaic cell E* _{TP}, A will change +0.1% with increasing temperature when the temperature zero point is 298K (25) [6]. Therefore:

$$I_{ph} = 5.46 \times 10^{-3} E_{TP}[1 + 0.001(T - 298)] \quad (3\text{-}2)$$

Assuming E = 100 Mw/cm², the temperature of the entire unit is 30°C higher than the air temperature. Find the temperature expression of the device:

$$T = T_a + 0.3E_{TP} \times 1000 \quad (3\text{-}3)$$

By establishing the equation system through the above formula, the ideal output characteristics of the photovoltaic array can be obtained.

Establish a simulation model based on the equivalent circuit of photovoltaic modules. Figure 3 shows the packaging model diagram of photovoltaic modules.

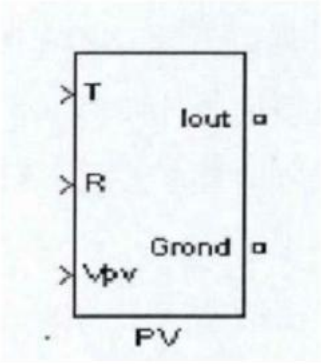

Fig.3. Photovoltaic cell packaging model diagram

In the above figure, T is the battery temperature, R is the light intensity, and V and I are the output voltage and output current of the photovoltaic array, respectively. This is a universal PV module packaging model. By inputting different parameters inside the component, the I-V characteristics and PV characteristics under different conditions can be simulated. Fig. 4 shows the simulation model of the output characteristics of photovoltaic modules [7].

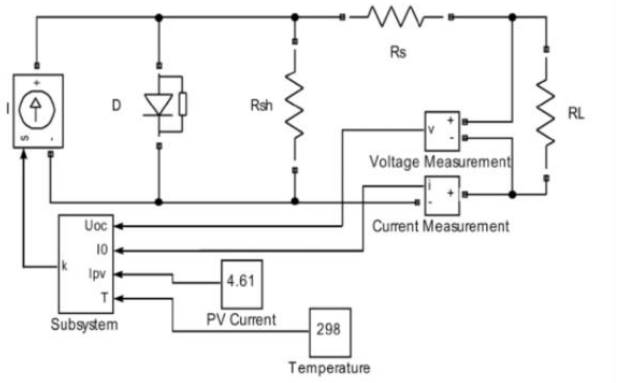

Fig.4. Solar PV module simulation model

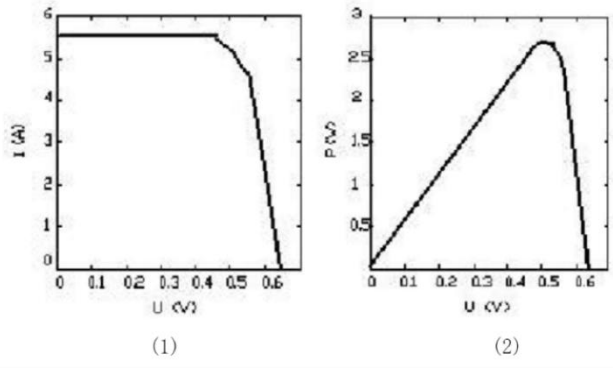

Fig.5. SOutput characteristic curve of a photovoltaic array

The photovoltaic cell model was simulated using the MATLAB environment. At this time, the light intensity is 100Mw/cm² and the atmospheric temperature is 25°C. As shown in Fig. 5, curve 1 is the simulation result of the output voltage-current characteristics of the photovoltaic array, and curve 2 is the simulation result of the output power-voltage characteristics of the photovoltaic array [8].

2.2.Analysis of solar greenhouse power generation technology

There are many types of traditional greenhouses, which can be classified according to roof truss material, lighting materials, appearance and heating conditions, such as: plastic greenhouse, Boer greenhouse; single-body greenhouse, multi-span greenhouse; single-roof greenhouse, multi-storey greenhouse; heated greenhouse, unheated greenhouse, etc. The typical structure is shown in Fig. 6 [9].

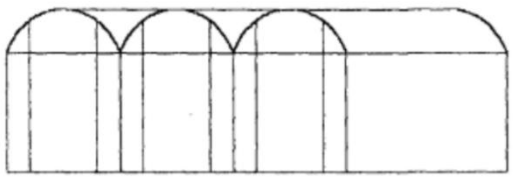

Figure.6. Typical structural form of a traditional greenhouse

The disadvantages of traditional greenhouses are as follows: Not suitable for long-term use,Greenhouses covered with plastic film usually need to be replaced every 1 to 2 years, which increases maintenance costs. At the same time, the replaced and discarded plastic film will cause secondary pollution and does not meet the requirements of energy conservation and environmental protection.

Various environmental parameters in the greenhouse are controlled to prevent plants from growing too slowly.Traditional greenhouses have poor control over

parameters such as temperature, humidity, and light, which affects the growth rate of plants. The temperature in the greenhouse in summer is too high, which prevents many vegetable varieties from growing properly. Poor greenhouse insulation performance in winter also affects the cross-season growth of many crops [10].

High energy consumption and poor environmental performance.Greenhouses are an important means for farmers to increase their yield and income. However, many parts of China have large temperature differences throughout the year, as well as large temperature differences between day and night. In order to ensure the normal growth of various crops, a variety of methods need to be used for constant temperature control. When the temperature is low in winter, some areas use the method of burning coal in the greenhouse to heat up, but this not only consumes resources but also pollutes the environment; When the temperature is high in summer, it is necessary to cover the greenhouse with a sunshade net and ventilate it with a fan. In remote areas, there is a lack of mains electricity, and the power supply of various equipment in the greenhouse mainly relies on diesel engines, which consumes both traditional resources and lacks environmental performance.

In view of the many shortcomings of traditional greenhouses, the introduction of solar power generation technology into the greenhouse system can not only solve the power supply problem of greenhouses and increase yield, but also establish an image of energy conservation and environmental protection, and shape the ecological and environmental protection concept of new modern agricultural vegetable greenhouses [11].

With the development of building-integrated photovoltaic (BIPV) technology, photovoltaic power generation systems are combined with greenhouses to give full play to the advantages of photovoltaic systems and make up for various defects and shortcomings of traditional greenhouses.

When the photovoltaic power generation system is combined with the greenhouse, it not only provides the required electricity for the greenhouse, but more importantly, the photovoltaic power generation system is fully integrated into the architectural design concept of the greenhouse. Its functional parameters are indispensable for greenhouses and are also an important part of building a new concept of green ecology.

The photovoltaic modules used in photovoltaic greenhouses need to be integrated into the greenhouse building materials, completely replacing the original building materials, rather than simply being attached to the original building. From a structural point of view, photovoltaic modules comply with various building codes, and many factors such as technology, practicality, aesthetics and safety are fully considered at the beginning of planning and design.

Photovoltaic modules need to have light transmission. While they generate electricity, they need to ensure that greenhouse plants receive the necessary light and block some of the harmful light, such as ultraviolet rays. Photovoltaic systems can ensure the light intensity and duration required by plants, promote the growth of various plants in the greenhouse, and increase their growth rate. In addition to powering various conventional and automated monitoring facilities in the greenhouse, the photovoltaic system can also provide LED auxiliary lighting to promote plant growth and solar energy for various insect repellent and insecticidal facilities.

Photovoltaic greenhouses need to have the characteristics of heat preservation, ventilation and convenience. On the one hand, the photovoltaic module itself can block part of the excess sunlight from entering the greenhouse, play a role in shading and energy saving, make the greenhouse warm in winter and cool in summer, suitable for plant growth; On the other hand, photovoltaic modules can convert the received solar energy into electricity required for greenhouses, playing a green, environmentally friendly, economical, and efficient role. Since the greenhouse itself has requirements for ventilation, light transmission and other functions, photovoltaic greenhouses need to meet the needs of ventilation irrigation, spraying, heat dissipation, sealing and insulation, temperature and humidity regulation, carbon dioxide concentration adjustment, plant pollination and natural ecology.

Photovoltaic greenhouse systems must be efficient and economical. It not only powers various necessary facilities in the greenhouse, but also meets the daily electricity needs of greenhouse growers. For large-scale photovoltaic vegetable greenhouses, it can not only solve their own electricity problems and save related costs, but also transmit excess electricity to the national grid. In addition to the original agricultural greenhouse construction subsidies and related agricultural subsidies, you can also enjoy national and local government subsidies, such as photovoltaic power generation subsidies for distributed photovoltaic power plants and income from electricity sales to power companies. In addition, photovoltaic greenhouses have good energy

conservation and emission reduction effects and high environmental benefits. They avoid environmental pollution caused by the use of traditional energy sources and reduce the cost of emission reduction, pollution control and environmental protection. Its economic, environmental and social benefits are very considerable. At the same time, photovoltaic greenhouses can also be built into modern agricultural ecological demonstration parks integrating production, environmental protection, demonstration education and tourism. The photovoltaic greenhouse is designed to have a service life of not less than 25 years, high quality and good safety [12].

According to the geographical location, regional characteristics and functional needs, as well as the scale and form of photovoltaic greenhouses, photovoltaic greenhouses can be divided into the following categories:

Independent photovoltaic greenhouse:In areas where power supply is insufficient or non-existent, small greenhouses often use freestanding photovoltaic greenhouses. Its working principle is shown in Figure 7.

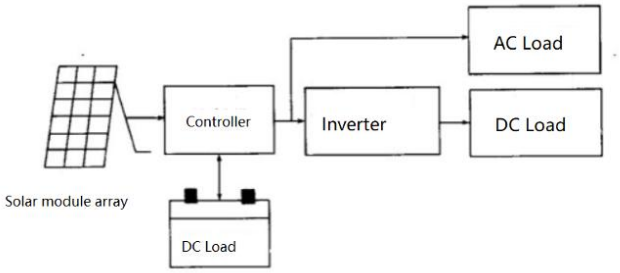

Figure.7. Schematic diagram of an independent photovoltaic greenhouse

The system is mainly composed of transparent photovoltaic modules, photovoltaic controllers, batteries, off-grid inverters, etc. The photovoltaic module converts sunlight into direct current, and the photovoltaic controller controls the charging and discharging of the cells. The PV controller can directly provide DC power output to the greenhouse DC load, or convert the DC power into 380V/220VAC AC power through an off-grid inverter to power the greenhouse AC load.

Grid-connected photovoltaic greenhouse:In areas with electricity, photovoltaic greenhouses are usually grid-connected. Grid-connected photovoltaic greenhouses can be divided into 380V low-voltage side grid-connected type and grid-connected type that is boosted to 10KV, 35KV or higher voltage levels by step-up transformers according to different voltage levels at grid-connected points.Considering the application characteristics of photovoltaic greenhouses, their structural forms generally include single photovoltaic greenhouses and combined photovoltaic greenhouses, and the roof forms are oblique ridge and zigzag. Taking a zigzag roof photovoltaic greenhouse as an example, its structure is shown in Fig. 8 and Fig. 9 [13].

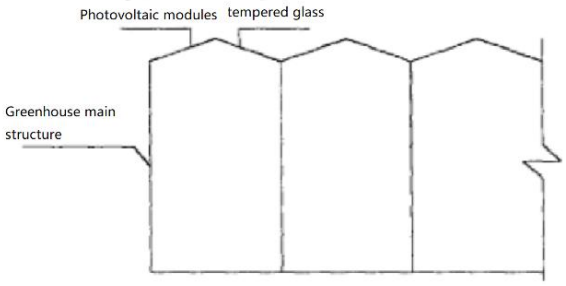

Figure.8. Photovoltaic greenhouse height

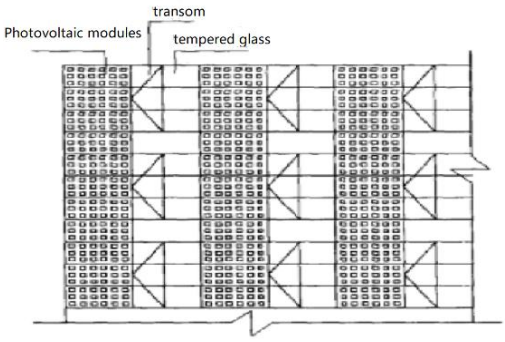

Fig.9. Floor plan of the photovoltaic greenhouse

Photovoltaic translucent modules are installed on each southern slope of the zigzag roof, which can be arranged continuously or at intervals as needed; The north slope is fitted with traditional tempered glass and is equipped with beamed windows. Photovoltaic modules can not only replace the original building materials, but also serve as power generation units to achieve true photovoltaic building integration.

The greenhouse roof structure needs to comprehensively consider factors such as structural weight and strength, pay attention to lightweight, comply with local climatic conditions, and meet relevant design specifications. The installation combination of photovoltaic modules and greenhouse structures mainly adopts aluminum profile open frame structures [14].

The photovoltaic modules installed in the greenhouse must first meet the various building and technical specifications related to the greenhouse, as well as the technical specifications of the photovoltaic system itself. Depending on the installation site, wind and snow loads will vary, and

the strength requirements of the components will also vary. For areas with large wind and snow loads, thicker double-glazed transmitting modules are usually used as needed; For areas with low wind and snow loads, thinner double-glazed translucent components can also be used. Single-layer glass + transparent TPT modules are also a viable option. The cell type can be crystalline silicon or thin-film cell. The structure of the greenhouse photovoltaic module is shown in Figures 10 and 11.

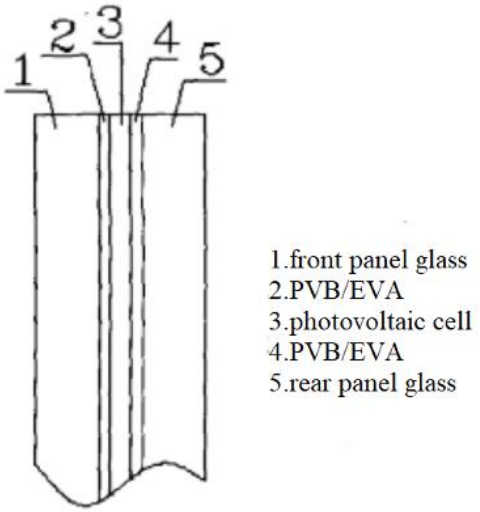

Fig.10. Double-layer clear glass photovoltaic module

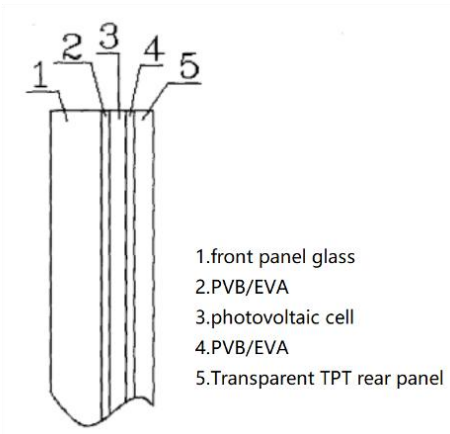

Fig.11 Single-layer transparent glass photovoltaic module**.**

One of the characteristics of double glazing components is light transmission, so different light transmittance can be customized according to the lighting needs of greenhouses and different plants. For crops, the 400~520nm (blue light) and 610~720nm (red light) bands in the solar spectrum are more suitable for plant growth. The relationship between solar spectra and plant photosynthesis is shown in Figure 12 [18].

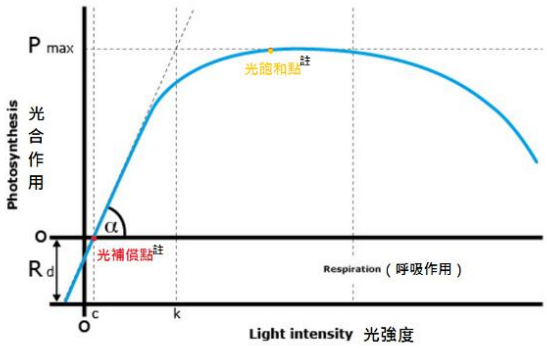

Fig.12. Relationship between solar spectra and plant photosynthesis

Here are the photovoltaic modules designed according to the demand of crops for the solar spectrum:For double-glass modules using thin-film photovoltaic cells, thin-film cells have good spectral characteristics and are able to transmit visible light from 400 to 800 nanometers. They can effectively block UV and infrared rays, preventing UV rays from causing damage to plants during the day. In addition, they prevent overheating in the greenhouse and prevent indoor infrared rays from radiating outward at night, providing good thermal insulation. Thin-film cells have good light transmission and can be customized with any percentage of light transmittance according to needs. At present, the light transmittance of commercially available light-transmitting thin film modules is 10%, 20%, and 30% [19].

For double-glass modules using crystalline silicon photovoltaic cells, they cannot promote plant growth by increasing the sun's spectral transmittance due to their lack of spectral properties. Crystalline silicon photovoltaic cells have the advantages of high power generation efficiency, low cost of Wp modules, and high installed capacity per unit area. Its light transmittance can be adjusted and customized as needed without affecting the light needs of the plants. The following example illustrates the design selection process.

Conclusion

This paper analyzes the principle and structure of photovoltaic power generation system to complete the modeling and simulation of photovoltaic power generation system. In the MATLAB/SIMULINK simulation environment, based on the IV mathematical function relationship of photovoltaic cells, the working principle of solar cells is analyzed, the simulation model of photovoltaic

cells is established, and the output characteristics of photovoltaic cells under different light intensities and temperatures are studied and analyzed. The simulation results verify that the output characteristics of photovoltaic cells are nonlinear, and change with the change of external environment. The main circuit of the photovoltaic power generation system is modeled.

At present, the efficiency of photovoltaic power generation systems is still not ideal and needs to be further improved. Therefore, it is imperative to enhance the application functionality of the system. If the functions of grid-connected power generation, independent control, seamless switching of grid-connected/independent working modes, multi-machine parallel connection, and multi-machine group control are integrated, it can be flexibly combined into various application systems, making them more versatile and multi-functional, thereby improving system efficiency. In recent years, photovoltaic power generation technology has become the focus of global attention, and photovoltaic power generation systems have been applied on a large scale at home and abroad. Although this paper conducts in-depth research on some key problems of photovoltaic power generation system through theoretical analysis and simulation, there are still many problems that need to be solved urgently.

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Analysis of Mechanisms for Improving the Efficiency of an Open Innovation Ecosystem

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KEYWORDS

Open innovation ecosystem;

Efficiency improvement mechanism;

Collaborative innovation;

Open symbiosis;

Industrial chain synergy;

ABSTRACT

In the context of public policy aimed at enhancing the overall effectiveness of the national innovation system and building a globally competitive open innovation ecosystem, the problem of enhancing the effectiveness of innovation ecosystems has attracted increasing attention from the academic community. This paper, using a coevolutionary perspective, explores the mechanism of coevolution at the micro- and macro-levels in an open innovation ecosystem. Based on this, using qualitative research methods, it interprets the key driving mechanisms for enhancing the effectiveness of an open innovation ecosystem in the Chinese context and analyzes effective ways to enhance systemic effectiveness.

INTRODUCTION

Against the backdrop of profound adjustments in the global innovation landscape and the accelerated integration of the digital economy and the real economy, open innovation ecosystems have become a core vehicle for driving industrial upgrading and breaking through core technological bottlenecks. Compared with closed innovation models, open innovation ecosystems integrate the resources and capabilities of heterogeneous participants (enterprises, universities, research institutions, governments, etc.) to achieve cross-entity, cross-domain, and cross-regional flow of innovation elements. Their efficiency improvement directly relates to national innovation competitiveness and sustainable industrial development capabilities. China, leveraging its massive market advantage, complete industrial chain layout, and continuously strengthened policy support, has formed a unique development path in the construction of open innovation ecosystems. However, current research is mostly qualitative, lacking systematic quantitative data support, resulting in insufficient concreteness and specificity in the demonstration of co-evolution mechanisms, efficiency drivers, and effective improvement paths within the ecosystem. Therefore, this paper focuses on the core research need of "Mechanism Analysis of Open Innovation Ecosystem Efficiency Improvement," centering on three core arguments: "co-evolution mechanism, driving factors, and path effectiveness." It supplements quantifiable and authoritative empirical data from four dimensions: macro environment, micro-entities, industry cases, and international comparisons, constructing a research framework of "qualitative analysis + quantitative support." The implementation of this data enhancement plan aims to address the shortcomings of insufficient data support in existing research, accurately verify the unique advantages and efficiency improvement patterns of China's open innovation ecosystem, and provide data references and empirical evidence for subsequent optimization of the innovation ecosystem layout and improvement of the policy support system.

1. Literature Review

In the 1990s, the rise of American industry and the success of Silicon Valley continually stimulated the development of

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innovation systems theory, ultimately leading to the formation of innovation ecosystem theory. A 2004 research report by the U.S. President's Science and Technology Policy Board emphasized that U.S. leadership in technology and innovation depends on a "vibrant and dynamic innovation ecosystem."

Moore first systematically described business ecosystems[1], and Adner and Kapoor pointed out[2] that an innovation ecosystem enables firms to create value that no single company could create alone[13]. An innovation ecosystem is a complex system that includes actors such as "government - industry - universities - research institutes - finance - intermediaries - users," as well as the ecological innovation environment, and is aimed at enhancing the results of scientific and technological innovation and integral competitive advantages[3]. It has become the fourth driving force of innovation after market forces, collective forces, and digital social forces[4]. The theory of the open innovation ecosystem is the result of the integration of the concepts of "open innovation" and "innovation ecosystems." The concept of "open innovation" was first proposed by Chesbrough[5], who, comparing American technology companies, found that companies with relatively weak internal R&D capabilities that actively engage external resources often demonstrate higher innovation performance than companies with strong internal R&D competencies. Digital technologies have blurred the boundaries of industries, organizations, and products[6], and the integration of internal and inter-firm innovation resources helps reduce innovation costs and accelerates the commercialization of results[4]. León defined an open innovation ecosystem as an ecosystem whose participants[7], sharing a common culture, continuously conduct activities within the framework of open innovation[8].

Domestic researchers primarily rely on the theory of network structures, analyzing at the micro level[9] factors influencing the development of an open innovation ecosystem at various stages of the innovation process[10], the formation of digital transformation ecosystems, as well as the key role of the state in open innovation ecosystems[11].

2.Coevolution Theory

Coevolution theory originates in biology and describes the dynamic process of mutual influence and co-evolution between two or more species coexisting in a common environment. The theory has subsequently been applied to studies of strategic alliances and innovation systems. Moore is considered a proponent of the coevolutionary approach[1], viewing the coevolution of participants as a central concept in business ecosystem theory. Coevolution theory provides a dynamic, spatio-temporal analytical framework for studying innovation ecosystems.

2.1.Coevolution and the Emergence of Heterogeneous Participants at the Micro Level

Innovation activity reflects the degree of activity of innovative actors; only by stimulating them to engage in sustained research can we ensure the constant iteration of an ecosystem, its adaptation to external changes, and the maintenance of long-term innovative capacity. Innovative activity is determined by two factors: the continuous emergence of heterogeneous actors and their co-evolution[14][15].

High-potential innovative entities, by overcoming growth stages, facilitate the ecosystem's transition from a low to a higher level of development. While previously open innovation ecosystems relied primarily on large transnational corporations as a core, the development of digital technologies has increased the heterogeneity of innovative entities, and small technology companies (especially Chinese enterprises in the "specialized, precise, unique, and innovative" category) are becoming the main drivers of innovation.

Large technology companies are strong in production and market entry, while small technology firms are flexible and have low trial and error costs. Their collaboration allows for the effective sharing of innovation risks, and once they reach maturity, they can become the primary drivers of innovation. In technologies, large companies can integrate developments through acquisitions or partnerships, achieving co-evolution among ecosystem participants.

Unlike Western ecosystems, where core companies are primarily focused on their own interests, Chinese state-owned corporations and large private technology firms often have a mission to overcome bottlenecks in critical technologies and ensure scientific and technological sovereignty, playing a key role in China's open innovation ecosystem.

Collaboration	In 2023, there were 23,000 collaborative

Scale	innovation projects between Chinese central state-owned enterprises (SOEs) and SMEs, driving over 150,000 SMEs to participate in supply chain support. Large technology companies (such as Huawei and Tencent) have empowered over 500,000 SMEs through an "open-source platform + ecosystem cooperation" model, with 70% of these SMEs achieving R&D efficiency improvements of over 30% (Source: State-owned Assets Supervision and Administration Commission of the State Council, "Report on High-Quality Development of Central Enterprises 2023").
Mergers and Acquisitions (M&A) and Cooperation	From 2021 to 2023, large enterprises accounted for 62% of M&A cases in China's technology sector, primarily concentrated in the semiconductor, artificial intelligence, and biomedicine fields. After M&A, the technology commercialization cycle for SMEs shortened by an average of 1.8 years, while the R&D costs for new products for large enterprises decreased by an average of 24% (Source: Tsinghua Research Center, "2023 China Technology M&A Market Report").
Contributions from Specialized, Refined, and Innovative Enterprises	By the end of 2023, the average R&D intensity of specialized, refined, and innovative "little giant" enterprises reached 6.8%, 4.9 times the national average for large-scale industrial enterprises (1.38%). They held over 1.3 million patents, with invention patents accounting for 34%, and undertook over 8,000 national-level research projects (Source: Data from the Ministry of Industry and Information Technology).
Core Enterprise Technological Breakthroughs	From 2021 to 2023, Chinese central state-owned enterprises (SOEs) achieved breakthroughs in 247 key core technologies in "bottleneck" technologies, covering fields such as semiconductor equipment, high-end chips, and aero-engines. In 2023, central SOEs were granted 126,000 invention patents, a year-on-year increase of 18.7% (Source: Data from the State-owned Assets Supervision and Administration Commission of the State Council).

Table.1. Collaborative data for large, medium and small enterprises

2.2.Macro-Level Co-Evolution Driven by Environmental Optimization

The innovation environment is the external conditions that provide actors with resources, information, and technologies. The co-evolution of the ecosystem and the macroenvironment is a more complex research question [4]. Each country's innovation activity is rooted in its specific context, forming a unique innovation ecosystem.

In the new era, the influence of the external environment on open innovation ecosystems has become more profound than ever. China's open innovation ecosystem is built not on principles of control or dominance, but on the ideas of openness, inclusiveness, and the values of co-creation, co-construction, and co-sharing, which facilitates the attraction of global innovative resources[16].

China possesses a unique set of advantages: a vast market, social stability, a favorable cultural and educational environment, an improving legal system, an improving business environment, a developed digital infrastructure, and open high-tech manufacturing and financial services.[12] Although China lags behind developed economies in a number of key technologies, it has significant advantages in market scale, government support, and the completeness of its supply chain, which is particularly evident in industries such as semiconductors, electric vehicles, and solar energy.

Industrial Categories and Market Demand	China is the only country in the world with all 41 major industrial categories, 207 medium categories, and 666 minor categories in the United Nations' industrial classification (Source: National Bureau of Statistics, 2023 data). In 2023, China's R&D expenditure reached 3.39 trillion yuan, accounting for 2.55% of GDP, maintaining double-digit growth for 10 consecutive years. Enterprise R&D investment accounted for over 76% of this (Source: Ministry of Science and Technology, "2023 National Science and Technology Expenditure Statistics

	Bulletin").
Digital Economy Scale	In 2023, China's digital economy totaled 55.6 trillion yuan, accounting for 48.8% of GDP. The added value of the core digital economy industries accounted for 10.2% of GDP. The number of internet users reached 1.079 billion, and mobile internet users reached 1.03 billion (Source: China Academy of Information and Communications Technology, "China Digital Economy Development Report (2024)"), providing the world's largest user base for "Internet+" innovation.
In terms of business environment ranking	China ranked 31st globally in the World Bank's "Doing Business 2023" report, an improvement of 47 places compared to 2019. From 2013 to 2023, China cumulatively reduced 115 items on its negative list for market access, achieving near-complete opening up of the manufacturing sector and expanding service sector opening pilots to cover 11 free trade zones (Source: Ministry of Commerce 2023 Business Environment Development Report).
Regarding policy support	From 2021 to 2023, the central government allocated over 30 billion yuan in special funds for the development of specialized, refined, and innovative SMEs, leveraging over 150 billion yuan in local government investment. By the end of 2023, a total of 12,000 specialized, refined, and innovative "little giant" enterprises and 98,000 provincial-level specialized, refined, and innovative SMEs had been cultivated nationwide (Source: Data from the SME Bureau of the Ministry of Industry and Information Technology).
Digital infrastructure	By the end of 2023, China had a total of 3.377 million 5G base stations, accounting for more than 60% of the global total; the total number of devices connected to industrial internet platforms exceeded 800 million, covering 41 major categories of the national economy (Source: Ministry of Industry and Information Technology's "2023 Statistical Bulletin on the Communications Industry"), providing technical support for collaborative innovation across the industrial chain.

Table.2. Market size data

3.Effective Paths to Enhance the Efficiency of China's Open Innovation Ecosystem

In the new development philosophy, the meaning of "openness" in terms of systems and policies refers more importantly to the openness of the entire national science and technology innovation system and mechanism. The continuous emergence of unforeseen global events and unstable geopolitical factors, coupled with changes in the technological competition landscape, poses more long-term and strategic planning requirements for improving the effectiveness of my country's open innovation ecosystem. There are significant differences between the Chinese government's and the governments of the US and the West's approach to science and technology openness, which are also reflected in the core value propositions of the open innovation ecosystems they have led the construction of. The US and Western countries often emphasize the consistency and similarity of values among ecosystem partners, as well as their own interests and discourse power, attempting to build an ecosystem with Western values at its core. They often use alliance or quasi-alliance strategies to combine non-technical factors such as geoeconomics, politics, and even security, exhibiting a strong exclusivity. Examples include the Chip and Science Act, the US-EU Trade and Technology Committee (TTC), and the Indo-Pacific Economic Framework (IPEF), all of which contain strategic containment intentions towards China. The Chinese government, in its efforts to promote science and technology openness, is committed to building a community with a shared future for mankind, promoting global scientific and technological innovation and development, actively participating in global science and technology governance, and driving the formulation and revision of international science and technology rules. It advocates for a more just, reasonable, and inclusive international science and technology governance system, and emphasizes the value proposition of "openness and symbiosis" in building an open innovation ecosystem. In a fully interconnected world, relying on building independent,

relatively closed innovation capabilities can only provide a temporary competitive advantage. However, by focusing on building an open and inclusive innovation ecosystem that does not seek ownership but rather benefits others, it acquires ecological value, thereby achieving a sustainable improvement in the effectiveness of the open innovation ecosystem.

Industrial chain support	China has formed a complete semiconductor industry chain covering design, manufacturing, packaging and testing, equipment and materials. In 2023, the scale of the semiconductor industry reached 1.4 trillion yuan, a year-on-year increase of 12.5%. The localization rate of domestic semiconductor equipment increased from 13% in 2019 to 28% in 2023, of which the localization rate of core equipment such as etching machines and thin film deposition equipment exceeded 30% (Source: China Semiconductor Industry Association "2023 China Semiconductor Industry Development Report").
International resource aggregation	From 2021 to 2023, 18 of the world's top 20 semiconductor design companies established R&D centers or production bases in China. In 2023, China's semiconductor sector attracted US$12.8 billion in foreign investment, a year-on-year increase of 9.2%, mainly invested in advanced packaging, semiconductor materials and other fields (Source: Foreign Investment Statistics from the Ministry of Commerce).
Industry scale and innovation	In 2023, China's sales of intelligent electric vehicles reached 9.495 million units, accounting for 60% of global sales; the number of patent applications for new energy vehicles reached 987,000, accounting for 58% of the global total; and the installed capacity of power batteries reached 415.4 GWh, accounting for 60.2% of the global installed capacity. Companies such as CATL and BYD have a global market share of over 50% (Source: China Association of Automobile Manufacturers' "2023 China Automobile Industry Development Report").
Advanced manufacturing empowerment	China's intelligent electric vehicle industry chain has achieved a supporting rate of over 95%, with the Yangtze River Delta and Pearl River Delta regions forming a "1-hour parts supply circle"; Tesla's Shanghai Gigafactory had a production capacity of 750,000 vehicles in 2023, with a localization rate of over 95%, driving more than 1,000 upstream and downstream supporting enterprises, of which small and medium-sized enterprises accounted for more than 70% (Source: Tesla China Annual Report 2023).
Global competitiveness	In 2023, China's photovoltaic module production reached 389GW, accounting for 85% of global production; the global market share of each link in the photovoltaic industry chain (silicon, silicon wafers, cells, and modules) all exceeded 70%; the R&D investment of photovoltaic companies increased by 22% year-on-year, and the conversion efficiency broke the world record for eight consecutive times (Source: China Photovoltaic Industry Association's "2023 China Photovoltaic Industry Development Report").
International Cooperation Data	In 2023, China's photovoltaic product exports reached US$56.9 billion, covering more than 190 countries and regions worldwide. Among the world's top 10 photovoltaic companies, 7 are Chinese companies, attracting more than 150,000 R&D talents in the global photovoltaic field. Among them, the proportion of overseas high-end talents increased from 8% in 2019 to 17% in 2023 (Source: Data from the General Administration of Customs and China Photovoltaic Industry Association).

Table.3. Semiconductor industry

The long-established open service capabilities of advanced manufacturing are a key entry point for maintaining a high level of openness and improving the efficiency of China's open innovation ecosystem in the context of deglobalization.

The new round of innovation is not in software or the internet, but in hard technology fields, such as high-end intelligent manufacturing, humanoid robots, new materials, new energy, and biomedicine. In the international innovation arena, a large number of small and medium-sized technology enterprises are gradually becoming the main force. These small and medium-sized technology enterprises are characterized by their small size and dispersed nature, and will not form a technological monopoly in China. Instead, they rely on the empowerment of China's advanced manufacturing industry to achieve mass production. For hard technology products, achieving mass production through the manufacturing sector is a crucial link in innovation. For a new technology to achieve mass production, it faces three challenges: first, manufacturing complex products on assembly lines; second, achieving mass production at a lower cost; and third, and most difficult, the openness of advanced manufacturing services. While the flexible and focused nature of small and medium-sized technology enterprises makes them the main force of the new round of innovation, their disadvantage is that they must coordinate resources externally to achieve mass production. Compared to large technology companies, small and medium-sized technology enterprises (SMEs) generally lack the financial resources and capabilities to build their own factories, relying on outsourcing for manufacturing. This places higher demands on the service capabilities, cost control, and openness of advanced manufacturing. These scarce capabilities are difficult to find in overseas innovation ecosystems, leading many SMEs to fail due to their inability to achieve mass production. Over the past decade or so, my country's advanced manufacturing industry chain has been continuously strengthening its advantages, enhancing its ability to serve global innovation, and attracting foreign technology companies to set up factories in China. Upstream and downstream manufacturers are also developing collaboratively and rapidly, resulting in a continuously strengthening effect of collaborative innovation and the aggregation of innovation resources across the industry chain. Internationally renowned technology companies are seeking suitable advanced manufacturing partners in China, and China's advanced manufacturing capabilities are being continuously honed by advanced global technologies, becoming increasingly open and demonstrating growing manufacturing advantages. It is becoming a super node in my country's open innovation ecosystem, establishing more and more connections with the outside world. Advanced manufacturing not only has a learning effect but also exhibits a significant aggregation effect during its development, attracting advanced technological resources from around the world and empowering my country's open innovation ecosystem.

Index	China (2023)	United States (2023)
Completeness of industrial sectors	100% (All categories)	89% (Missing low-to-mid-end categories)
Manufacturing value added (trillion US dollars)	4.5	2.9

Table.4. Comparison of market data between China and the United States

Source: United Nations Industrial Development Organization, U.S. Department of Commerce data

4. Research Conclusions

4.1.Core Research Findings

First, the "three-dimensional support" effect of the macro environment is significant, laying the foundation for improving the efficiency of the innovation ecosystem. Data shows that China's comprehensive industrial system (100% industrial coverage), continuously growing R&D investment (RMB 3.39 trillion in 2023, accounting for 2.55% of GDP), and well-developed digital infrastructure (accounting for over 60% of global 5G base stations) have constructed a three-dimensional support system of "market-policy-infrastructure[16]." Among these, the deep integration of the digital economy and the real economy (the digital economy accounting for 48.8% of GDP) provides an efficient platform for the flow of innovation factors, while the continuous optimization of the business environment (ranking 31st globally) and supportive policies for specialized and innovative enterprises (cultivating 12,000 "little giant" enterprises) have further lowered the participation threshold for innovation entities and stimulated market innovation vitality.

Second, a "co-evolution" mechanism among micro-entities has taken shape, with collaboration among large, medium, and small enterprises becoming the core driving force for efficiency. Data shows that collaborative innovation among

large, medium, and small enterprises in China has achieved a scale effect, with 23,000 collaborative projects between central state-owned enterprises and SMEs. Large technology companies have empowered over 500,000 SMEs, and 70% of these empowered SMEs have seen their R&D efficiency improve by more than 30%. Specialized, refined, and innovative "little giant" enterprises, as core innovation units, have an R&D intensity (6.8%) 4.9 times that of large-scale industrial enterprises, and their invention patent share reaches 34%, confirming the core value of resource complementarity and collaborative innovation among heterogeneous entities. Meanwhile, mergers and acquisitions of SMEs by large enterprises (accounting for 62%) have accelerated the industrialization of technological achievements, achieving a win-win situation of "cost reduction for large enterprises and acceleration for small enterprises."

Third, "path validation" in typical industries demonstrates that advanced manufacturing services and open cooperation are key to efficiency improvement. Data from the semiconductor, intelligent electric vehicle, and photovoltaic industries show that a complete industrial chain layout is a prerequisite for the efficient operation of the innovation ecosystem — the supporting rate of the intelligent electric vehicle industrial chain reaches 95%, the global market share of each link in the photovoltaic industrial chain exceeds 70%, and the localization rate of semiconductor equipment has increased from 13% to 28%, all reflecting the supporting role of industrial chain synergy in innovation efficiency. At the same time, the positive effects of open cooperation are significant. China's semiconductor sector attracts US$12.8 billion in foreign investment annually, and photovoltaic products are exported to more than 190 countries. Meanwhile, the US's exclusive policies (restricting 347 cooperation projects with China) have led to a 15% increase in the withdrawal rate of foreign-funded R&D centers, which in turn confirms the superiority of the open symbiotic model.

4.2.Targeted Discussion

Based on the research findings, the following targeted discussion addresses key issues in improving the effectiveness of China's open innovation ecosystem:

First, targeted recommendations for optimizing the macroeconomic environment. Although China's macroeconomic support system has taken initial shape, problems remain, such as uneven distribution of regional innovation resources and insufficient infrastructure adaptability in some areas. Based on data, further investment in digital infrastructure in the central and western regions should be increased (currently, 5G base stations are mainly concentrated in the east), the structure of R&D funding should be optimized, and the proportion of funding for basic research should be increased (currently, enterprises account for over 76% of R&D investment, while investment in basic research is relatively insufficient). At the same time, the scope of pilot programs for opening up the service sector should be expanded, market access barriers for SMEs should be lowered, and the innovation potential of the ultra-large-scale market should be fully unleashed.

Second, regarding addressing the pain points of collaboration among micro-entities. Information asymmetry and uneven distribution of benefits in collaboration among large, medium, and small enterprises remain core obstacles to the effective functioning of co-evolution mechanisms. Based on data reflecting collaborative effectiveness, it is recommended to establish a national-level cross-entity collaborative innovation platform, promote the open-source ecosystem model of companies like Huawei and Tencent, and establish a benefit-sharing mechanism of "large enterprises taking the lead, SMEs providing support, and research institutions providing backing." Simultaneously, it is crucial to increase targeted support for specialized and innovative enterprises, focusing on their core technology R&D (currently, "little giant" enterprises are undertaking 8,000 national-level projects, but there is still significant room for improvement), and strengthen innovation collaboration among heterogeneous entities.

Thirdly, regarding the optimization direction of industry innovation paths. The practices of three typical industries show that the integrity and openness of the industrial chain are key to improving efficiency, but different industries have different pain points: the localization rate of core equipment in the semiconductor industry is still less than 30%, the high-end chips in the intelligent electric vehicle industry rely on imports, and the photovoltaic industry faces international trade barriers. In response, differentiated policies should be formulated according to the characteristics of different industries — the semiconductor industry should increase investment in equipment and materials R&D, the intelligent electric vehicle industry should strengthen collaboration

between chip and vehicle manufacturers, and the photovoltaic industry should expand diversified international cooperation channels. At the same time, the integration of cross-industry innovation elements should be promoted to cultivate a composite innovation ecosystem.

Fourthly, we need to rationally consider international cooperation models. Comparative data on the openness of innovation ecosystems in China and the US show that exclusive policies hinder the flow of global innovation resources and the improvement of ecosystem efficiency. China should adhere to an "open-symbiotic" innovation model, further expand the scope of foreign-invested R&D centers (currently totaling over 2,200), deepen Belt and Road science and technology cooperation (currently covering 65 countries), while simultaneously preventing the risk of core technology leakage, and building an "open, controllable, safe, and efficient" international innovation cooperation system to occupy a proactive position in the global innovation landscape.

Conclusion

This study, by supplementing data from multiple dimensions including the macro environment, micro-entities, industry cases, and international comparisons, systematically analyzes the mechanisms and pathways for improving the effectiveness of China's open innovation ecosystem, and draws the following core conclusions:

First, the improved efficiency of China's open innovation ecosystem is due to the construction of a three-dimensional macro support system of "market-policy-infrastructure". The comprehensive industrial system, continuous growth in R&D investment and the improved digital infrastructure provide a basic guarantee for the operation of the innovation ecosystem. Its supporting role has been empirically verified by multi-dimensional data.

Second, the co-evolution mechanism of micro-entities is the core driving force for efficiency improvement. Collaborative innovation among large, medium and small enterprises, core breakthroughs of specialized and innovative enterprises, and mergers and acquisitions among enterprises have formed an innovation pattern of "resource complementarity and efficiency superposition". Data such as the 70% improvement in R&D efficiency of SMEs and R&D intensity 4.9 times higher than the average level directly confirm the effectiveness of this mechanism.

Third, advanced manufacturing services and open cooperation are key paths to improve efficiency. Typical industry data show that a complete industrial chain layout (with a matching rate of over 95%) and open international cooperation (attracting foreign investment and covering exports) can significantly improve the collaborative efficiency and global competitiveness of the innovation ecosystem, while exclusive policies will restrict the realization of ecosystem efficiency.

Fourth, China's open innovation ecosystem has formed a unique development model of "openness-symbiosis-cooperation" in practice. Compared with the exclusive ecosystem of the United States, it is more in line with the laws of global innovation resource flow. However, it still faces problems such as uneven regional resource distribution, pain points of collaboration among small and medium-sized enterprises, and shortcomings in core technologies, which need to be addressed through targeted policy optimization and mechanism improvement.

The innovation of this study lies in transforming the qualitative mechanism analysis of open innovation ecosystems into quantitative empirical research through systematic data supplementation, thus addressing the empirical shortcomings of previous studies. The research findings can provide targeted references for government departments to optimize innovation policies and for enterprises to participate in ecosystem construction. Future research can further focus on the innovation ecosystem effectiveness of specific regions and industries, combining panel data to conduct longitudinal analysis, providing more precise theoretical support and practical guidance for the continuous optimization of open innovation ecosystems.

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Research on the Application of the Neuhaus School in Modern Piano Performance and Education

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KEYWORDS

Neuhaus school;
Piano performance;
Piano teaching;
Practice;

ABSTRACT

As one of the world's most influential schools of piano playing, the Russian school, particularly the Neuhaus school, holds irreplaceable importance as its core representative. This article focuses on the practical application of the Neuhaus school in piano performance and teaching. Through literature review and interviews, the author analyzes the significant role the Neuhaus school has played in piano performance to date. Furthermore, the article analyzes existing problems in piano performance and teaching in China, concluding that teachers lack theoretical knowledge and practical experience, and performers over-interpret performances. To address these issues, the author offers feasible suggestions to promote the healthy development of piano performance and education.

INTRODUCTION

As one of the most famous and influential schools of piano in the world, the Russian piano school is characterized by its profound national cultural heritage and rigorous technical and musical style. They have gradually formed five major piano schools in terms of artistic and teaching achievements, namely the Igumnov school, the Gordon-Weiser school, the Feinberg school, the Neuhaus school and the Nikolayev school. These five schools have inherited the core spirit of the Russian piano school and established its position in world piano performance and teaching [1] . Compared with the other four major Russian piano schools, the Neuhaus school has well integrated the rigor of German and Austrian music, the expressiveness of Russian national music and the Stanislavsky dramatic performance system. Its core concept is to "make the piano sing" and to teach according to students' aptitude, cultivate students' humanistic heritage and personalized expression. Wang Jia pointed out in her research that Neuhaus's piano school thought not only plays a very important role in performance, but also plays a positive role in teaching [2] .

In conclusion, the Neuhaus school of piano music, by absorbing excellent European cultural concepts and integrating them with its own national music, has an inseparable connection with piano performance and teaching worldwide. This article focuses on discussing and offering suggestions regarding the application and analysis of the Neuhaus school's theory in modern piano performance and education, and the problems that have emerged in contemporary piano education in my country. It is hoped that readers will grasp and practically apply the theoretical knowledge of the Neuhaus school, thereby promoting the healthy development of piano art in my country.

1. A theoretical overview of Neuhaus school

The Neuhaus school, the most representative school of Russian piano music, centers on the concept of "musical wholeness and individual expression," emphasizing "sound as the carrier of emotion" and stressing the importance of listening attentively and playing with heart. World-renowned pianist Horowitz once said, "Nehaus is the soul of Russian piano; his school makes the piano 'speak, sing,' representing the pinnacle of Romanticism." To this day, the Neuhaus school's teaching model continues in the teaching of the Tchaikovsky State Conservatory and the Saint Petersburg State Conservatory. The Neuhaus school

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emphasizes the control of touch. In terms of basic finger skills, it emphasizes the weight of the fingers and even the whole arm, the speed of key press, and the sensitivity of fingertips. In terms of musical expressiveness, Neuhaus emphasizes the flexible balance between sensibility and rationality. When performing a piece, the performer should be familiar with the score and interpret it according to their own understanding. It is important to grasp the balance between technique and emotional expression. [3]

In order to enable students to have a very clear logic in playing the piano, Neuhaus would explore the control of the human physiological structure on the physical properties of the piano itself and the change of tone from the perspectives of mechanics, anatomy, psychology and other aspects. He pointed out that "what kind of movement will produce what kind of force, and what kind of force will produce what kind of tone" and that the two are mutually restrictive and developing. If there are problems such as stiff arms and insufficient finger dexterity when playing, then the sound produced by the strings will definitely be harsh and heavy; on the contrary, if you pay attention to the force, speed and touch of the fingers falling naturally on the piano, then the tone of the performance will be relaxed and controlled. [4]

In terms of psychology, Neuhaus also emphasized “natural playing” by using psychological knowledge to summarize the problems that students encounter when performing on stage, and to guide students to have a healthy and natural mindset when playing, so that the sound produced can resonate positively with the audience. [5]

2. Research Mehods

2.1. Literature Review Method

By reading excellent domestic and foreign journals and literature, I have concluded that the Neuhaus piano school not only plays a necessary role in promoting piano performance, but also provides positive guidance for students in education, thereby inspiring students to have innovative thinking and creative inspiration in performance and teaching. Yang Peilin pointed out in his research that compared with other piano schools, the Neuhaus school integrates different disciplines from different angles, transforms the musical image from abstract to concrete, and creates a variety of timbres through arm weight, key speed, and fingertip sensitivity, highlighting the singing and naturalness of the melody [6] . Liu Xinxin also pointed out in her research that Neuhaus not only explored the piano path himself, but also understood music in close connection with poetry, drama and painting art . At the same time, he also had different solutions for different students' mental states at the time in teaching [7] . Bao Huiqiao said in an interview with the famous pianist Zalar Berman that Neuhaus is the most representative of the Russian piano school. Compared with other schools, the Neuhaus school pays more attention to the beauty of the sound quality itself and the romance of the music itself. Of course, Neuhaus not only analyzed the musical phrases when reading the score, but also discovered the beauty of the essence of music from different angles, thus emphasizing a natural and personalized approach to performance. [8]

Therefore, although the students of the Neuhaus school have vastly different playing styles, they all share the common goal of playing naturally, relaxing, and enjoying the music and the stage. This approach nurtured many pianists in the 20th century, including renowned pianists such as Sviatoslav Richter, Yakov Zak, and Emil Gilels.

2.2. Interview Method

To further explore the significance of the Neuhaus school of piano playing in modern piano performance and education, the author engaged in discussions with Professor Vladimir Nikolayevich Nekhanko, a People's Honored Artist and professor at the Belarusian State Academy of Music. Detailed interview questions are available in Appendix 1. In the interview, Vladimir Nikolayevich stated: "I believe the Neuhaus school of piano playing has made a tremendous contribution to piano performance and education worldwide. Even in my current teaching, I have consistently followed the Neuhaus school's principles. Unlike the other four major piano schools, the Neuhaus school, in terms of both technical skill and musical expressiveness, is a product of the academic ideals of European music academies. Specifically, this means that the performance must strictly adhere to all the expressive markings left by the composer on the score, followed by a natural technical performance, while avoiding over-interpretation. For example, Schubert's Impromptu Op. 142 No. 3..."

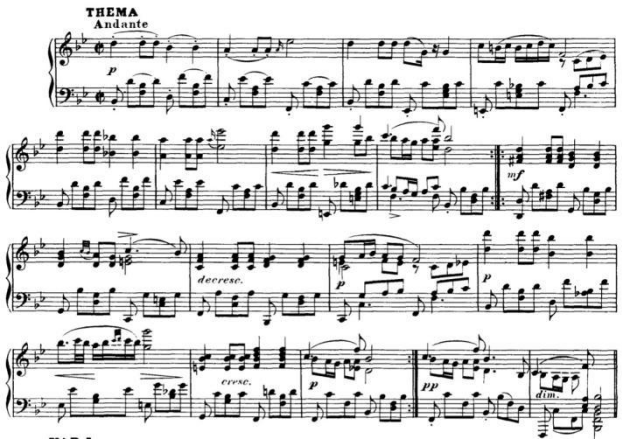

Fig.1. Schubert Impromptu op142no3 analysis legend

This section is the main body of the piece, strictly speaking in 2/2 time, and can be roughly divided into three parts. The first part is a single note in the right hand, which is also the main theme of the piece. The overall style is lyrical. The right hand can be divided into two parts: a progression on the root note and a progression on the middle note. Therefore, one needs to sing along while playing, but singing is fluid, and one must also pay attention to the emotional fluctuations of the expressive terms in each phrase. These are all necessary preparations for a good performance, not just a superficial playing. If one doesn't rationally study the work and the composer's intentions while performing, it will be difficult to play good music on stage and resonate with oneself and the audience.

"The Nikolayev school might be better suited for playing Russian folk music, as their philosophy emphasizes a strong, resonant sound from finger dexterity on the piano. However, this is only true for Russian folk music; it might not be as effective for other composers. The Gordon-Weiser school, while also emphasizing the score and phrasing, is rather thin from a sonic perspective, lacking Neuhaus's focus on timbre. Feinberg, largely a student of Gordon-Weiser, largely continued his teaching philosophy. The Igunov school excels at combining classical and romantic elements, but in my opinion, this isn't beautiful. Composers of each era have their own rigorous stylistic characteristics. As performers, we should respect these styles and allow for some personal interpretation of the score, but only within the acceptable range of the piece's style; otherwise, it will be counterproductive. "

3. Existing problems in piano performance and education

3.1.Lack of research on theoretical system

Currently, students lack theoretical knowledge and haven't explored the theoretical framework of piano schools of thought. This leads to basic problems such as wrist and arm pain, finger stiffness, and unstable rhythm during practice. Many believe playing the piano is simply about plucking the strings and producing sound, including dynamic contrasts, and this is largely attributed to the teacher's teaching methods. In China's piano education system, aside from the 11 major music conservatories, other comprehensive universities and teacher training colleges generally suffer from weak theoretical knowledge, including a lack of understanding of these specific school-based theories among most teachers.

China is the country with the greatest influence of the Russian piano school, but many college teachers still use the "high finger lifting" teaching method. This teaching method originated from Nikolayev's teaching method, which aims to enable young students to support their fingers when playing the piano and maintain the "transparency" of the tone. Without a sound education system to support it, people will think that playing the piano should always be done with the fingers lifted high, regardless of the stage. The finger lifting technique training itself is correct, but nowadays, for teachers and students, without multi-dimensional theoretical knowledge as a foundation, the music played will be lifeless, like a robot playing the piano, and it will be impossible to educate students to have the ability to innovate in music. [9]

3.2.Weak fundamentals skills

Fundamental skills are crucial for a pianist. The root cause of a weak foundation lies in the lack of a solid understanding and mindset regarding the act of playing the piano—the questions of "how to play, how well to play, and how well to play." Currently, most pianists experience nervousness and fear when performing on stage, largely because they haven't focused on relaxing their arms and rigorous sight-reading during independent practice. Especially in my country's piano education system, most students learn in groups at institutions. While institutional learning is beneficial for cultivating musical interest and cultural literacy, most teachers are not from professional institutions and lack

systematic academic training. This leads to a lack of mastery of professional vocabulary and language in their teaching, resulting in confused thinking among students and only superficial instruction that doesn't lead to significant improvement.

4. The Practical Application Value of the Neuhaus Piano School and Suggestions for Modern Piano Performance and Education

4.1.The practical application value of the Neuhaus piano school

In terms of fundamentals, the core of the Neuhaus school is to utilize the weight of the arm to effectively address stiff, mechanical playing. Regarding touch, Neuhaus believed that the entire finger should not be used mechanically at the fingertips, but rather with the three joints of the finger, and that the sound should not be overly loud at the moment of striking the key, but rather focused on the propagation of the sound. In terms of score, strict adherence to the composer's terminology is essential, using different touches to achieve different timbres in different phrases. In terms of stage practice, Neuhaus believed in participating in numerous concerts and competitions, not just for the sake of performing, but ultimately to allow performers to achieve a deeper understanding of the work and a profound appreciation of life through their performances. Furthermore, Neuhaus encouraged students to collaborate in chamber music, piano concertos, and vocal coaching, fostering intellectual exchange and collaboration to promote the healthy development of the piano as a discipline for future generations.

4.2.Suggestions for modern piano performance and education

By integrating multiple disciplines, a scientific theoretical system can be established. For piano teachers, when teaching students piano, they should not only teach professional knowledge about the piano, but also combine multiple disciplines such as physics, human biology, and psychology to gain a deeper understanding of students' logical thinking and practice in learning the piano. This can enhance their interest in learning the piano and also play a positive role in promoting the development of piano studies in my country.

For pianists, when performing, they should deeply integrate the scientific theoretical characteristics of the Neuhaus piano school to improve their cognitive literacy and ability, pay attention to the combination of rationality and sensibility, so as to achieve a higher level of understanding, and at the same time avoid problems such as excessive virtuosity and excessive lyricism in performance.

Guided by the Neuhaus piano school, the program provides a multifaceted analysis of the repertoire. For example, instruction should cover touch, dynamics, tempo, harmonic progression, harmonic characteristics, and expressive terminology when teaching each phrase. Students are encouraged to participate in concerts and competitions to understand individual stage presence and to grasp the psychological state of different students, allowing for specific problem-solving approaches. This helps students rationally understand their strengths and weaknesses, effectively promoting their piano performance development. Furthermore, the program can incorporate four-hand piano duets, double piano performances, and chamber music performances to facilitate interaction and learning between students and between students and teachers, thereby enhancing students' aesthetic appreciation and cultural literacy.

Conclusion

Neuhaus, as the most representative core school of the Russian piano school, not only greatly benefits pianists in performance but also provides theoretical support for piano teachers. Firstly, in the learning process, exploring the core theories of the Neuhaus piano school helps understand human anatomy and the principles of piano sound production. Then, individual training in fundamental skills, such as rhythm training, touch training, and arm relaxation exercises, is conducted. Secondly, in performance, emphasis should be placed on the rigor of the score. A good performance requires strict adherence to the score. While adding one's own interpretation, excessive virtuosity and lyricism should be avoided, ensuring a balance between rationality and sensibility. Similarly, in teaching, the teacher acts as a guide on the student's path. This requires the teacher to possess professional knowledge and adopt different teaching methods tailored to different students, promoting a positive future for students' piano learning,

improving their cognitive abilities and overall quality, and contributing to the healthy development of the piano as a discipline.

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The Scientific Progress of Culture Communication: Opportunities and Challenges in the Age of Artificial Intelligence

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KEYWORDS

Artificial Intelligence;
Culture Communication;
AI Interpretation;

ABSTRACT

Artificial intelligence (AI) technology is deeply reshaping how culture is communicated, creating both chances to improve efficiency and reach a global audience, but also raising concerns about the loss of authentic culture and biased algorithms. This work builds a three-part structure — technology support-culture fit-system regulation—combining Hofstede's cultural dimensions and new institutionalism to study how generative AI performs in understanding cultural symbols and in cross-cultural storytelling. An examination of how the ChatGPT model series interprets Chinese traditional symbols shows that current AI systems have limits, like oversimplifying culture (for example, linking the dragon symbol too closely with royal power) and creating logical conflicts (the differing Western and Chinese views of the phoenix). It also shows that the cultural alignment of GPT-4 in Chinese (68%) is much better than GPT-3.5 (42%). This research suggests a cultural digital governance approach: creating diverse cultural knowledge banks, creating cultural sensitivity assessment measurements, and applying graded cooperation between people and machines. This provides a source for balancing tech progress and cultural heritage.

INTRODUCTION

A 2025 UNESCO study found that 44% of cultural organizations use AI tools to create content. 67% of those surveyed believe today's systems risk cultural shallowness (UNESCO, 2025)[1]. This contradiction shows AI's split nature in cultural communication. For example, the Palace Museum's Ancient Paintings Can Talk project used AI to understand the meaning of the painting, A Thousand Miles of Rivers and Mountains. This made the overseas exhibit 300% more interactive. On the other hand, Yin & Ocon (2025) found that ChatGPT only had 59% accuracy in understanding the cultural meaning of the lotus flower, and showed serious misunderstandings of Eastern collectivist values[2].

The scientific progress of cultural communication faces three concerns: the conflict between standard technology and cultural differences, the imbalance between algorithm speed and human depth, and the competition between global spread and local identity. Traditional ideas can't explain cultural changes in the age of AI. Hofstede's cultural dimensions can measure differences, but can't capture cultural movement in a digital setting. Richness of media also has weaknesses when it comes to generative AI. This paper creates an interdisciplinary structure to study these questions: How does AI rebuild the culture communication chain of making, sharing, and using? How does AI system performance differ across different cultures? And how can we create cultural governance that include both progress and ethics?

1.Digital Expansion of Cultural Dimensions Theory

Hofstede's cultural dimensions theory offers a quantifiable basis for cultural adaptation in AI. A test developed by Masoud et al. (2025) shows that GPT-4 aligns with Chinese culture on the long-term orientation dimension by 72%. But, there's a 41% difference with Arab culture on the uncertainty avoidance dimension (Figure 1)[3]. This finding confirms

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that cultural dimensions theory is useful in the digital age. It also points to a Western-centric bias in LLMs. All tested models scored 28 points higher than the global average on the individualism dimension.

Cultural Dimensions	GPT-4 (USA)	GPT-4 (China)	Llama 2 (Arab)
Power Distance	56	78	82
Individualism/Collectivism	89	32	27
Uncertainty Avoidance	41	63	76

Fig.1. Alignment scores of major LLMs in three cultural regions (Hofstede's CAT test)

2.Cultural Governance from a New Institutionalism Viewpoint

A comparison by Cai & Yin (2025) shows the cultural roots of AI governance[2]. It points out systemic differences between China's "development first" model (based on Confucian ethics) and the EU's liberal "risk prevention" model. These differences appear in data localization and algorithm transparency rules. This clash in institutional logic causes global AI cultural items to face, on average, a regulatory discount of 23%. This means firms need to invest more so they can meet different institutional settings.

The concept of isomorphic pressures in institutional theory helps explain why AI cultural items are becoming similar. As shown by Zouhir , multinational tech firms often accept the U.S. FCC standard for their AI content review systems[4]. This leads to a high misjudgment rate (37%) for content related to the collective honor values common in Arab culture. This institutional cultural dominance puts non-Western cultures in a secondary coding problem in digital spaces.

2.1.Empirical Analysis

Research Design and Data Sources

his study takes on a mixed-methods approach and builds on the symbolic interpretation experiment made by Yin & Ocon (2025)[2]. This study includes these steps:

Text Analysis: Three models, GPT-3.5, GPT-4o, and ChatGPT o1, were selected to assess their ability to interpret twelve Chinese traditional symbols like the phoenix, dragon, and lotus. The evaluation criteria included accuracy (factual correctness), depth (layers of cultural meaning), and logical consistency (coherence of explanations).

User Experiment: One hundred and twenty university students from the United States and China were recruited to evaluate the cultural acceptability of the AI-generated content. A seven-point Likert scale was used to measure indicators such as perceived authenticity and emotional resonance.

Policy Analysis: Seventeen AI governance documents from China, the United States, and the European Union were coded to extract semantic features related to cultural clauses.

Research Findings

Variations in Cultural Interpretation Skills: GPT-4o demonstrated an accuracy rate of 89% in interpreting the dragon'龙' symbol's representation of imperial power. But only 11% of the original agricultural meaning of abundant rainwater was mentioned. All models over-associated the lotus with Buddhist symbolism (average mention rate of 92%), while neglecting its ethical metaphor of emerging from the mud unsullied in Confucianism (mention rate of 18%) '出淤泥而不染'. This tendency to simplify supports the finding of Yin & Ocon (2025) that AI systems tend to adopt explicit symbolic meanings from popular culture rather than deeper cultural encodings[5].

Cross-Cultural Acceptability Differences: American users showed significantly lower acceptance (M=4.2/7) of AI-generated interpretations of the Analects than Chinese users (M=5.8/7). An independent samples t-test showed that the difference was statistically meaningful (t=3.76, p<0.001). Semantic analysis showed that 31% of the AI's explanations of benevolence were framed by the Western notion of Christian universal love, which caused cultural cognitive conflict.

Differences in Institutional Discourse: In Chinese AI policy documents, words such as security (appearing 217 times) and development (189 times) were much more frequent than words such as rights (203 times) and risks (178 times) in EU documents. This difference in discourse directly affects the cultural orientation of AI systems. Models trained with Chinese datasets had a 29% higher accuracy rate on collectivist values than the international version.

Conclusions and implications

Conclusion

sults of tech assistance: While AI improves the production efficiency of cultural content by three to five times (for

example, reducing the design cycle of Jingdezhen ceramic patterns from two weeks to 72 hours), it also results in a flattened reading of 38% of traditional cultural symbols .

Asymmetrical Effects of Cultural Dimensions: The individualism/collectivism dimension has the biggest effect on the cultural performance of AI systems (β=0.63, p<0.001), followed by uncertainty avoidance (β=0.41, p<0.01).

Path reliance of institutional logic: The current AI governance framework has cultural embeddedness characteristics. The Confucian cultural circle is more inclined to adopt tech standards (such as the *Interim Measures for the Management of Generative AI Services* in China), while the West is more dependent on legal regulations (such as the EU AI Act).

Future Research Directions

This study has three limitations that need to be addressed in later work. First, the scope of cultural regions in our sample is limited. We focus on areas with well-developed digital technologies, such as China, the United States, and Europe. We don't look as much at areas with rich cultural diversity but less available research data, like Africa and Latin America. This could affect how well our findings apply globally. In the future, we should use a cross-continental comparative design. It is vital to pay special attention to how AI works within non-Western cultural systems, for example, the Ubuntu philosophy of sub-Saharan Africa and the collectivist values of Latin America.

Second, our current cultural alignment assessment relies mainly on text. It doesn't fully include different ways that cultural symbols are shown, such as images and audio. Nakamura's (2024) multi-modal cultural assessment approach points out that at least 40% of cultural meaning is passed on without using text. Because of this, we urgently need to create complete assessment tools that include things like visual symbol recognition (such as religious symbols) and audio sentiment analysis (such as features of ethnic music).

Third, this study is a comparative analysis across a period of time, but it doesn't track the dynamic development of cultural-AI interaction. We recommend creating a 5- to 10-year longitudinal research database. This database should record the co-evolution of AI technology development (like moving from GPT-4 to the AGI stage) and changes in cultural understanding. In particular, we need to pay attention to differences between generations. Also, cultural data ethics is a research area that urgently needs to be explored. Right now, most AI training data comes from the English-speaking world. This means that non-Western cultural understanding hasn't improved much, and indigenous knowledge systems are often gathered without permission. This likely creates a new form of digital colonialism.

Therefore, we suggest that future research focus on three areas: First, building a cultural data ethics assessment approach that includes the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP)'s principles of free, prior, and informed consent (FPIC). Second, creating culture-sensitive data management tools, like blockchain-based systems for tracking the origin of intangible cultural heritage data. Third, exploring cultural alignment techniques for languages with few resources to reduce hidden discrimination against groups that speak Swahili, Filipino, and other languages.

Practical Implications

Tech Level: Develop cultural adapter additions to achieve cultural dimension adaptation by dynamically adjusting model parameters. For example, AI’s hierarchical expressions should be improved for cultures with high power distances, and historical context association capabilities should be improved for cultures with long-term orientations. According to the China News Network (2025), the Palace Museum’s practices showed that fine-tuning with feedback from cultural experts could improve the accuracy of AI interpretations to 89%[6].

Institutional Level: Establish a cultural impact assessment system that requires AI products to pass the Hofstede cultural dimensions test before they can be launched. The Recommendation on the Ethics of AI (2021) proposed by UNESCO has been adopted by 193 countries. But its cultural sensitivity indicators need to be further refined. It is recommended to add quantitative indicators such as depth of symbolic interpretation and alignment of values[7].

Education Field: Educate cultural data scientists by including cultural anthropology content in computer science courses. The interdisciplinary program at Nanyang Technological University shows that graduates who have LLM tech and cultural studies backgrounds design AI systems with a 62% lower rate of cultural misjudgment (NTU, 2025).

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From Single to Configurable: A Multidimensional Analysis of Drivers of Green Product Purchase Intention

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KEYWORDS

Green Product Purchase Intention;

Planned Behavior Theory;

Value Belief Norm Model;

Configuration Research;

ABSTRACT

To investigate the drivers and mechanisms of consumers 'green product purchase intention, this study selects consequence awareness, environmental cognition, incentive policies, collective efficacy, and eco-centrism as independent variables. Using fuzzy set qualitative comparative analysis (fsQCA) and structural equation modeling (SEM), the theoretical model was validated. The results reveal four configurations influencing consumers' green product purchase intention: environment-cognition-driven (social responsibility-led), comprehensive-driven, eco-belief-driven (social responsibility-led), and consequence-awareness-driven collective. These configurations highlight the critical roles of different factors in promoting green product purchase intention, providing valuable insights for policy formulation and corporate marketing strategies.

INTRODUCTION

In contemporary society, environmental protection and sustainable development have become global priorities. As key participants in socio-economic activities, consumers 'willingness to purchase green products plays a vital role in promoting green consumption and the growth of eco-friendly industries. Therefore, in-depth exploration of the critical factors and their interconnections influencing customers' purchasing preferences for environmentally friendly goods holds significant value for advancing eco-conscious shopping behaviors and driving sustainable progress. This paper integrates two analytical techniques—Fuzzy Set Qualitative Comparative Analysis (fsQCA) and Structural Equation Modeling (SEM)—to comprehensively examine the primary determinants of consumers' environmental product procurement preferences. The study aims to clarify the configuration patterns, causal relationships, and path connections among these elements, providing a foundation for policy formulation and corporate promotion strategies. Building upon existing research, this paper constructs a theoretical framework incorporating factors such as consequence awareness, environmental cognition, incentive policies, collective efficacy, and ecocentrism. By applying fsQCA and SEM methodologies, the research seeks to reveal the configurational relationships, causal connections, and path dynamics among these factors.

1.Literature Review

1.1.Green products

The definition of green products encompasses multiple dimensions, including fundamental elements such as technological advancement, environmental sustainability, and economic viability[1]. The core components of green products involve minimizing ecological impact throughout the entire lifecycle — from production to consumption and disposal — while ensuring high performance and technological sophistication alongside cost-effectiveness. These characteristics are reflected in several aspects: First, new product development fully considers eco-friendly attributes and a comprehensive product lifecycle concept (spanning the entire industrial chain). Second, there is deep exploration and integration of creative values to enhance overall quality[2]. In other words, "green" should not be confined to the R&D phase but permeate all business

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activities, emphasizing sustainable development and efficient use of natural resources. Additionally, green product design prioritizes innovation by adopting new technologies and materials to improve performance and efficiency, achieving dual goals of environmental protection and economic benefits. From a market and consumer perspective, introducing green products can enhance brand image and improve consumer attitudes toward the brand[3]. This indicates that green products serve not only as a corporate strategy to address environmental challenges but also as a key tool to boost competitiveness and attract consumers. However, the lack of a universally accepted definition of green products has led to inconsistent evaluation standards in both academia and practice [4]. This situation has prompted scholars to propose more comprehensive and dynamic definitions of green products to better guide their development and assessment.

The definition of green product is not only limited to the environmental protection attribute, but also includes the advanced technology, economy and the minimization of the environmental impact in the whole life cycle. The design and development of green product is a process of considering the environmental protection, technological innovation and market demand, aiming to achieve sustainable development and competitive advantage.

1.2.Consumers' willingness to make green p urchases

The consumer green purchase intention is the intention of consumers to purchase products or services with less environmental impact[5].

The purchase behavior of Chinese consumers towards green products is influenced by the relationship between individuals and nature, the degree of collectivism, ecological emotions, and ecological knowledge [6]. This indicates that consumers 'green purchase intention is not only constrained by their attitudes and knowledge levels regarding environmental protection but is also significantly influenced by their cultural background and psychological state. Additionally, the perceived value and perceived risk of green products in consumers' minds have a significant impact on their green purchase intention[7]. When consumers perceive green products as having high value, their trust and purchase intention increase; conversely, if they perceive higher risks, these intentions may decrease. Consumer characteristics (such as external control and collectivist values) and social influencing factors (such as environmental visibility and subjective norms) also affect green purchase intention [8]. This means that consumers 'personal traits and the social environment they are in both influence their attitudes and behaviors towards green products. Government environmental policies can promote green technology development and help people form environmental awareness by improving CSR (corporate social responsibility) levels, thereby positively influencing green consumption behavior [9]. This suggests that policy incentives can, to some extent, indirectly influence consumers' green purchase intention. Ecological values and personal perception relevance are important factors affecting consumers 'green purchase intention[10.] This emphasizes the role of cultivating consumers' ecological values and enhancing their awareness of the importance of green products in promoting green purchase behavior. Environmental labels effectively enhance public willingness to purchase green products, with their functional, social, and natural attributes serving as crucial bridges[11.] This demonstrates that clearly presenting environmental data and obtaining certifications helps strengthen public trust and preference for green goods. Overall, public green shopping preferences represent a complex and multifaceted concept. This study selects five second-order factors—consequential awareness, environmental cognition, incentive policies, collective efficacy, and ecocentrism—to explore how these elements and their combinations influence the pathways of green consumption intentions.

1.3.The theory of planned behavior

The Theory of Planned Behavior posits that individual behavioral tendencies are shaped by three key elements: attitudes, subjective norms, and perceived behavioral control [12]. This framework comprises five core components[13]. Consumers 'environmental attitudes—specifically their perceptions and emotional responses toward environmental issues—significantly influence green consumption willingness. Positive environmental attitudes are typically associated with higher green consumption willingness [14]. Secondly, subjective norms, which represent societal expectations and pressures regarding individual behaviors, play a crucial role in shaping green consumption willingness. Research demonstrates that social norms positively impact

consumers' environmental purchasing intentions [15]. Additionally, individuals' confidence in their ability to perform specific behaviors serves as a critical factor influencing environmental purchasing intentions. When consumers perceive that green consumption is manageable, their willingness to engage in such behaviors tends to increase [16]. This study selects perceived behavioral control and subjective norms from the Theory of Planned Behavior as primary variables to examine their effects on green consumption willingness.

1.4.Value belief norm model theory

The Value-Belief-Norm Theory (VBN) is a theoretical framework that explains individual behavioral tendencies and decision-making processes, emphasizing the roles of values, beliefs, and norms in shaping and supporting behavioral choices [17]. This theory posits that individual behavior is influenced not only by internal values but also by beliefs about these values and societal expectations or demands regarding behavior. The core of VBN lies in the observation that individuals are more likely to adopt behaviors consistent with their values when these align with social norms. Furthermore, personal beliefs significantly impact behavioral decisions, as they determine how individuals perceive and interpret their actions and their consequences. Beliefs also influence behavioral choices by shaping how individuals understand and explain their actions and their outcomes [17]. For instance, in environmental protection movements, supporters who embrace fundamental environmental values, recognize the threat to the environment, and believe their efforts can help restore and protect it feel a sense of responsibility to take action . The application of VBN is extensive, not only explaining individual support for social movements but also studying low-carbon travel choices [18]. This study selects responsibility attribution as a primary variable, integrating Planned Behavior Theory and VBN to gain a more comprehensive understanding of the factors influencing individual behavioral choices.

2.Research Hypotheses

2.1.Level of responsibility attribution

The Value-Belief-Rule (VBN) model posits that individual actions are governed by personal values, beliefs, and rules. Within this framework, responsibility attribution stems from two key drivers: the perception of unintended consequences (result awareness) and the negative emotions arising from unfulfilled expectations[19]. This demonstrates that both consequence awareness and environmental cognition are pivotal in shaping an individual's sense of responsibility [19 20 21]. Accordingly, this study treats responsibility attribution as the primary variable, with consequence awareness and environmental cognition serving as secondary variables.

Consequence awareness refers to an individual's recognition and understanding of the potential impacts of their actions. This awareness fosters accountability, as people recognize how their behaviors may affect the environment and others. Research shows that the public's understanding of risks—particularly their consequences—can predict environmental behaviors to some extent [20].Environmental cognition refers to an individual's understanding and perception of environmental issues. A positive environmental cognition can help individuals develop a stronger sense of responsibility, as they become aware of their role and duty in environmental protection. Research shows that global values, such as altruism and ecocentrism, significantly influence personal norms, which in turn affect pro-environmental behaviors [21].

2.2.The level of subjective norms

The Theory of Planned Behavior (TPB) model is widely used in social psychology to explain how individuals shape their intentions based on their perspectives, subjective criteria, and perceived behaviors, which profoundly influence their actions [22.] Within this framework, collective efficacy is viewed as an extension of self-efficacy in group settings, closely interacting with individual efficac[y23].

As a vital management function, incentive policies are designed to effectively motivate individuals[24]. In public institutions, well-crafted incentive strategies can optimize human resource utilization by aligning organizational goals with personal objectives, thereby enhancing operational efficiency [25]. The design and implementation of such incentive mechanisms inherently involve expectations and norms governing individual or collective behaviors, which aligns with the concept of subjective norms in TPB. Therefore, this study employs subjective norms as the primary variable, with collective efficacy and incentive

policies serving as secondary variables.

2.3.The level of perceptual and behavioral control

From the perspective of Theory of Planned Behavior (TPB), perceived behavioral control refers to an individual's assessment of the capabilities required to perform a specific behavior. Ecocentrism, however, emphasizes harmonious coexistence between humans and nature, with its core values and ethical pursuits focused on promoting the well-being of the entire ecosystem rather than merely human self-interest [26]. Therefore, ecocentrism can be seen as a manifestation of perceived behavioral control within TPB, as it involves individuals' cognition and evaluation of how to balance human activities with ecological conservation.

Ecocentrism is a holistic thinking theory that emphasizes the interdependence and interaction between humans and nature, as well as life and the environment. It originated from the profound reflection on the plundering of natural resources and environmental pollution during the industrialization process, aiming to address the ecological crisis faced by humanity[27].

Empirical studies reveal that consumers' green purchasing behaviors are influenced by multiple factors. For instance, exposure to energy-saving information significantly impacts their green consumption choices [28]. Consumer innovation also plays a role in shaping green purchasing behaviors[29]. Moreover, environmental guilt is a key factor affecting green purchasing decisions[30]. However, despite many consumers embracing eco-friendly concepts, only a minority consistently buy environmentally friendly products in practice, highlighting a notable discrepancy between their beliefs and actions[31].

In conclusion, green purchasing behavior constitutes a complex decision-making process influenced by multiple factors. While theoretical research provides frameworks for understanding and explaining this behavior, empirical studies reveal the specific factors affecting consumers 'green purchasing decisions. This research project therefore focuses on green consumption intention, employing fuzzy set qualitative comparative analysis to investigate how various elements influence consumers' behavioral patterns in selecting green products and their interactions with other factors, thereby promoting more widespread green shopping practices.

Therefore, the ontology proposes the following hypothesis

H1: The impact of a single factor on green consumption intention is not significant.

H2: The combined effects of multiple factors can significantly influence green consumption willingness.

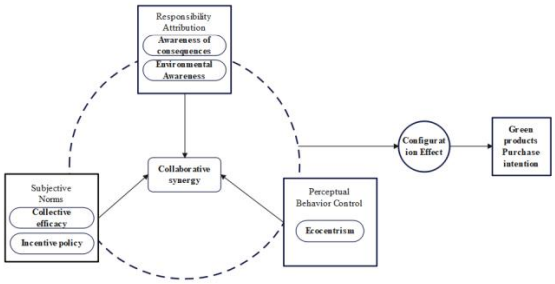

Fig.1. Conceptual model

3.Empirical analysis

The data foundation of this study comes from the 2021 China Comprehensive Social Survey, which was officially released by the China Academic Survey Database of Renmin University of China. As a comprehensive and in-depth sociological research project, the survey covers important issues across multiple fields.This study specifically focuses on one particular section—the environmental survey—aimed at gaining a deeper understanding of the public's awareness, attitudes, and behavioral patterns regarding environmental protection in China.

To ensure the breadth and representativeness of the study, we meticulously selected survey participants from 19 provincial-level administrative units across China. These units, with their diverse geographical distribution and varying levels of economic, cultural, and social development, provide a comprehensive reflectionof regional differences and commonalities in public environmental protection awareness. Specifically, the study included 347 participants from diverse social groups, encompassing different age groups, genders, occupations, and educational backgrounds. This approach enhances the generalizability and persuasiveness of the research findings.

3.1.Reliability Analysis

The reliability assessment of the questionnaire was conducted using SPSS 26.0, with results presented in Table

1. The 26-item questionnaire achieved an overall Cronbach's αcoefficient of 0.803, exceeding the 0.7 threshold, indicating strong consistency and stability in the respondent data. All factors demonstrated Cronbach's α coefficients above 0.7, confirming the high consistency reliability of the tested variables.

dimension	Clonal Alpha	number of terms
consequence consciousness	0.755	6
environmental cognition	0.716	3
incentive policy	0.773	4
collective efficacy	0.849	5
ecocentrism	0.752	5
Consumer purchase intention	0.770	3
global scale	0.803	26

Table.1. Scale reliability analysis

3.2.Validity Analysis

Table 2 presents the model fit test results, demonstrating that the CMIN/DF ratio of 2.489 falls within the optimal range of 1 to 3. The RMSEA value of 0.066 also meets the standard of being below 0.08. Furthermore, all indicators including IFI, TLI, and CFI have achieved the required standards. In conclusion, the analysis results conclusively demonstrate that the CFA model for consumer purchase intention exhibits excellent fit.

metric		measured result
CMIN/DF	1-3 is excellent, 3-5 is good	2.474
RMSEA	<0.05 is excellent, <0.08 is good	0.065
IFI	>0.9 is excellent,>0.8 is good	0.858
TLI	>0.9 is excellent,>0.8 is good	0.837
CFI	>0.9 is excellent,>0.8 is good	0.856

Table.2. Scale validity analysis

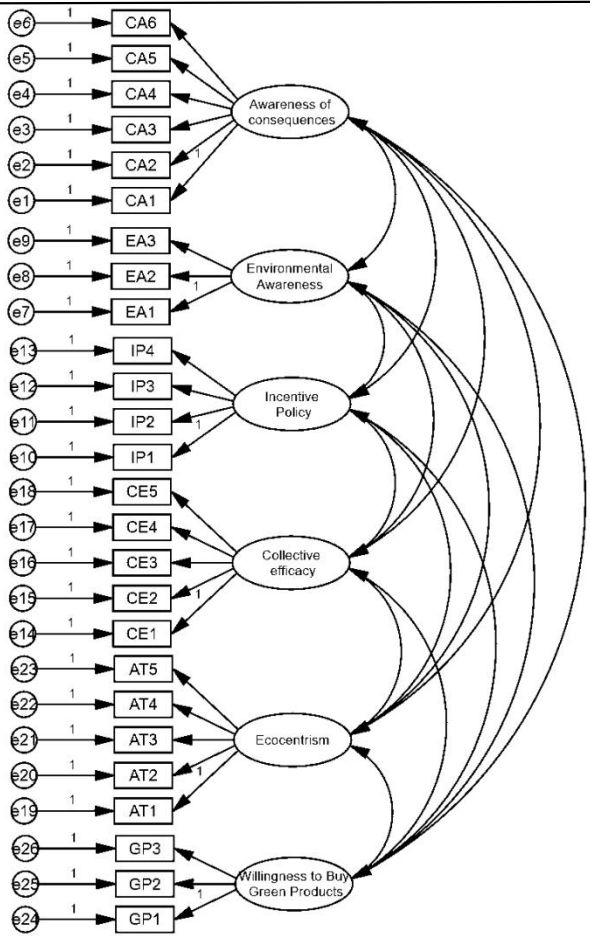

Fig.2. Confirmatory factor analysis of the green consumption willingness scale

3.3.Reliability Analysis

3.3.1.Validity Analysis

Table 2 presents thSEM is a statistical analysis tool that combines the advantages of factor analysis and path analysis, enabling the prediction of multiple correlations simultaneously.Structural equation modeling (SEM) provides a robust framework for testing complex hypotheses. In this study, we formulated a conceptual model regarding consumers' green consumption intentions and conducted an SEM analysis. The model was fitted and its goodness-of-fit was evaluated, which not only validated the hypotheses but also revealed the intricate relationships among the factors influencing green consumption intentions.

3.3.1.1. SEM model fit test of the factors influencing green consumption intention

As shown in Table 3, the model fit test results indicate that

the CMIN/DF ratio (chi-square to degrees of freedom) is 2.489, falling within the 1-3 range. The RMSEA (root mean square error) is 0.065, below the 0.08 threshold. Additionally, all indicators including IFI, TLI, and CFI meet the established criteria. In conclusion, the SEM (structural equation model) for consumer purchase intention demonstrates excellent fit.

metric		measured result
CMIN/DF	1-3 is excellent, 3-5 is good	2.489
RMSEA	<0.05 is excellent, <0.08 is good	0.066
IFI	>0.9 is excellent,>0.8 is good	0.858
TLI	>0.9 is excellent,>0.8 is good	0.837
CFI	>0.9 is excellent,>0.8 is good	0.857

Table.3. Model fit test

3.3.1.2. Results of path relationship hypothesis t est of SEM model

As shown in Table 4, the SEM path coefficients indicate that only collective efficacy significantly influences green product purchase intention, while other factors are not statistically significant. This confirms Hypothesis H1.

The aforementioned discussion highlights that consumers 'green consumption willingness constitutes a multifaceted phenomenon influenced by multiple factors. For instance, research demonstrates that eco-labels positively influence purchasing decisions by conveying functional, social, and environmental values, thereby enhancing consumers' willingness to purchase green products. This indicates that when evaluating green products, consumers consider various factors rather than relying solely on a single eco-label. Studies also reveal a gap between consumers 'green purchasing behavior and their actual green consumption willingness [33]. This discrepancy further demonstrates that no single factor can fully explain consumers' green consumption intentions. In actual purchasing decisions, consumers may be influenced by other unconsidered factors such as situational factors and habitual tendencies. Consequently, no single factor can adequately explain or predict consumers' green consumption willingness[32 33].

path relationship			Estimate	S.E.	C.R.	P
incentive policy	<---	consequence consciousness	0.74	0.193	7.366	***
collective efficacy	<---	consequence consciousness	0.298	0.122	3.719	***
ecocentrism	<---	consequence consciousness	0.089	0.695	0.183	0.855
ecocentrism	<---	environmental cognition	0.263	0.123	2.926	0.003
Intention to purchase green products	<---	ecocentrism	0.047	0.06	0.709	0.478
Intention to purchase green products	<---	incentive policy	0.192	0.083	1.517	0.129
Intention to purchase green products	<---	collective efficacy	0.425	0.065	5.473	***
Intention to purchase green products	<---	consequence consciousness	-0.101	0.155	-0.829	0.407
Intention to purchase green products	<---	environmental cognition	-0.075	0.08	-1.134	0.257
incentive policy	<---	ecocentrism	0.175	0.279	0.846	0.398
incentive policy	<---	collective efficacy	0.101	0.128	0.993	0.321
ecocentrism	<---	incentive policy	-0.176	0.475	-0.274	0.784

Table.4. Results of Path Coefficient Analysis for the SEM Model

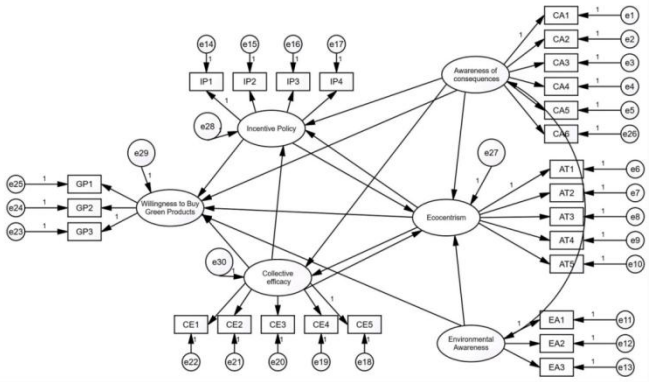

Fig.3. Structure equation fitting

3.3.2. Multivariate Analysis of Configuration

As previously noted, consumers 'purchase intention for green products constitutes a complex decision-making process involving multiple interacting factors, where no single element can independently determine this intention. To address this, our study employs the advanced fuzzy set qualitative comparative analysis (fsQCA) method. This approach aims to systematically examine how various factors interact in combination to influence consumers' green product purchase decisions, while revealing the underlying pathways and conditional combinations of their impact. Through this research methodology, we seek to gain a more comprehensive understanding of the intricate psychological and behavioral mechanisms driving consumers' choices

when selecting green products.

fsQCA is a non-parametric statistical method designed for analyzing complex causal relationships, particularly when traditional SEM approaches are impractical due to limited sample sizes or model complexity [34]. This method effectively reveals how different factor combinations influence outcomes, even when individual factors may not show significant effects [35].

3.3.2.1. Data calibration

When applying the Fuzzy Set Qualitative Comparative Analysis (fsQCA), converting data from conditional factors and outcome indicators into 0-1 range fuzzy values constitutes a critical step known as "variable calibration". This phase involves transforming variables into set representations, a process requiring both theoretical understanding and practical experience. The study adopted the three calibration benchmarks (95%,50%, and 5%) proposed by Larkin (2008) to ensure all calibrated sets fall within the 0-1 interval[36]. Typically, data calibration can be implemented through intuitive methods or indirect approaches. While intuitive methods are simpler, indirect methods require specialists to establish appropriate fuzzy value distribution rules based on relevant principles. The indirect method demands explicit specification of set membership allocation, which proves highly complex. Therefore, we utilized the software's built-in calibration function to convert pre-existing factor and outcome scores into fuzzy ratings [37].

Based on the calibration values calculated by SPSS, Table 5 presents the numerical values of all variables. These values are processed in the fsQCA software, where they are uniformly converted into 0-1 fuzzy values through function processing. The software is then standardized according to the principles of qualitative comparative analysis, ultimately generating a truth table.

variable	complete membership value	Intersection point	completely non-membership value
CA	4.33	3.67	2.67
EA	3.33	2.67	1.33
IP	4.75	3.50	2.50
CE	5.00	4.00	2.60
AT	4.00	2.80	1.60
GP	4.00	3.00	2.00

Table.5. Data Calibration Anchor

3.3.2.2. Single factor necessary condition analysis

Based on existing FSQCA research findings, we conducted necessary tests to verify the rationality of the conditions. As shown in Table 6, all consistency correlations are below 0.9, indicating that the associations between these conditions and the target are not sufficiently strong to justify their existence—individual influencing factors cannot effectively impact the final outcome. Therefore, we conclude that the key drivers of customers' choice of eco-friendly products are not determined by one or a few factors alone, thus confirming Hypothesis 2 (H2).

	GP		~GP	
condition variable	Consistency	Coverage	Consistency	Coverage
CA	0.676741	0.659079	0.646508	0.557967
~CA	0.546122	0.635485	0.604981	0.623846
EA	0.571615	0.631591	0.633872	0.620660
~EA	0.656683	0.669309	0.623751	0.563380
IP	0.647063	0.685597	0.570877	0.536025
~IP	0.562103	0.596471	0.665154	0.625483
CE	0.661304	0.755419	0.524874	0.531326
~CE	0.589716	0.583437	0.758388	0.664909
AT	0.611132	0.671907	0.592407	0.577183
~AT	0.615427	0.630156	0.663253	0.601825

Table.6. Necessity analysis of purchase intention for green products

3.3.2.3. Configuration analysis

Through qualitative comparative analysis using fuzzy set theory (fsQCA), we identified three solution types: simplified, transitional, and complex. A condition is deemed a key factor when it appears in both simplified and transitional solutions, while a boundary factor[38] exists exclusively in transitional solutions. Following Lakin's (2008) research, we set the initial consistency threshold at 0.8 [36]. As shown in Table 8, the QCA analysis revealed five configurations (M1, M2, M3a, M3b, M4) influencing consumers' green product purchase intention, with consistency values of 0.84,0.84,0.84,0.86, and 0.82 respectively. The overall consistency of 0.81 exceeds the 0.80 threshold, confirming these configurations as sufficient determinants. Notably, M3a and M3b form equivalent configurations with identical core conditions [39]. The following sections will examine each configuration's specific impacts on consumers' green product purchase intention.

The social responsibility is the driving force of

environmental cognition.

The M1 model demonstrates that high incentive policies, strong collective efficacy, and elevated environmental awareness serve as core conditions, while high consequence awareness acts as a moderating factor in enhancing consumers 'willingness to purchase green products. In the planned behavior theory framework, subjective norms (as primary variables) are influenced by incentive policies and collective efficacy (as secondary variables). Subjective norm strength refers to an individual's perception of others 'attitudes toward their behavior and the importance they attribute to these attitudes. Consequently, individuals with high subjective norm strength are more susceptible to social expectations and norms, often aligning their actions with societal expectations. This implies that in contexts with strong social responsibility, consumers are more likely to adopt socially expected behaviors, such as purchasing green products. Similarly, environmental awareness and understanding are recognized as critical determinants of green product purchase intention. Therefore, when social responsibility, incentive policies, collective efficacy, and environmental awareness are all elevated, consumers' willingness to purchase green products shows significant improvement.

Integrated drive mode.

M2 indicates that consequence awareness, environmental cognition, collective efficacy, and ecocentrism serve as moderating factors that enhance consumers' willingness to purchase green products. The preceding analysis employs responsibility attribution as the primary variable, with environmental cognition and collective efficacy as secondary variables. Subjective norms are treated as the primary variable, with collective efficacy as its secondary variable. Perceived behavioral control is used as the primary variable, with ecocentrism as its secondary variable.

Consequence awareness reflects consumers 'recognition of environmental issues' severity, which motivates their willingness to adopt eco-friendly behaviors. Environmental cognition refers to individuals' understanding and perception of environmental challenges, influencing their acceptance and purchase intention for green products. Collective efficacy denotes the belief that collective action can yield positive outcomes; when consumers perceive such actions as capable of environmental improvement, they are more likely to purchase green products. Ecocentrism, a value system emphasizing harmonious coexistence between humans and nature, leads consumers who embrace this philosophy to pay greater attention to environmental issues and engage in eco-conscious behaviors.

Social responsibility leads to the driving force of ecological belief.

M3a and M3b constitute an equivalent configuration, indicating that high incentive policy, high collective efficacy, high eco-centrism as core conditions and consequence awareness or environmental cognition as marginal conditions can promote consumers' purchase intention of green products.

This demonstrates that when consumers hold strong eco-centric beliefs and are influenced by high incentive policies and collective efficacy, their willingness to purchase green products significantly increases under the impetus of social responsibility. Moreover, environmental awareness or consequence consciousness, as a marginal condition, further amplifies this willingness. This highlights the crucial role of social responsibility and eco-centrism in promoting environmentally conscious consumer behavior, while high incentive policies and collective efficacy provide the necessary motivation and support for action.

Consequence awareness reflects consumers 'recognition of environmental issues' severity, which can motivate their willingness to adopt eco-friendly behaviors. Environmental cognition, representing individuals' understanding and perception of environmental challenges, influences their acceptance and purchase intention for green products. When consumers recognize the severity of environmental issues and comprehend the positive impact of green products on the environment, they are more likely to purchase such products.

Ecocentrism is a more profound environmental value that emphasizes the harmonious coexistence between humans and nature. When consumers embrace this value, they are more likely to genuinely care about environmental issues and take proactive eco-friendly actions, such as purchasing green products.

Consequence awareness drives collective type.

M4 indicates that high consequence awareness, high collective efficacy and non-high incentive policy are the core conditions, while non-high environmental cognition and non-high eco-centrism are the marginal conditions that can promote consumers' purchase intention of green products.

The findings demonstrate that consumers with strong

environmental awareness and a sense of collective action can still develop willingness to purchase green products, even without aggressive incentive policies. Meanwhile, the presence of low environmental consciousness and ecocentrism as marginal factors suggests that in this context, consumers' green product purchase decisions may not be solely driven by deep environmental understanding or ecological values, but rather more influenced by consequence awareness and collective efficacy.

Notably, the M4 model does not emphasize the importance of environmental awareness or eco-centrism. This may be because, under this framework, consumers 'willingness to purchase green products is more influenced by consequence awareness and collective efficacy than by a deep understanding of environmental issues or ecological values. This also reflects how different driving models may lead to varying factors affecting consumers' green product purchase intentions.

condition variable	M1	M2	M3a	M3b	M4
consequence awareness	●	●	●		●
environmental awareness	●	●		●	⊗
incentive policy （IP）	●		●	●	⊗
collective efficacy	●	●	●	●	●
ecocentrism		●	●	●	⊗
Raw consistency	0.324509	0.300211	0.353481	0.302603	0.244333
Unique coverage	0.033048	0.014730	0.063162	0.029352	0.046366
consistency	0.836837	0.841407	0.840506	0.856461	0.821454
Solution coverage			0.50742		
Solution consistency:			0.80655		

Table.7. Consumer's purchase intention for green products

Note that if the core condition exists, the edge condition exists in it; if the core condition is missing, the edge condition is missing in it.

In China's eastern coastal regions, the social responsibility-driven environmental awareness model proves particularly effective in shaping consumers' green product purchasing behavior. These economically developed areas boast strong consumer purchasing power and robust demand for eco-friendly products. With ample government funding, authorities actively promote environmental awareness campaigns and green product initiatives. Consumers demonstrate heightened environmental consciousness, readily recognize the value of sustainable products, and exhibit strong purchasing intent. Collective efficacy also plays a crucial role, as people firmly believe that collaborative efforts can effectively improve environmental conditions.

The integrated driving model is well-suited for China's northeastern region, where consumers' willingness to purchase green products is shaped by multiple factors. As a key industrial base, the region has seen growing consumer interest in eco-friendly products in recent years as it seeks to balance economic development with environmental protection. Factors such as environmental awareness, ecological consciousness, collective efficacy, and eco-centrism collectively drive this trend. Consumers not only recognize the severity of environmental issues but also develop a deeper understanding and sensitivity to them. Moreover, their belief in the power of collective action to bring about positive environmental change motivates them to actively participate in conservation efforts.

In central China, the pattern where social responsibility drives ecological beliefs shapes consumers' green product purchase intentions is particularly pronounced. With stable economic development, consumers in this region have grown increasingly environmentally conscious and demonstrate strong commitment to social responsibility. Under this framework, their green product purchasing decisions are primarily influenced by eco-centric beliefs. They firmly believe in the harmonious coexistence of humanity and nature, viewing environmental protection as both a duty and obligation. Meanwhile, high-incentive policies and collective efficacy have played a positive role in promoting green consumption. Government agencies have implemented incentive measures to encourage eco-friendly product purchases. Additionally, consumers are convinced that collective action can improve the environment, which motivates them to actively participate in green consumption practices.

The consequence-driven collective model demonstrates remarkable applicability in China's western regions. Given the vast territory and diverse natural environments, consumers in these areas develop direct awareness of environmental issues. When consumers fully recognize the severity of environmental problems and feel the power of collective action, their willingness to purchase green products significantly increases. High consequence awareness and strong collective efficacy, as core conditions, effectively motivate consumers' environmental behavior and drive them to take concrete actions for environmental

protection.

Conclusion

In summary, consumers' willingness to purchase green products is influenced by multiple factors across different regions, resulting in diverse driving patterns. In the eastern coastal areas, consumers with strong purchasing power and high environmental awareness exhibit an environmental cognition-driven pattern. In the northeastern regions, consumers are influenced by a combination of consequence awareness and environmental cognition, forming a comprehensive driving pattern. In the central regions, consumers place greater emphasis on ecological centrism beliefs, with social responsibility-driven ecological belief patterns being prominent. In the western regions, consumers are influenced by consequence awareness and collective efficacy, leading to a consequence awareness-driven collective pattern. These regional differences suggest that promoting green consumption requires considering geographical, cultural, and consumer-specific characteristics to adopt targeted strategies.

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Innovation of Sustainable Management Models Oriented towards Circular Economy in Manufacturing Enterprises: Micro Practices Based on Industrial Chain Collaboration

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KEYWORDS

Manufacturing enterprises;

Sustainable management;

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Industrial chain synergy;

Digital management and control;

ABSTRACT

Gainst the backdrop of dual carbon goals and stricter global green trade rules, manufacturing enterprises face micro-challenges like insufficient industrial chain synergy and cost-benefit imbalance in sustainable management transformation. Focusing on their circular economy pain points, this paper explores three innovative paths: circular production system, digital control platform, and stakeholder co-governance, verified by three typical enterprise cases and visual data. The study shows that connecting industrial chain synergy links enables enterprises to balance economic and environmental benefits. It provides implementable guidance for similar enterprises and micro-perspective reference for sub-sector research, with future extension to electronic and chemical manufacturing.

INTRODUCTION

Global climate change and green trade barriers are profoundly reshaping the development logic of manufacturing enterprises. The United Nations 2030 Agenda for Sustainable Development explicitly sets the goal of doubling global resource efficiency by 2030. The European Union's Carbon Border Adjustment Mechanism (CBAM) and new battery regulation Domestic policy documents such as the dual carbon goals and the implementation plan for carbon peaking in the industrial sector impose strict requirements on the resource utilization efficiency and carbon emission levels of manufacturing enterprises. Compared with the macro perspective of pan-industry and pan-subject in traditional enterprise management research, this paper strictly locks the research scope to the manufacturing enterprise as a sub-subject, and focuses on the specific problem of industrial chain synergy dilemma in its circular economy transformation, starting from micro practical scenarios to provide theoretical and practical references for enterprises to break through transformation bottlenecks.

At present, the traditional management model of manufacturing enterprises, which is centered on profit maximization, is difficult to adapt to the demands of green transformation: On the one hand, the EU's carbon border adjustment mechanism requires the full life cycle carbon footprint of manufactured goods such as steel, machinery, and aluminium products to be accounted for. Data from 2023 shows that about 37% of China's mechanical products exported to the EU have increased compliance costs by an average of 12% due to non-compliance with carbon accounting standards; On the other hand, the circular transformation of manufacturing enterprises requires the linkage of upstream raw material suppliers and downstream recycling enterprises, and the uneven environmental protection levels at each link of the industrial chain have led to only 21% of manufacturing enterprises being able to achieve sustainable management throughout the entire process.

In practice, manufacturing enterprises generally face micro problems such as scattered upstream scrap metal recycling

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channels and long payback periods for initial investment in circular transformation, rather than industry-wide predicaments at the macro level. Based on this, this paper systematically explains the innovative path of circular economy-oriented sustainable management through embedded data comparison tables, mechanism logic diagrams, in-depth analysis of typical cases, etc., and provides practical operational solutions for the transformation of manufacturing enterprises.

1.Specific challenges of manufacturing enterprises' circular economy transformation

The challenges of manufacturing enterprises' circular economy transformation are concentrated in three dimensions: cost-benefit imbalance, disconnection of cross-border standards, and disruption of industrial chain synergy. The specific manifestations and core impact data of each challenge are quantified through the following three-line table.

1.1.Short-term cost-benefit imbalance in circular transformation

Manufacturing enterprises need to invest special funds in upgrading specialized equipment and building recycling systems to advance the circular economy transformation, and the returns from such investments are significantly lagging. The 2023 special research data of the domestic machinery industry association is presented in Table 1, which intuitively reflects the transformation pressure of enterprises of different scales.

Enterprise size (Annual output value)	Average investment per set of recycling/smelting equipment (ten thousand yuan)	The proportion of enterprises under cash flow pressure
< 50 million yuan	80-150	0.89
50 million - 200 million yuan	150-300	0.76
200 million - 500 million yuan	300-500	0.61
More than 500 million yuan	500-800	0.43
Industry average	268	0.72
Enterprise size (Annual output value)	Payback period (years)	Proportion of green outcome enterprises without premium
< 50 million yuan	45752	0.92
50 million - 200 million yuan	45720	0.85
200 million - 500 million yuan	45691	0.71
More than 500 million yuan	45659	0.53
Industry average	3.2	0.81
Enterprise size (Annual output value)	Proportion of companies with low willingness to transform	
< 50 million yuan	0.78	
50 million - 200 million yuan	0.62	
200 million - 500 million yuan	0.45	
More than 500 million yuan	0.22	
Industry average	0.57	

Table.1. Survey of Investment and Payback Period for Circular Transformation of Small and Medium-sized Manufacturing Enterprises

Take a small mechanical processing enterprise with an annual output value of 30 million yuan as an example. To build a closed-loop recycling system for metal waste, it purchased a set of intelligent sorting equipment worth 1.2 million yuan and a set of medium-frequency melting furnaces worth 1 million yuan, with a total investment of 2.2 million yuan, accounting for 35% of the enterprise's annual working capital. After the transformation was completed, the enterprise could recycle about 5 tons of scrap metal per month, saving only 12,000 yuan in raw material

procurement costs. Based on this calculation, it would take at least 4.6 years to recoup the investment. At the same time, the company's recycled metal parts, lacking a unified green certification in the industry, cannot apply for product premium from downstream customers. In 2023, the sales price of its green products was on par with that of traditional products, significantly weakening the company's initiative to transform.

In addition, it is difficult to quickly translate the environmental benefits of the circular transformation into market revenue. According to research, 81% of manufacturing enterprises said their green production achievements could not be used as a basis for product premium due to the lack of authoritative certification, and some enterprises even experienced short-term capacity reduction due to transformation, resulting in an awkward situation of increased environmental costs and reduced profits.

1.2.The cross-border carbon accounting standards are disconnected from the actual operations of enterprises

Export-oriented manufacturing enterprises need to adapt to both domestic and overseas carbon accounting rules. The differences in accounting scopes of different standards pose significant compliance challenges for enterprises, as shown in Table 2.

Accounting dimensions	Domestic carbon accounting standards for mechanical manufacturing	Eu CBAM carbon accounting standards
Accounting scope	Production end	Full life cycle
Accounting indicators	Only direct carbon emissions are counted	Direct, indirect carbon emissions
Data traceability requirements	The enterprise records independently and reports annually	Full chain data is traceable and uploaded in real time to the EU system
Accounting dimensions	Additional costs for businesses due to differences in diameters	Additional costs for businesses due to differences in diameters
Accounting scope	Additional raw materials, link data collection teams are required, and labor costs increase by 20% to 30%	Additional raw materials, link data collection teams are required, and labor costs increase by 20% to 30%
Accounting indicators	To access carbon emissions data from power suppliers, the cost of data connection increases by 15%	To access carbon emissions data from power suppliers, the cost of data connection increases by 15%
Data traceability requirements	A data traceability platform needs to be built, and the technical investment will increase by 500,000 to 1,000,000 yuan	A data traceability platform needs to be built, and the technical investment will increase by 500,000 to 1,000,000 yuan
Accounting dimensions	Cross-border certification fees increase by 80,000 to 150,000 yuan per year	Cross-border certification fees increase by 80,000 to 150,000 yuan per year

Table.2. Comparison of Differences in Carbon Accounting Standards for Manufacturing Enterprises at Home and Abroad

Take a company mainly engaged in the export of construction machinery as an example. Its carbon footprint per excavator in 2023, calculated based on domestic standards, was 82 tons of CO_2 . However, when calculated based on the EU CBAM standards, it needs to take into account upstream iron ore mining, inter-provincial transportation of raw materials, and indirect emissions from purchased electricity. The carbon footprint per excavator rose to 117 tons of CO_2 , exceeding the EU carbon tariff exemption threshold. To meet compliance requirements, the company hired an additional six carbon accounting specialists and established a dual-track accounting system. In 2023, related management costs increased by 1.2 million yuan, and due to inconsistent certification standards, its scrap metal recycling results could not be recognized in cross-border trade. In 2023, orders for green products in the EU market decreased by 18% compared with the previous year.

1.3.Disruption of the chain of upstream and downstream circulation and coordination

The circular economy transformation of manufacturing enterprises is highly dependent on industrial chain synergy, but the current shortcomings in the capabilities of upstream and downstream entities make it difficult to break through the resource closed-loop chain. The specific case data of a certain auto parts enterprise is presented in Table 3.

Types of recycled materials	Planned usage ratio	Actual usage proportion
Recycled aluminium	0.35	0.06
Recycled plastic	0.2	0.12
Recycled steel	0.4	0.28
Overall	0.32	0.15
Types of recycled materials	Core blockage reasons	The impact on cycle modification
Recycled aluminium	The purity of raw materials from upstream suppliers is only 95%	Only 17% of the recycling target has been achieved
Recycled plastic	The recycling channels are scattered and the supply stability is insufficient	Production requires additional reserves of traditional raw materials, increasing costs by 5%
Recycled steel	The carbon footprint in the smelting process exceeds the standard	The carbon footprint of the product does not meet the requirements of downstream automakers
Overall	There is a mismatch in environmental protection capabilities between upstream and downstream	The idea of a closed loop of resources across the entire industrial chain has not been implemented

Table.3. Statistics on the reasons and impacts of the obstruction in the use of recycled materials in a certain auto parts manufacturing enterprise

The company launched a circular transformation in 2022, planning to increase the overall use of recycled materials to 32%, but upstream recycled aluminum suppliers, lacking high-precision purification technology, provided raw materials with excessive impurity content that could not meet the mechanical performance requirements of automotive parts, forcing the company to abandon its 70% recycled aluminum procurement plan. Downstream recycling enterprises, due to their outdated sorting technology, were unable to distinguish different grades of waste plastics, resulting in intermittent supply of recycled plastics. The enterprises had to stockpile additional traditional plastic raw materials, and the related storage costs increased by 230,000 yuan in 2023. Ultimately, the company's actual use of recycled materials in 2023 was only 15%, the completion rate of the recycling transformation target was less than 50%, and the idea of a closed-loop of resources throughout the entire industrial chain was completely dashed.

2.Sustainable management innovation path oriented towards circular economy for manufacturing enterprises

In response to the three major challenges mentioned above, this paper proposes a three-dimensional innovation path of

resource closed-loop production system, customized digital control platform, and stakeholder precision co-governance mechanism. The effectiveness of each path is verified in combination with in-depth cases and three-line data comparison tables.

2.1.Build a resource closed-loop production system in the manufacturing process

Based on the production characteristics of manufacturing enterprises, build a circular economy management system from the three core links of raw material procurement, production processing, and waste recycling. In the procurement of raw materials, establish a priority procurement mechanism for recycled raw materials, sign long-term cooperation agreements with compliant recycling enterprises, and specify purity and carbon footprint standards for recycled metals and plastics; In production and processing, clean production technologies are promoted, such as the introduction of dry cutting in mechanical processing enterprises to reduce cutting fluid consumption and the use of medium-frequency furnace smelting technology in foundry enterprises to reduce coal consumption; In the waste recycling process, build an in-plant classification recycling network for specialized treatment of waste metals, waste cutting fluids, etc., and link up with downstream professional recycling institutions to achieve resource regeneration of production waste.

The metal waste closed-loop system of the Heavy machinery manufacturing group in Minsk, Belarus, is a typical case, and its specific implementation steps and achievements are presented in Table 4

Core indicators	2020 (Before implementation	2023 (post-implementation)
Metal scrap recovery rate	0.22	1
Raw material procurement costs	$120 million per year	$92 million per year
Carbon emissions from the production process	182,000 tons of CO_2 per year	121,000 tons of CO_2 per year
Recycled billet usage share	0	0.42
Orders in the EU market	12,000 sets per year	18,000 sets per year
Core indicators	Extent of change	
Metal scrap recovery rate	Increase by 78 percentage points	
Raw material procurement costs	Down 23.3%	
Carbon emissions from the production process	Down 33.5%	
Recycled billet usage share	Increase by 42 percentage points	
Orders in the EU market	A 50% increase	

Table.4. Comparison of Core Indicators Before and After the Implementation of the MTZ closed-loop system in Belarus

In 2020, MTZ metalworking waste reached 18%, raw material procurement costs accounted for 62% of production costs, and carbon emissions at the production end exceeded EU export standards. In 2021, the company invested $4.2 million to purchase three German-made SORT-3000 intelligent spectral sorting equipment and two ZP-10 10-ton medium-frequency induction melting furnaces. Among them, the intelligent sorting equipment can precisely classify scrap steel, scrap iron and scrap copper within 3 seconds through spectral analysis, with a sorting accuracy of 99.8%. Far more than 75% of traditional manual sorting; The

medium-frequency melting furnace, which uses electromagnetic induction heating technology, is 35% more energy-efficient than traditional coal-fired furnaces and emits no sulfur dioxide.

In terms of process construction, MTZ first sets up classified waste bins in each production workshop, and AGV robots transport the waste to the sorting workshop for secondary sorting; The sorted scrap metal is then sent into the medium-frequency melting furnace, where alloying elements are proportioned according to product requirements to melt into qualified billets, and the remelting recovery rate of scrap steel reaches 98.5%. Finally, the recycled billets are fed into the original production line and processed into core components for loaders and excavators. At the same time, the company established a mechanical property testing system for recycled billets. From 2021 to 2023, the quality inspection pass rate of recycled billets reached 99.9%, on par with that of primary billets. The environmental benefits of the system also received the EU green certification, and its recycled metal parts could enjoy a 5% product premium in the EU market in 2023.

A domestic mechanical processing company also introduced dry cutting instead of traditional wet cutting. In 2023, the company's purchase cost of cutting fluid decreased by 80%, the cost of hazardous waste treatment of waste cutting fluid was reduced by 95%, the tool life was doubled, and production efficiency was increased by 18%.

2.2.Implement a digital control platform exclusive to manufacturing enterprises

Build customized digital sustainable management platforms tailored to the characteristics of manufacturing enterprises' production processes to address data discontinuity in the transition to a circular economy. The platform integrates three core modules: the first is the carbon emissions accounting module, which connects to production equipment sensors to collect energy consumption data in real time and automatically convert it into carbon emissions data, and is compatible with domestic and EU accounting standards; The second is the supplier management module, which inputs data such as the proportion of recycled raw materials and carbon emission levels of upstream suppliers, establishes A dynamic rating system, and prioritizes cooperation with A-level suppliers; Third, the resource closed-loop traceability module records data such as scrap metal recycling volume and recycling rate to ensure closed-loop traceability of resources.

The achievements of the platform construction cases of domestic Zhejiang HZ-WH automotive wheel hub manufacturing enterprises are presented in Table 5.

Core indicators	2022 (before implementation)	2023 (after implementation
Share of recycled raw materials in the supply chain	0.15	0.38
Carbon account for labor costs	450,000 yuan per year	120,000 yuan per year
Product carbon footprint	12.5kgCO_2 per piece	9.8kgCO_2 per
Share of A-class supplier partnerships	0.22	0.68
Green orders for automakers	800,000 per year	1.25 million per year
Core indicators	Extent of change	Extent of change
Share of recycled raw materials in the supply chain	Up 23 percentage points	Up 23 percentage points
Carbon account for labor costs	Down 73.3%	Down 73.3%
Product carbon footprint	Down 21.6%	Down 21.6%
Share of A-class supplier partnerships	Increase by 46 percentage points	Increase by 46 percentage points
Green orders for automakers	Up 56.25 percent	Up 56.25 percent

Table.5. Comparison of Indicators Before and after the implementation of the Digital Control Platform for Zhejiang HZ-WH Enterprises

Hz-wh started building a digital control platform in October 2022, with a total investment of 3.8 million yuan, due to the inability to accurately calculate the carbon footprint of its products and the lack of transparency in environmental data of its suppliers, which led to supply disruption to automakers such as Tesla and BYD. The platform is connected to the energy consumption sensors of 120 production equipment in

the workshop, with a carbon accounting data error rate of less than 3%, and can generate a dual-standard carbon footprint report with one click; Its supplier management module enters data from 86 upstream suppliers and automatically prioritizes A-level suppliers; The resource closed-loop traceability module generates full-chain traceability codes for scrap aluminum, recycled aluminum ingots and wheel hubs, and customers can scan the codes to query the relevant data. In 2023, the company successfully passed Tesla's green supply chain audit through the platform and became its core hub supplier, increasing annual orders by 300,000 and generating additional revenue by 120 million yuan.

2.3.Build a precise stakeholder co-governance mechanism for manufacturing enterprises

The sustainable management of manufacturing enterprises requires the collaboration of targeted stakeholders, which can be specifically divided into three types of collaborative objects: First, connect with local industrial and information technology departments, apply for special funds for circular transformation, and participate in the formulation of industry green standards; 2 Provide product carbon footprint reports to downstream customers and customize low-carbon components to achieve product premium; Third, build waste recycling sites with recycling enterprises, clarify recycling prices and raw material purity standards, and ensure a stable supply of recycled raw materials.

The results of the co-governance practices and the return on investment of domestic Luoyang LY-BC bearing manufacturing enterprises are presented in Table 6.

Project Categories	Specific amount/data	Earnings/recoveries
Total investment in circular transformation	4.2 million yuan	-
Government special subsidies	2.6 million yuan	Covering 61.9% of the initial investment
Premium for recycled steel bearing products	8% per set	520,000 units sold from June to December 2023, with a premium revenue of 6.24 million yuan
Procurement costs of recycled raw materials	12% lower per ton than primary steel	In 2023, 850,000 yuan was saved in procurement costs
Input payback period	-	6 months, net income 3.49 million yuan

Table.6. Comparison of Investment and Revenue Recovery in Circular Transformation of Luoyang LY-BC Enterprises

When LY- BClaunched its circular transformation in 2022, it faced three major problems: insufficient funds, unstable supply of recycled raw materials, and no premium for green products. By connecting with the Industry and information Technology Bureau of Luoyang City, it received a special subsidy of 2.6 million yuan for green factories and participated in the formulation of the "Certification Standard for Recycled Steel Components in the Machinery Industry of Henan Province". In 2023, its recycled steel bearings received the first batch of green certifications in Henan Province; Provide full life cycle carbon footprint reports to automakers such as FAW and SAIC, customize products with 45% recycled steel and 28% lower carbon footprint than traditional bearings, sign green purchase agreements with an 8% product premium and annual purchase volume of no less than 500,000 sets; In collaboration with three specialized recycling enterprises in Luoyang, a scrap steel recycling site was established, with an agreement that the recycling price would be 5% higher than the market price and the raw material purity would be ≥99.7%. The recycling enterprises invested 800,000 yuan to purchase purification equipment for this, and LY-BC promised an annual scrap steel purchase volume of no less than 2,000 tons. In 2023, the company's market share of recycled steel bearings in the domestic market rose to 18%, and it entered the European market, increasing its annual export volume by 8 million yuan.

3.Implementation paths for sustainable management and industrial chain synergy in manufacturing enterprises

To facilitate the large-scale implementation of the three-dimensional innovation path, a guarantee system needs to be constructed at three levels: standard alignment, technological breakthroughs, and talent cultivation. The relevant core contents are presented in the three-line table.

3.1. Promote the alignment of carbon accounting standards in the manufacturing industry

In response to the pain points of cross-border compliance for manufacturing enterprises, industry associations will take the lead in promoting the alignment of domestic standards with the EU CBAM rules, and the core alignment dimensions are presented in Table 7.

Alignment dimensions	Domestic standard optimization direction	Key points of alignment with the EU CBAM
Scope of accounting	Extend to the supply chain end	Define the accounting boundaries for each link in the entire life cycle
Data traceability	Establish an electronic data traceability system	Connect to the EU CBAM data upload port
Mutual recognition of certification	Promote mutual recognition of domestic green certifications with EU EPD certifications	Unify the certification indicators for the utilization rate of recycled materials
Accounting tools	Develop dual-standard compatible carbon accounting software	The software data format complies with EU requirements
Alignment dimensions	Domestic standard optimization direction	Key points of alignment with the EU CBAM
Alignment dimensions	Responsible entities for implementation	Responsible entities for implementation
Scope of accounting	China Machinery Industry Association	China Machinery Industry Association
Data traceability	Industry leaders, technology companies	Industry leaders, technology companies
Mutual recognition of certification	State Administration for Market Regulation (SAMR)	State Administration for Market Regulation (SAMR)
Accounting tools	University research teams	University research teams
Alignment dimensions	Responsible entities for implementation	Responsible entities for implementation

Table.7. Comparison Table of Core Dimensions for Alignment of Carbon Accounting Standards in the Manufacturing Industry

In 2023, the China Machinery Industry Association led the establishment of a carbon accounting standard connection working group for the manufacturing industry, in collaboration with 12 leading enterprises and 5 research institutions, to formulate the "Guidelines for Carbon Accounting in Machinery Industry with Dual Standards", clarifying the accounting boundaries between the production end and the supply chain end, and developed the first carbon accounting software compatible with dual standards, which was promoted in 30 pilot enterprises in 2024. The average cost of cross-border compliance for enterprises has decreased by 25 percent.

3.2. Focus on green technology breakthroughs in manufacturing

Manufacturing enterprises should collaborate with research institutions to focus on breakthroughs in sub-technologies of the circular economy. The core research directions and responsible entities are presented in Table 8.

Technical fields	Specific directions to tackle	Responsible parties
Metal scrap sorting	Multi-category intelligent sorting technology, impurity purification technology	Leading enterprise, Materials College of the university

Low-carbon smelting	High-frequency induction melting, hydrogen energy melting technology	Research institutes, smelting equipment enterprises
Performance enhancement of recycled materials	Recycled aluminium, a technology for enhancing the mechanical properties of steel	Enterprise research and development center, university laboratory
Digital control	Full-chain real-time monitoring technology for carbon footprint	Technology companies, manufacturing enterprises
Technical fields	Specific directions to tackle	Responsible parties
Metal scrap sorting	Multi-category intelligent sorting technology, impurity purification technology	Leading enterprise, Materials College of the university
Technical fields	Expected breakout time	Application value
Metal scrap sorting	2025	Sorting accuracy increases to 99.9%
Low-carbon smelting	2026	Reduce carbon emissions from the smelting process by 40 percent
Performance enhancement of recycled materials	2025	The performance of recycled materials meets the standards of virgin materials
Digital control	2024	Carbon accounting efficiency increased by 80%
Technical fields	Expected breakout time	Application value
Metal scrap sorting	2025	Sorting accuracy increases to 99.9%

Table.8. Key Technological Research and Development Directions and Responsible Entities for Circular Economy in the Manufacturing Field

At the same time, a manufacturing industry circular economy technology sharing platform was established within the industry. Leading enterprises such as XCMG and Sany Heavy Industry opened up 18 mature technological achievements, helping small and medium-sized enterprises reduce technology research and development costs by more than 60% in 2023. A small machinery company completed its circular economy transformation with an investment of only 800,000 yuan through technology sharing, saving 2 million yuan compared to independent research and development.

3.3. Cultivate compound sustainable management talents for manufacturing enterprises

Universities and enterprises need to work together to build a system for cultivating compound talents. The specific courses and training modules are presented in Table 9.

Training subjects	Course Training module	Core content
Colleges	Fundamentals of Mechanical Manufacturing	Traditional manufacturing processes, circular production techniques
	Green management and carbon accounting	Dual carbon policy, carbon accounting standards, circular economy theory
	Industrial chain collaboration practices	Supply chain environmental management, stakeholder co-governance

Manufacturing enterprises	Carbon footprint training for production team leaders	Workshop carbon emissions accounting, low-carbon process operation
	Green supplier assessment training for procurement personnel	Supplier environmental rating, recycled raw material standard review
	Target Competence	
Training subjects	The ability to integrate manufacturing processes with circular technology	
Colleges	Carbon accounting and sustainable management capabilities	
	Industrial chain synergy capabilities	
	Low-carbon control capabilities for front-line production	
Manufacturing enterprises	Green supply chain management capabilities	
	Green product market conversion capabilities	
	Target Competence	

Table.9. Curriculum System for Cultivating Compound Sustainable Management Talents in the Manufacturing Industry

In 2023, Henan University of Science and Technology launched an interdisciplinary experimental class in mechanical manufacturing and green management, with an initial enrollment of 50 students. The curriculum incorporates practical content such as carbon accounting practice and recycled material technology, and builds internship bases with enterprises such as LY-BC. In 2024, the first batch of interns completed three carbon accounting optimization plans for enterprises, saving 150,000 yuan in costs.

Conclusion

This paper discards the macro-level generalization research and focuses on the micro-level pain points of manufacturing enterprises' circular economy transformation. It clarifies the specific problems that enterprises face in circular transformation, such as cost-benefit imbalance, cross-border standard disconnection, and industrial chain synergy disruption, and systematically presents the resource closed-loop production system and customized digital control platform by embedded in 9 sets of three-line data comparison tables. A three-dimensional innovative path for the precise co-governance mechanism of stakeholders, and the feasibility of the path was verified through in-depth cases of three typical enterprises.

The research shows that the sustainable management transformation of manufacturing enterprises requires a circular economy as the core approach, linking up the upstream and downstream of the industrial chain with multiple entities such as policies and markets, to achieve a balance between efficient resource utilization and carbon emission control at the micro operational level. Among them, the resource closed-loop production system can achieve 100% recycling and regeneration of waste materials and reduce raw material costs by more than 20%; Customized digital control platforms can solve the problem of multi-standard carbon accounting and increase the proportion of recycled materials in the supply chain by more than 20 percentage points; The precise co-governance mechanism of stakeholders can quickly recover transformational investment and achieve market premium for green products.

This study not only provides implementable transformation solutions for manufacturing enterprises, but also offers a micro-perspective reference for sustainable management research in sub-sectors. In the future, it can be further extended to different manufacturing sub-sectors such as electronic manufacturing and chemical manufacturing to explore differentiated circular economy management models.

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Organizational Management Disasters During the Anti Japanese War: A study on the Negative Impact of the "Wang-Kang Directive" on the Northeast United Resistance Army

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KEYWORDS

Wang-Kang Directive;

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Anti-Japanese War in Manchuria;

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ABSTRACT

This paper examines the multifaceted negative impact of the "Wang-Kang Directive" (the June 3, 1936, "Secret Letter to the Comrades in Charge of Eastern Manchuria") on the operations and cohesion of the Northeast United Resistance Army (NURA). While acknowledging the directive's intended role in broadening the anti-Japanese united front by combating "Leftist" closed-doorism, the analysis focuses on its profound internal contradictions and their detrimental consequences. It argues that the directive's core problematic tenets—including the passive strategic concept of "awaiting the major turn of events," the politically compromising injunction to "not couple anti-Manchukuo with anti-Japanese," and a grave misjudgment of the Japanese-puppet "collective hamletization" policy — collectively acted as a debilitating force on the NURA. These errors, emanating from a center remote from the Manchurian battlefield, induced strategic confusion, undermined effective political mobilization, and critically fractured organizational unity during a period of intense Japanese military pressure. The case of Commander Zhao Shangzhi's vehement criticism and subsequent political suppression is presented as a pivotal illustration of the directive's role in catalyzing destructive internal strife, which silenced pragmatic frontline expertise and weakened the NURA's leadership.

INTRODUCTION

this study contends that the directive's positive aspects were far outweighed by its role in exacerbating the NURA's operational dilemmas. The historical episode serves as a stark case study highlighting the imperative of grounding policy in local reality, fostering constructive dissent, and balancing central guidance with tactical autonomy — lessons with enduring relevance for organizational theory and public administration.

1.The Core Content and Internal Contradict -ions of the "Wang-Kang Directive"

The "Secret Letter to the Comrades in Charge of Eastern Manchuria" (commonly known as the "Wang-Kang Directive" or the "June 3 Directive"), issued on June 3, 1936, and jointly signed by Wang Ming and Kang Sheng, key members of the Chinese Communist Party Delegation to the Communist International, was a guiding document that profoundly influenced the later struggles of the Northeast United Resistance Army (NURA). This directive, formulated in Moscow in an attempt to dictate strategy and tactics for the NURA fighting in isolation thousands of miles away, was not monolithic in content. It was marked by a sharp tension between profound progressiveness and serious limitations, between correct tactical adjustments and erroneous strategic judgments. This inherent dissonance constituted the root cause of the immense controversy and complex impact it later generated.

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1.1.The Paradox of "Deconstruction" and "Construction": The Coexistence of Broadened United Front and Strategic Passivity

The most praised and genuinely positive aspect of the directive was its clear demand to break with "Leftist" closed-doorism and vigorously expand the anti-Japanese national united front. It stated the need to "universally establish upper and lower-level united fronts with various anti-Japanese forces, uniting all anti-Japanese armed forces to resist Japan together," and emphasized "absorbing all elements willing to participate in armed anti-Japanese struggle to expand the organization of guerrilla units." This guideline addressed the tendency within some Party organizations and NURA units to be wary of and insufficiently integrate with old army units, forest forces, and other anti-Japanese armed groups. On a practical level, it encouraged NURA armies to more actively absorb and unite with other anti-Japanese forces, contributing to the short-term bolstering of the NURA's momentum and the cohesion of anti-Japanese strength. For instance, influenced by this spirit, the NURA's forces were once organized into eleven armies, creating an impressive panorama of resistance.

However, forming a fatal paradox with this tactical instruction for active "expansion" was the latent tendency toward strategic passivity and waiting embedded in its overarching strategic thinking. The directive famously proposed the thesis of "awaiting the major turn of events." It argued that the anti-Japanese guerrilla warfare in the Northeast was, "at present, not for 'preparing' for the decisive struggle, but for 'awaiting' the timing of the decisive struggle." It pinned the fundamental hope for victory in the Northeast on the occurrence of a "major turn of events"—namely, the full outbreak of a nationwide War of Resistance or a major international incident (such as the Soviet Union declaring war on Japan). While this assessment stemmed from the Delegation's specific reading of domestic and international situations and had its observational basis, its delivery as strategic guidance to the NURA, then enduring brutal Japanese-puppet "mop-up" campaigns, had profoundly negative consequences.

This logic of "waiting" essentially downgraded or diminished the NURA's heroic, independent, and autonomous guerrilla warfare to a "preparatory" and "supporting" action aimed at accumulating strength, creating conditions, and providing coordination for the "major turn of events." It subtly weakened the consciousness of subjective strategy — the resolve to proactively attack the enemy, establish consolidated base areas, and ultimately strive for local victory or even influence the overall situation through persistent, active, and flexible guerrilla warfare in the Northeast theater. The subtle shift in strategic positioning—toward "awaiting" rather than "striving," "supporting" rather than "leading"—in the extremely harsh environment behind enemy lines easily bred military conservatism, indecision in action, and an insufficient sense of urgency regarding the need to establish consolidated rear base areas. When "preserving strength and awaiting the major turn of events" became a latent psychological suggestion, it inevitably clashed violently with the practical demands of surviving and developing by actively fighting back against the enemy's frenzied "mop-up" campaigns.

1.2.The Ambiguity and Compromise in Political Principle: The Substantive Harm of "Not Coupling Anti-Manchukuo with Anti-Japanese"

Another core instruction in the directive that sparked great controversy and subsequent confusion was its explicit proposition regarding political slogans: "not to couple anti-Manchukuo with anti-Japanese." The letter demanded, "Do not combine the fight against Japan and the overthrow of Manchukuo," emphasizing that "our slogan is to resist Japan and save the nation... Regarding the Manchukuo government, we do not proclaim opposition to it; instead, we propagate to the masses that it is merely a puppet of the Japanese government." Its starting point was likely an attempt to distinguish between the primary enemy (Japan) and a secondary contradiction (the puppet Manchukuo regime), to avoid creating too many enemies, or perhaps the illusion that this tactic would soften the hostility of some officials, police, and military personnel under the puppet regime, facilitating united front work.

However, in the practical political context of the Northeast, this formulation constituted a serious retreat in political principle and a strategic error. The puppet state of Manchukuo was by no means a "secondary contradiction" entity that could be set aside. It was the core political instrument and legal "mask" of Japanese imperialist colonial rule over Northeast China, the direct executive apparatus for

Japan's economic plunder, cultural enslavement, and conscription of labor and soldiers. "Japan and Manchukuo as One" and "Harmony of the Five Races" were its fundamental national policies. The anti-Japanese struggle in the Northeast, in its concrete form, necessarily manifested as a life-and-death battle against this puppet regime and its entire ruling machinery. The dual oppression suffered by the people of the Northeast—invasion by a foreign nation and collaboration by a puppet regime of their own ethnicity—was inseparable in reality.

"Not coupling anti-Manchukuo with anti-Japanese" blurred the nature of the struggle politically and fettered the sharp edge of the NURA's political mobilization. It forced the NURA to adopt a circuitous, even self-limiting posture when exposing the puppet nature of the Manchukuo regime, calling on puppet officials, police, and soldiers to defect, and mobilizing the enslaved masses to resist the colonial order. This was tantamount to tying one's own hands on the ideological and propaganda battlefield. In practical work, this directive also caused confusion: grassroots commanders, political workers, and soldiers struggled to understand why they should "not couple" opposition to the puppet regime that directly organized "mop-ups," implemented the "concentrated hamlets" policy, and oppressed the people. This politically unrealistic fantasy not only failed to divide the enemy as intended but potentially caused some masses to become confused about the NURA's political stance, weakening its appeal as a clear banner of firm resistance against Japan and its puppet regime.

1.3.The Grave Misjudgment of a Key Enemy Policy: The Absurd Perception of "Concentrated Hamlets"

Perhaps the most glaring demonstration of the directive's drafters' detachment from and misjudgment of the realities of struggle in the Northeast was their attitude toward the Japanese-puppet policy of "collective hamletization" or "concentrated hamlets." The directive not only failed to clearly call for resolutely crushing this sinister scheme but instead proposed a view that appears nearly absurd today: that "concentrated hamlets" could have "some benefits for the anti-Japanese struggle as well, because with the masses concentrated, it is easier to conduct mass work and establish secret organizations." This assessment, based entirely on an impractical, ivory-tower imagination, formed a lamentable contrast with the bloody reality on the ground in the Northeast.

The "collective hamlet" policy implemented by the Japanese and their puppets was an extremely cruel colonial control measure designed to completely strangle the NURA's foundation for survival. Its specific method was to utterly destroy scattered villages located near mountains and forests through a "burn all, kill all, loot all" policy, forcibly driving villagers into tightly controlled "hamlets" surrounded by walls, watchtowers, barbed wire, and heavily guarded by military and police. A baojia mutual surveillance system was simultaneously enforced, strictly restricting the movement of people and goods. The aim was explicit: to completely sever the vital links between the NURA and the masses in physical space, turning the NURA into a "fish out of water," deprived of sources for recruits, provisions, and intelligence. During the implementation of "collective hamletization," countless Northeast civilians were displaced, with untold numbers dying from exposure, starvation, or direct killing, creating vast "uninhabited zones" and "death belts."

In this context, the directive's suggestion that "concentrated masses" facilitated work completely ignored that this "concentration" was enforced at bayonet point behind barbed wire, under tight surveillance and the terror of collective punishment. It became extremely difficult for NURA personnel to enter the "hamlets," and masses faced death for attempting to make contact. The notion of "easier mass work" was pure wishful thinking. This erroneous judgment directly interfered with the NURA's clear understanding of the policy's lethality and delayed the adoption of a combined strategy of determined military raids and flexible political persuasion to counter it. Some units, possibly influenced by this directive, may not have treated the destruction of "collective hamlets" as a strategic task of vital importance in a timely manner. Consequently, during the peak period of its implementation from 1936 to 1938, the most effective resistance was not mounted, accelerating the loss of existing guerrilla zones and base areas and drastically worsening the troops' living conditions.

In summary, the "Wang-Kang Directive" was a text riven with internal contradictions. In one hand, it raised the reasonable banner of expanding the united front; in the other, it proffered the bitter fruits of a passive-waiting strategy, compromised political principles, and a grave misjudgment of the enemy. This paradox of "retreat within progress" and "error within construction" was not a simple case of

coexisting merits and flaws. Because it originated from an authoritative body distant from the practical struggles in the Northeast, it carried the force of an order to be implemented. When these contradictory instructions were collectively delivered to the Northeast anti-Japanese battlefield — an arena of extreme cruelty, poor communication, and desperate need for clear, firm guidance — the resulting confusion, divergence, and operational paralysis became inevitable. While attempting to inject new ideas into the Northeast resistance, the directive also sowed the seeds for military passivity, political disorder, and organizational friction. These latent issues would gradually manifest in subsequent practical struggles, first provoking the most intense reaction and conflict from one of the NURA's most perceptive and practically grounded leaders — Zhao Shangzhi.

2.The Military and Political Dimensions of Negative Impact: The Dilemmas in NURA's Practical Struggle

The inherent contradictions within the "Wang-Kang Directive" were not merely theoretical flaws confined to paper. When these directives, emanating from a distant center of authority, intersected with the brutal, day-to-day realities of the anti-Japanese war in the Northeast, they produced a series of concrete and detrimental consequences. The directive's problematic tenets directly translated into military confusion, political enfeeblement, and organizational discord within the Northeast United Resistance Army (NURA), exacerbating the already immense challenges it faced during a critical phase of its existence.

2.1.Confusion and Passivity in Military Strategy

The "await the major turn of events" thesis introduced a paralyzing element of strategic uncertainty into NURA's military decision-making. This notion implicitly discouraged large-scale, proactive strategic initiatives aimed at fundamentally altering the military balance in the Northeast. Instead, it fostered a mindset where the primary role of guerrilla warfare was reconceptualized as preserving strength and maintaining a presence until external salvation arrived. This shift had several tangible effects on military operations.

First, it potentially dampened the initiative and aggressiveness crucial for guerrilla survival. Facing increasingly systematic and ruthless Japanese "encirclement and suppression" campaigns from late 1936 onward, the optimal response for dispersed guerrilla forces often lay in extreme mobility, daring raids to secure supplies, and the constant creation of new zones of activity to disperse enemy attention. A strategy overly influenced by "waiting" could lead to excessive caution, a reluctance to engage in necessary but risky actions to break blockades or punish collaborators, and an over-reliance on evasion that sometimes bordered on mere survivalism. While preservation of forces was vital, the directive's strategic framing risked tilting the balance away from the dynamic, offensive-minded operations that were often the lifeblood of guerrilla morale and effectiveness.

Second, it undermined the urgency of establishing and defending consolidated base areas. The construction of relatively stable rear areas — secret camps, logistical networks, and local governments — was essential for treating wounded soldiers, training troops, manufacturing rudimentary arms, and providing a political anchor among the populace. The "waiting" mentality, by de-emphasizing the NURA's role in actively shaping the Northeast's future, could inadvertently lead to a neglect of the painstaking, long-term work required to build such bases. When the Japanese intensified their "mop-up" campaigns and the "concentrated hamlets" policy began to bite, some units found themselves without secure hinterlands, transforming tactical retreats into desperate, sustained flights that eroded strength and cohesion. The loss of key base areas like those in the Sanjiang Plain or around the Changbai Mountains in the late 1930s, while primarily caused by overwhelming enemy force, was arguably facilitated by a strategic context that did not sufficiently prioritize their active defense and development as non-negotiable cornerstones of protracted war.

Third, the directive contributed to inconsistent and uncoordinated military responses across different NURA theaters. As the directive was interpreted and implemented variably by different army leaders and regional Party committees, it led to a lack of unified strategic action. Some commanders, particularly those in closer contact with the East Jilin transmission line, might have been more inclined to adopt a conservative posture in line with the "waiting" idea. Others, like Zhao Shangzhi in the North Manchuria

region, vehemently rejected it. This divergence meant that the NURA armies failed to act as a fully coordinated strategic force. Opportunities for large-scale mutual support, diversionary attacks, or unified responses to enemy offensives were harder to realize, allowing the Japanese to exploit these divisions and deal with the NURA armies in a more piecemeal fashion.

2.2.The Weakening of Political Mobilization and Mass Work

The directive's political compromises had a corrosive effect on the NURA's relationship with the very people it relied upon for survival: the masses of Northeast China.

The injunction to "not couple anti-Manchukuo with anti-Japanese" created significant confusion in political propaganda and agitation. NURA political workers and local activists found themselves in a difficult bind. They were forbidden from openly calling for the overthrow of the puppet regime, even as that regime's police, local officials, and "self-defense" militias were directly hunting them, extracting grain taxes to feed the Japanese war machine, and implementing the "concentrated hamlets" policy. This created a dissonant message. How could they effectively mobilize hatred against the Japanese aggressor while treating the latter's immediate, visible, and brutal local enforcers with rhetorical kid gloves? In practice, this policy hampered efforts to win over the "middle elements"—those who might have been alienated by the puppet regime's excesses but were not automatically committed to armed resistance. It also complicated work among puppet troops and lower-level officials, as the call to defect was not coupled with a clear, powerful denunciation of the illegitimate regime they served.

Most critically, the directive's misguided analysis of "concentrated hamlets" amounted to a profound disconnect from the lived reality of the peasantry, which severely damaged the NURA's mass base. The directive's bizarre suggestion that concentration might aid mass work revealed a complete failure to grasp the terroristic nature of the policy. Far from being "easier to work with," the masses trapped inside these fortified hamlets lived under a regime of constant surveillance, collective punishment, and restricted movement. Establishing contact became exponentially more dangerous. Trusted local contacts were isolated or eliminated. The traditional flow of food, intelligence, and recruits from scattered mountain villages dried up virtually overnight.

By not issuing a clarion call for the absolute, uncompromising resistance to this policy—through military attacks on hamlet construction teams, raids to liberate captured villagers, and relentless propaganda exposing its horrors—the directive left some NURA units without a clear, urgent mandate to counter this existential threat. Consequently, the implementation of "collective hamletization" between 1936 and 1939 proved devastatingly effective. It successfully created vast "no-man's-land" belts between the hamlets and the mountains, strangling the NURA's logistical lifelines. Soldiers faced starvation and frostbite not just because of enemy action, but because the connective tissue linking them to the people had been surgically severed by a policy the directive had catastrophically misdiagnosed.

2.3.Internal Ideological Confusion and Strategic Divergence

Perhaps the most immediate and damaging impact was the deep division and internal strife the directive sowed within the NURA and its supporting Party apparatus. The document was not a clear, actionable plan but a bundle of contradictions. This inherent ambiguity guaranteed varied interpretations.

A major fault line emerged between the East Jilin leadership (which had received and generally supported the directive) and the North Manchuria Provincial Committee under the leadership of Zhao Shangzhi and Feng Zhongyun. Based on their bitter frontline experience, Zhao and his comrades viewed the directive's core messages as dangerously "Rightist" capitulationism. They saw "waiting for the major turn of events" as an excuse for inaction, "not coupling anti-Manchukuo" as political suicide, and the stance on "concentrated hamlets" as sheer fantasy. Their vehement opposition was rooted in a practical understanding that survival in Manchuria required unwavering militancy, clear political banners, and relentless struggle against all forms of enemy control.

This was not a minor tactical disagreement. It escalated into a fundamental dispute over political and military line. The East Jilin side, backed by the authority of the International Delegation, accused the North Manchuria leaders of "Leftist" closed-doorism and insubordination. The North

Manchuria side accused the East Jilin line of implementing a harmful right-opportunist retreat. This conflict consumed enormous energy in bitter debates, written polemics, and mutual accusations at a time when all efforts should have been focused on the Japanese enemy.

The directive thus became a catalyst for organizational fragmentation. It broke the already tenuous unity of the NURA forces operating in different regions. Instead of a cohesive army under a unified strategic command, the NURA increasingly resembled a collection of separate detachments following different guiding principles. Coordination broke down. Meetings between armies became forums for ideological recrimination rather than military planning. This internal disunity presented a critical vulnerability that the Japanese were quick to exploit through their own "divide and pacify" tactics. The bitter internal struggle over the "Wang-Kang Directive" weakened the NURA from within, making it less capable of resisting the onslaught from without. The stage was thus set for the personal and political tragedy of the directive's most prominent critic, Zhao Shangzhi, whose fate would become the most poignant illustration of the directive's corrosive impact on the NURA's leadership and unity.

3.The Consequences of Organizational Friction

The "Wang-Kang Directive" stands as a historical document riven with internal paradox. Its positive aspect — the advocacy for broadening the anti-Japanese united front — proved insufficient to counterbalance the severe harm wrought by its passive strategy, political compromises, and fatal misjudgments of the enemy's tactics. In the extreme context of the Northeast United Resistance Army's (NURA) arduous, isolated struggle with tenuous links to the central Party leadership, the directive's erroneous propositions — "awaiting the major turn of events," "not coupling anti-Manchukuo with anti-Japanese," and the fantastical view of "concentrated hamlets"—acted as invisible shackles. These ideas interfered with and weakened the NURA's combat effectiveness across multiple levels: from overarching strategic doctrine and concrete tactical choices to the very unity of its ranks. The result was not cohesive action, but profound ideological confusion and organizational schism. The tragic resistance of Zhao Shangzhi encapsulates this dual legacy: it embodies the invaluable quality of frontline cadres adhering to practical reality, while simultaneously exposing the bitter fruits of dogmatic command divorced from actual conditions and of inner-Party practices that suppressed dissenting voices.

3.1.The Directive as a Catalyst for Destructive Internal Struggle

The internal contradictions of the directive did not merely cause debate; they institutionalized conflict. By presenting a mix of sound advice and perilous error under the imprimatur of the International Delegation, it forced NURA commanders and political commissars into an impossible position. To implement it fully was to court military disaster and political irrelevance; to reject its core flawed tenets was to risk being accused of defying Party authority. This created a fault line that fractured the NURA's fragile operational unity.

The bitter, protracted dispute between the East Jilin line (which generally advocated following the directive) and the North Manchuria leadership under Zhao Shangzhi (which denounced it as rightist capitulationism) consumed scarce resources of time, energy, and political capital. Meetings that should have focused on coordinating military campaigns against the Japanese devolved into ideological polemics. Precious opportunities for joint operations were lost amidst mutual suspicion and accusations. This internal friction provided a critical vulnerability that the Japanese military intelligence exploited, adeptly using their own propaganda to widen the rifts within the anti-Japanese forces. The NURA, instead of presenting a united front to the enemy, was often distracted by an internal front, significantly diluting its collective strength during a period of escalating enemy pressure.

3.2.The Zhao Shangzhi Case: A Microcosm of the Cost

The personal and political ordeal of Zhao Shangzhi serves as the most poignant case study of the directive's corrosive organizational impact. His critique was not that of a dissident but of a pragmatic military commander whose survival and successes were rooted in a clear-eyed understanding of Manchuria's harsh realities. His opposition to the directive's passivity and compromise was a defense of the NURA's core operational principles. However, the mechanism for handling this dissent proved catastrophic.

The response from the Party center, via the International

Delegation, was not engagement with his substantive arguments based on frontline experience, but organizational discipline and political ostracization. The dismissal of his envoy, Zhu Xinyang, and the subsequent labeling of Zhao's stance as "anti-Party" for opposing Wang Ming's line, established a dangerous precedent. It elevated doctrinal adherence to a specific, remotely formulated line over practical military and political effectiveness. The suppression of Zhao Shangzhi — a brilliant, charismatic, and fiercely determined commander — deprived the NURA of one of its most capable leaders at a most critical juncture. His removal from command, his subsequent struggles to regain a position, and his ultimate tragic death in 1942, were all linked, directly or indirectly, to the fallout from this political dispute.

This episode demonstrated that the cost of the "Wang-Kang Directive" was measured not only in missed opportunities and lost bases but also in the silencing of practical wisdom and the loss of vital leadership. It exposed how an incorrect line, when enforced through rigid organizational discipline, could physically and politically eliminate the very individuals best equipped to save the movement from the pitfalls of that line. The NURA's subsequent difficulties in maintaining cohesion and strategic direction in the late 1930s are inextricably linked to this purge of its most independent-minded commander.

3.3.Re-evaluating the Legacy: The Imperative of Reality-Check and Autonomy

A reassessment of the "Wang-Kang Directive" and its negative impact is essential for a fuller, more profound understanding of the NURA's struggle. It moves the historical analysis beyond a simple narrative of heroic resistance against overwhelming Japanese force to a more complex appreciation of the multifaceted internal and external pressures that shaped the NURA's fate. The extreme hardship faced by the NURA was not solely imposed by the enemy; it was compounded by strategic misguidance and internal fragmentation stemming from a flawed central directive.

This history underscores, with stark clarity, the paramount importance of the principles of seeking truth from facts and maintaining independent initiative in revolutionary warfare. The NURA's greatest successes in its early and middle phases were built upon strategies developed locally in response to immediate conditions. Its periods of greatest crisis coincided with the imposition of strategies conceived in abstraction, far from the Manchurian battlefield. The "Wang-Kang Directive" affair is a powerful testament to the dangers of divorcing command from reality and to the devastating consequences of stifling grassroots initiative and pragmatic critique within a revolutionary organization.

Ultimately, the story of the directive and its aftermath is a sobering chapter in the history of the Chinese revolution. It highlights that the path to victory in a struggle as complex and brutal as the War of Resistance required not only courage and sacrifice but also the intellectual flexibility to adapt theory to practice, the political wisdom to tolerate debate informed by experience, and the operational autonomy to make swift, realistic decisions in the field. The tragedy of the internal strife it sparked within the NURA remains a lasting lesson on the critical need to harmonize central guidance with local reality, and ideological discipline with practical effectiveness.

Conclusion

The crisis within the Northeast United Resistance Army (NURA), precipitated by the profound disconnect between the "Wang-Kang Directive" and the operational realities of the Manchurian battlefield, transcends its specific historical moment. It serves as a stark, enduring case study in the systemic vulnerabilities of any hierarchical organization — particularly governing or administrative bodies — when critical decision-making becomes isolated from contextual truth and dissenting expertise. The core lessons emanating from this episode speak directly to perennial challenges in modern public administration: the imperative of grounding policy in empirical reality, the necessity of safeguarding channels for constructive dissent, and the strategic balance between unified purpose and localized autonomy.

The directive’s most consequential failure lay in its epistemic rupture — the gap between its theoretical prescriptions and the ground truth of Japanese colonial policy and local sociopolitical dynamics. Conceived in the abstract, geopolitical calculus of Moscow, it misdiagnosed lethal enemy strategies like “collective hamletization” as potential opportunities and advocated political compromises, such as the “non-coupling” of anti-Manchukuo sentiment, that undermined the NURA’s mobilizing logic. This reflects a timeless administrative pathology: the formulation of

policy within a contextual vacuum, reliant on second-hand data, ideological assumptions, or wishful thinking, rather than on direct, unvarnished feedback from the level of implementation. For contemporary public administration, this underscores the non-negotiable need to institutionalize robust "reality-check" mechanisms. Effective governance requires embedded feedback loops that continuously funnel intelligence from street-level bureaucrats and affected communities back into the policy cycle. It demands a commitment to "deliberate disconfirmation," actively seeking out evidence that challenges initial assumptions, and an adaptive management approach that treats policies as hypotheses to be tested and refined through pilot programs, rather than as immutable decrees.

Furthermore, the organizational response to criticism, exemplified by the suppression of Zhao Shangzhi, highlights the catastrophic costs of confusing loyalty with conformity. Zhao's dissent was not sedition; it was a pragmatic, experience-based critique essential for the NURA's survival. Its dismissal and the punitive measures that followed crippled the organization's adaptive capacity by silencing its most vital source of corrective feedback. Modern bureaucracies are equally susceptible to such insularity, where hierarchical pressures and institutional culture can stifle necessary debate, leading to groupthink, policy blind spots, and avoidable failures. The modern imperative, therefore, is to consciously cultivate a culture of psychological safety and constructive contention. This can be operationalized through formalized procedures like "red-teaming" or designated devil's advocate roles in policy formulation, protected channels for anonymous reporting, and, most importantly, leadership that explicitly models receptivity to challenging viewpoints. The goal is to transform dissent from a perceived threat to authority into a recognized asset for institutional resilience and innovation.

Finally, the directive's attempt to impose a rigid, uniform strategic template across all NURA units, despite vastly differing local conditions, points to the folly of prioritizing procedural uniformity over effective outcomes. It disregarded the principle of subsidiarity — that decisions are best made at the lowest competent level closest to the problem. In modern terms, this manifests as the inefficiency and ineffectiveness of top-down, one-size-fits-all mandates imposed on local schools, police departments, or social service agencies operating in unique contexts. The lesson for contemporary public administration is to shift focus from micromanaging processes to clearly defining and measuring outcomes. Central authorities should establish strategic goals, performance standards, and accountability frameworks, while empowering local actors with the autonomy and necessary capacity to devise context-appropriate methods for achieving them. This fosters innovation, improves responsiveness, and builds a more agile and resilient administrative ecosystem.

In conclusion, the tragedy of the "Wang-Kang Directive" is a powerful historical metaphor for the foundational principles of sound administration. It demonstrates that legitimate authority derives not merely from hierarchical position but from the epistemic quality of its decisions and the procedural integrity of its deliberative processes. For the modern public administrator, this history reinforces the critical need to design systems that are humble in their reliance on ground-level intelligence, agile in their capacity for iterative learning, and wise in their balance of cohesive direction with empowered local execution. By internalizing these lessons, public administration can better fulfill its core mission: crafting and executing policies that are not merely formally correct but authentically responsive and effective in the complex, unpredictable realities they are meant to govern.

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The Role of Decarbonization in Ensuring Sustainable Development

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KEYWORDS

Sustainable development;

Energy sector;

Improving the efficiency of the existing energy system;

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ABSTRACT

This article examines the role of decarbonization in achieving the sustainable development goals of the Republic of Belarus. It identifies the main sources of greenhouse gas emissions and strategic areas for their reduction. Particular attention is paid to measures to improve the efficiency of the existing energy system, the development of renewable energy (biomass and biogas), and electricity generation at the Belarusian Nuclear Power Plant. It is emphasized that the transition to low-carbon technologies contributes to improved environmental quality, the fulfillment of international commitments (the Paris Agreement) to slow global warming, and provides economic and social benefits.

ВВЕДЕНИЕ

В новых условиях развития стран мирового сообщества (этапа "Индустрия 4.0") Национальная стратегия устойчивого развития (НСУР) Республики Беларусь на период до 2040 г. определяет три основные компоненты: развитие человека как личности и генератора новых идей; поддержание и развитие конкурентоспособной экономики; обеспечение благоприятной окружающей среды и экологической безопасности [1].

Трансформация перспективной модели национальной экономики направлена на внедрение принципов «зеленой экономики» при сохранении природного капитала, а также формирование высокотехнологичного производственного сектора. Формирование целостной стратегии происходит на основе принципов национальной ответственности.

1.Возможными угрозами для устойчивого развития являются

Возможными угрозами для устойчивого развития являются: увеличение техногенной нагрузки на окружающую среду и нарушение ее способности к самовосстановлению; проблема исчерпаемости невозобновляемых ресурсов и неустойчивого использования возобновляемых ресурсов.

Для Республики Беларусь в ближайшее время доминируют глобальные экологические риски в виде усиления «парникового эффекта» и глобального потепления климата, снижения биологического разнообразия, негативного влияния на здоровье людей изменяющихся условий жизнедеятельности. Известно, что во всех странах мира предприятия теплоэнергетики являются основными источниками выбросов парниковых газов в атмосферный воздух. Эта закономерность сохраняется и для республики. В 2023 г. структура выбросов парниковых газов была следующей: теплоэнергетика – 62%, землепользование (растениеводство) – 24%, промышленные выбросы – 7%, складирование органических отходов 7% [2].

Рисунок.1.Динамика выбросов парниковых газов по секторам экономики (миллионов тонн CO_2-эквивалента

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в год)

Анализ структуры выбросов парниковых газов в Беларуси за период с 2010 г. по 2023 г. (рис. 1) показывает, что энергетический сектор является основным источником эмиссии парниковых газов, со значительной тенденцией снижения этого показателя (с 60,2% в 2010 г. до 53,9% в 2023 г.). Примечательным является то, что выбросы парниковых газов от полигонов хранения отходов ЖКХ за этот же период увеличились с 5,7% до 6,9%, что можно объяснить увеличением объемов складируемых отходов, включая органическую фракцию.

Эмиссии парниковых газов в результате землепользования (в сельском хозяйстве) остаются стабильными, на достаточно высоком уровне – 20,8%. Это можно объяснить неустойчивым использованием почвенно-земельных ресурсов в растениеводстве, в частности нерациональным применением минеральных азотных удобрений, приводящим к денитрификации почв. Результатом денитрификации являются значительные потери азота и оксидов азота, которые поступают в атмосферу из почв, усиливая парниковый эффект. Объемы выбросов парниковых газов от промышленных предприятий за анализируемый период остаются стабильными - на уровне 5,5-5,6%.

Значимую роль в достижении целей устойчивого развития выполняет декарбонизация энергетического сектора, основными аспектами которой является сокращение выбросов парниковых газов, связанных с использованием ископаемого топлива (рис. 2). Стратегической целью декарбонизации является удовлетворение потребностей в энергоносителях производственной сферы и жилищно-коммунального хозяйства (ЖКХ), на основе их максимально эффективного использования при снижении нагрузки на окружающую среду. Аспекты декарбонизации энергетического сектора представлены на рисунке 2.

Рисунок.2. Аспекты декарбонизации энергетического сектора

2.Современная деятельность по декарбонизации топливно-энергетического комплекса включает четыре основных направления

повышение энергоэффективности посредством модернизации оборудования и внедрения новых, более эффективных технологий в различных отраслях народного хозяйства, которые способствуют снижению общего потребления энергии и, следовательно, уменьшению выбросов парниковых газов при сжигании ископаемого топлива; дальнейшее развитие атомной энергетики; вовлечение в энергобаланс возобновляемых источников энергии (ВИЭ), основанных на трансферте международных технологий и системных решений (биогаз, солнечная и ветровая энергетика); максимально возможное использование собственных топливно-энергетических ресурсов, в т.ч. местных видов топлива (древесины, биомассы).

Основные направления декарбонизации представлены на рисунке 3.

Рисунок.3.Основные направления декарбонизации

3. Среди основных направлений повышения энергоэффективности действующих производственных объектов, можно выделить следующие

внедрение передовых технологий, таких как утилизация тепла дымовых газов, и вывод из эксплуатации устаревших генерирующих объектов;

повышение доли электроэнергии в структуре конечного потребления при одновременном сокращении использования импортируемого углеводородного топлива;

активное использование низкопотенциальных вторичных энергоресурсов для отопления и горячего водоснабжения;

применение современного оборудования и

автоматизированных систем управления, позволяющих минимизировать потери при транспортировке тепловой и электрической энергии [3].

К ключевым направлениям декарбонизации энергетического сектора относится развитие сферы возобновляемой энергетики. Использование ВИЭ для производства тепловой и электрической энергии обеспечивает синергию трех составляющих устойчивого развития: экологической, экономической и социальной (рис. 4).

Рисунок.4.Аспекты возобновляемой энергетики

Наиболее перспективными направлениями возобновляемой энергетики в Беларуси, демонстрирующими экономическую эффективность при соблюдении технических регламентов, являются использование биомассы и биогазовые технологии. Следует отметить, что именно они составляют основную долю (56%) в структуре снижения потребления традиционных видов топлива за счет ВИЭ (рис. 5) [4].

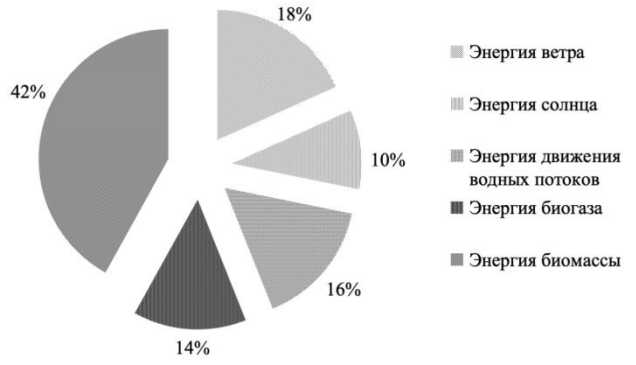

Рисунок.5.Снижение потребления традиционных видов топлива за счет ВИЭ, %

Биомасса представляет собой продукты, полностью или частично содержащие материалы растительного или животного происхождения, которые могут быть использованы в качестве топлива для получения энергии при их сжигании [5]. Значительный ресурсный потенциал в этом направлении сосредоточен в растительных отходах агропромышленного комплекса. Наиболее объемными и готовыми к использованию видами сырья являются побочные продукты переработки льна (костра), солома зерновых и рапса, а также отходы, образующиеся при уборке кукурузы на зерно. Их энергетическая утилизация вносит прямой вклад в декарбонизацию, поскольку при их сжигании в атмосферу возвращается лишь тот диоксид углерода (CO_2), который был аккумулирован растениями в течение жизненного цикла, что поддерживает углеродный баланс.

Значительными технологическими преимуществами перед другими видами ВИЭ обладает биогаз. Ключевое преимущество его использования – управляемость процессами и способность аккумулировать энергию на длительный срок. В отличие от солнечной или ветровой генерации, биогаз можно синтезировать поэтапно, а полученный метан – хранить в емкостях и транспортировать без значительных потерь, обеспечивая тем самым надежность поставок и многоцелевое его использование [6].

Данная технология является отраслью циркулярной экономики, поскольку для метаногенеза используются органические отходы агропромышленного и коммунального секторов. Критически важным аспектом для эффективности процессов является обеспечение стабильной подачи субстрата в метантенки (ферментеры) в течение всего времени микробиологического цикла, что требует четко организованной логистики. Развитая инфраструктура подъездных путей и создание мест хранения и резервов сырья являются неотъемлемым условием успешного функционирования биогазовых комплексов.

Помимо производства метана, биогазовые технологии решают ряд экологических проблем. Они способствуют сокращению площадей, занятых под полигоны твердых бытовых отходов, предотвращают эмиссию парниковых газов (в т.ч. аммиака) с их поверхности, а также служат барьером на пути загрязнения почвенных слоев, грунтовых и поверхностных вод органическими веществами и соединениями азота.

Заключение

Декарбонизация выполняет значимую роль в достижении целей устойчивого развития. Она способствует обеспечению энергетической безопасности,

снижению техногенной нагрузки на экосистемы, выполнению международных климатических обязательств и созданию основы для «зеленого», технологичного и социально ориентированного роста в долгосрочной перспективе.

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Роль Декарбонизации В Обеспечении Устойчивого Развития

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Аннотация: в статье показана роль декарбонизации в достижении целей устойчивого развития Республики Беларусь. Выделены основные источники выбросов парниковых газов и стратегические направления по их сокращению. Особое внимание уделяется мерам повышения эффективности действующей энергосистемы, развитию возобновляемой энергетики (использованию биомассы и биогаза), производству электроэнергии на Белорусской АЭС. Подчеркивается, что переход на низкоуглеродные технологии способствует улучшению качества окружающей среды, выполнению международных обязательств (Парижское соглашение) по замедлению глобального потепления, а также обеспечивает экономические и социальные выгоды.

Ключевые слова: декарбонизация, устойчивое развитие, энергетический сектор, повышение эффективности действующей энергосистемы, атомная энергетика, возобновляемые источники энергии.

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An Exploration of Social Entrepreneurship and its Social Impact in Thailand

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KEYWORDS

Human Capital;

Social Entrepreneurship;

Social Impact:

ABSTRACT

This research paper aimed to identify the human capital drive to social entrepreneurship in Thai context, so we can understand how knowledge and skill that can influence to social entrepreneurship. In addition, this research is also to explore the social entrepreneurship that can describe the experience to create social impact on society in Thailand. Finally, it is to generate the new conceptual framework of social entrepreneurship that can be led to social impact. The sample size for multiple case designs was 5 social entrepreneurs for qualitative research. Semi-interview question is used as a tool to collect data through target group. This research is using grounded approach to analyze the data. Findings show that knowledge and personality are the key point antecedent for human capital that drive to social entrepreneurship. For social entrepreneurship, I have found three more factors that can be used to measure, which are passionate, information seeking, and opportunity seeking. Finally, social impact can be measured in two types that the impact can be seen as the society is increasing on income or profit and improved their quality of living.

INTRODUCTION

The emerging of social entrepreneurship has been rapidly increasing in the private, public, and non-profit sectors over the last few years and so as interest of social entrepreneurship continues to grow (Jiao, 2011; Johnson, 2000; Nicholls, 2008). Social entrepreneurship has become a global phenomenon that has an impact to the society by employing innovative approaches to solve social problems (Jiao, 2011; Robinson et al., 2009). The term social entrepreneur refers to the individual person who starts up the business to serve and to produce the product in the innovative way for social change (Dee, 2001). In order to create social entrepreneurship, the entrepreneur is motivated by many factors such as personal interest, lifestyle, acknowledge and entering network, and profit (Dee, 2001). Thus, social entrepreneurship is the field in which entrepreneurs aim to create their activities to be directly tied with the ultimate goal of creating social value. In doing so, they often perform with little or no intention to gain personal profit. The main purpose of social entrepreneurship is to maximize the social welfare. With the change in funding, traditional third sector and Benefits Corporation forms such as nongovernmental organizations (NGOs), philanthropies, and charities have tried to adopt the social entrepreneurship concept and have begun to identify themselves as social enterprises for more dependence on donations and government resources. In addition, some for-profit organizations have claimed to be social enterprises as well because their social purposes are not private profit proposes as a whole. The use of the term social entrepreneurship is gaining increased popularity. However, the need for understanding and promoting on social entrepreneurship is quite limited. This kind of organization is formally emerged by The Regulations of the Office of the Prime Minister that is Thai Social Enterprise Office in 2010 all around over developing countries and Thailand.

In Thailand, it has adopted the concept of social innovation (Drucker, 1990) and that has created Thai Social Enterprise Office in 2010. The development of social enterprise in

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Thailand, it started from Hamburger crisis on 2009. All the parties in Thailand see the important of sustaining and recovery to the problem that has occurred from the crisis. Due to the problem on social, economic and environment, the practitioners and academics in Thailand have realized the concept and important of social entrepreneurship that could be other way of helping to recover and sustain the social, economic, and environment (Robinson et al., 2009). According to Thai SE Catalog on 2012, it has put together of registered as social enterprise for 70 well-known enterprises, but these are some example of social enterprises, so there is still more social enterprise existing in Thailand that has not been registered in Thai Social Enterprise Office. In addition, many non-profit organization has tried to adopt the social entrepreneurship concept to sustain financial due to the decreasing of donation from their source. With social entrepreneurship concept, this concept can help to find the way of sustaining the organization and continuing to create social value or social impact to the society. However, there is a few research has confirmed that adopting social entrepreneurship is better than tradition non-profit organization on social impact and how does it be measured. The empirical research that shows the ability to gain and utilize on social impact is limited. Therefore, this research aim to focus on how social impact is being measured.

Hence, social entrepreneurship research is increasing. Even though, from 1991 to 2004, the result of research on social entrepreneurship was at a very low level. The publication productivity per annual has steadily increased from 2005 to 2009 but, it has dramatically risen on the 2010 (Maria et al., 2011). However, recently, academics have disappointed that there is a lack of research in top-tier journals that demonstrates the social impact of organizations (Hinnings and Greenwood, 2002; Margolis and Walsh, 2003; Walsh, Weber and Margolis, 2003). According to the research study that has gathered in the field of social entrepreneurship research, Desa (2007) found that 70 papers from 1985 to 2006 that were gathering from ABI information database showed that there were a study on definition, resource-constrained environment, governance regulations, and performance metrics of social entrepreneurship research. Next, Douglas (2008) that has concluded from the Web of science database for 57 identified papers and 20 analyzed from 1994 to 2007 found that there was a research on methodology. In addition, Short et al. (2009) found the research paper from 1991 to 2008 on EBSCO, ABI, and Science Direct database from 1991 to 2008 on the research domain of social entrepreneurship, delimited boundaries of social entrepreneurship, and categorization of papers into conceptual. Finally, Hill et al. (2010) found the research from 1968 to 2008 on academic research premier, business source premier, and EconLit database that there were researches on semantic network patterns, meaning emerging schools of thought of social entrepreneurship. As a result, I can conclude that there is a gap and there is a few research study on social impact assessment and evaluation. To fill this gap, this research paper is attempting to do a research on social impact measure in which it can be benefit to other organization or business that can use the model that can be applied in their organization to measure the social impact.

Another point of view related to the social entrepreneurship is human capital. There has been an amount of research on organizational practices and arrangements that is knowledge and skill (Schultz, 1961; Becker, 1962; Coleman, 1990). Human capital has long been acknowledged to be an important factor for the productivity of individuals (Schultz, 1961a, b; Becker, 1962) and more recently has been increasingly identified as a factor influencing the competitiveness of firms (Bartel,1989; Senker and Brady, 1989; Howell and Wolff, 1991; Prais, 1995). As the value of knowledge, social entrepreneur needs to create and plan for entrepreneurial activity to solve the social problem and also to create a better organizational performance. As the skill that has accumulated over time, this capabilities or skill contribute to the development of social entrepreneurship activities, which is the underlying mechanism of social transformation. Thus, human capital could be the important antecedent that can lead to social entrepreneurship in which this research study is trying to focus as the model to the social impact.

Therefore, at this point of this research, the antecedent and consequence of social entrepreneurship are identified that can be led to social impact, so once I recognize the key factors, we can build up the social impact measurement for the future research.

Research Questions

How does human capital drive to social entrepreneurship?

Objectives

The purposes of this research aim to identify the human capital drive to social entrepreneurship in Thai context, so we can understand how knowledge and skill that can

influence to social entrepreneurship.

1.Literature reviews

1.1.Human Capital of Social Entrepreneurs

In the sense of human capital, it broadly defines as the mixture of human and capital. In the view of economics, capital is referring to factors of production that used to create goods or services, which are not self-consumed in the product process. In term of human, it is the subject to take charge of all economic activities such as production, consumption, and transaction (Boldizzoni, 2008). Thus, human capital means one of production element, which can generate added-values through inputting it. In this research, the boundary of human capital can broadly define as value of knowledge and skill that has accumulated in such a period of time (Schultz, 1961; Becker, 1962; Coleman, 1990). As the value of knowledge, social entrepreneur needs to create and plan for entrepreneurial activity to solve the social problem and also to create a better organizational performance. As Dee et al. (2001) has researched, it has found that social entrepreneurs need to have a knowledge to look for the opportunity and analyze how to find the customer's need to satisfy by using social innovative way. In addition, Guclu et al. (2002) has mentioned on their research that inspired idea is the important factor for operating the venture and also, knowledge is another important factor for success.

The skills to integrate and utilize resources are also the human capital of social entrepreneur. The integrating capabilities contribute to the development of social entrepreneurship activities, which is the underlying mechanism of social transformation. Therefore, social entrepreneurs are considered as the changing agents in the social sector by engaging in a process of continuous innovation (Dees, 2001). Danna and Porche (2008) found that social entrepreneurs utilize and integrate others' resources to realize the objective of social entrepreneurship activities. Furthermore, Dees (2003) compared social entrepreneur with administrative staff in the government department and found that the former's logic is valuable. Social entrepreneur mainly focuses on the idea and then integrate the resources to realize it.

Thus, value of knowledge and skill of using resources that has accumulated for a period of time are the main factors of human capital in order to build social enterprise or social business to success.

Therefore, I propose that; Proposition 1: The greater level of value of knowledge and skill of using resources that has accumulated for a period of time will be related to the positive effect on social entrepreneurship.

1.2.The consequence of social Entrepreneurship

For hybrid business model, the objectives are to create self-sustaining business and to solve pinpoints societal problem (Zeyen et al., 2012). Another word, these businesses not only want to make a profit to sustain business, but with that profit, they will use it to create social value to the society. Social impact (Austin et al., 2006; Austin, 2006; Bourstein, 2004) and performance (Tepthong, 2014) are the key consequence of being social entrepreneurs especially in the hybrid business model. It is associated with Mair and Marti (2006). They stated that social entrepreneurs is another different model from other that mainly purposes for building social value and also to make a profit in order to sustain the business. In addition, Robert and Woods (2005) mention that social entrepreneurship is building the venture that connect between business and philanthropic, environmental problem, and to fill the gap of income and employment difficulties.

In addition, the words of social entrepreneurship may be new, but its spectacle is not. The definition of social entrepreneurship is vary. In the most general sense, social entrepreneurship is an activity of social enterprise that has created in the innovative way to accomplish a social mission. Peter Drucker (1979, p. 453) introduced the concept of social enterprise when he advocated that even the "most private of private enterprise is an organ of society and serves a social function additionally he advocated a need for a social sector in addition to the private sector of business and the public sector of government to satisfy social needs and provide a sense of citizenship and community".

Such oversight does not extend to the outcomes of social entrepreneurial activities, although there are some foundations and nonprofits that provide support to these entrepreneurs based on some evaluation. For example, Ashoka (www.ashoka.org) provides funding to fellows base on five criteria: the knockout test: a new idea; creativity; entrepreneurial quality; social impact; and ethical fiber.

For the Schwab Foundation (www.schwabfound.org) uses criteria of innovation, sustainability, and direct social impact, in quantifiable results. As two outstanding organizations for social entrepreneurship support, one thing in common for acquiring supportive to that social business venture is social impact.

Further reflections on the SE academic literature, reveal a number of themes, preoccupations and domains, that have emerged (Weerawardena and Mort, 2006), broadly these are: first, SE may be expressed in a vast array of economic, educational, welfare and social activities, reflecting diverse initiatives and activities; second, SE many conceptualized in a number of contexts, public sector, community and social action organizations; third, the role of innovativeness, proactiveness, and risk taking in SE have been emphasized in distinguishing SE from of community work; and fourth, social enterprises also provide an alternative business model for firms to trade commercially in an environmentally and socially sustainable way, where they focus on an alternative delivery system for public services such as health, education, housing and community support (Dee, 2001; Harding, 2006).

Notwithstanding the obtaining of SE literature, little effort is devoted to measuring results involving the double bottom line (financial and social performance) or the triple bottom line (financial, social, and environmental). For many social entrepreneurs, profit is not the gauge of value creation, nor is customer satisfaction, but rather social impact (Giddens, 1998; Jackson, 2006). However, social impact is hard to measure (Cook et al., 2003; Economist, 2006; Seelos and Mair, 2005).

Thus, the most important criteria for "qualifying" as a social venture is establishing the organization to create a certain social impact and measure the success of the organization based on the achievement of the social impact. Social business do not focus on outputs, or in other words, service provision. Social entrepreneurs create sustainable change and they measure the success of their organizations based on the creation of this change. While business entrepreneurs measure the success of the organization through the provision of services/goods and financial returns, social businesses measures the success of the organization not by their ability to provide services to the community they serving, but through their ability to create sustainable social impact (Young, 2006; Kozma and Wagner, 1997; Drucker, 2001; Robinson, 2006; Zappala and Lyons, 2009; Mair and Marti, 2006).

Therefore, I propose that;

Proposition 2: The greater level of being social entrepreneurs will be related to the positive effect of social impact and performance.

1.3. Social impact

There is no commonly acknowledged definition of the term social impact. Social impact, according to businessdictionary.com, is the net effect of an activity on a community and the well-being of individuals and families. In addition, Juslen (1995) has defined social impact that is the impact on people, communities and society, which have an effect on well-being. For the Centre for Social Impact in Australia, social impact means outcomes-led adaptive thinking and action taken by businesses, government, social purpose organization and knowledge creators that contribute to creating a positive, meaningful and sustainable change for the benefit of society and particularly those at disadvantage as a result of systemic, long-term problems. Vanclay (2002) stated that social impact is the all impact to the humans.

Moreover, Barrow (2002) has defined that social impact is the significant or lasting change in people's lives that brought about by a given action. The impact can be positive or negative, intentional or unintentional, immediate and direct, or it can manifest later over time and reach out to different persons, persons who were not even included in the target, but who indirectly benefit from the impact.

Another point, earning income concept might not be a defining characteristic of social entrepreneurship, but it is crucial for social entrepreneurs to sustain their ventures (Anderson and Dees, 2006; Boschee and McClurg, 2003). Once the social entrepreneur operates at full cost recovery or beyond (i.e. generating profits), he/she has entered the business world and thus is called ''social business entrepreneur'' (Yunus, 2006, p. 40). According to the Global Entrepreneurship Monitor (2006), in social businesses, profits might be dispersed to shareholders; however, most of the profits are recycled back into the business to maximize social impact and not to maximize profit.

Fig.1. Conceptual framework of this research

2.Methods

The unity of analysis in this study is individual person, which is social entrepreneurs. The social entrepreneurs as samples are over hundreds of them that have registered with Thai Social Enterprise Office. However, on this research, the researcher will focus on Chiang Mai province, which is the largest province in the northern part of Thailand. The purposive sampling is used in this research. Given the population from which the sample was drawn, the sample size for multiple case designs was 7 social entrepreneurs for qualitative research.Thus, qualitative research, the key informants are drawn from Thai Social Enterprise Office in 2015. There are 7 social businesses:Thai tribal crafts fair trade; Buddy homecare; House of potentiality; POET; Thai message by blind; AKHA AMA Coffee; Y-development Craft Shop.

Therefore, the samples have drawn out from the criteria of Thai Social Enterprise Office. According to Thai Social Enterprise Office (tseo), the office has stated criteria for being social enterprise or social business, so there are 5 criteria as following; 1) target and social purpose 2) financial sustainable that has income from selling the product or services 3) the process of producing goods or services that has to be environmental friendliness and fairness to society 4) the business has to circulate income or profit to invest the business for future or expand for more of social impact rather focusing on the stakeholder of business, and 5) the business is being good governance and transparency.

The researcher used a semi-structured interview as a data collection instrument. Semi-interview questions will be used as a tools to collect data through target group. The data will be recorded by using electronic recorder and note taker. Before scheduling for interview, the researcher will use the telephone call requesting the permission to interview the social entrepreneurs. In addition, the researcher ask for permission and agreement for interview. Also, the research ask the key informant for permission to use name or other name that depend upon the key informant allow us to use which name in the research. The in-depth interview is scheduled and used the time for at least one hour or more if it needed. The in-depth-interview will be taken place in each of social entrepreneurs' organization.

This research is mainly focusing on social entrepreneurs, which operated their business or organization in Chiang Mai province. According to Thechatakerng (2012), to get validity and reliability information, the interview to the expert of social entrepreneurship who has experienced in many years, this will give a reliable on the information. However, this may limited the generalizability of the findings. This may limited the generalizability of the findings.

In this research study, the research is a using multiple case designs approach to find the answer. However, for qualitative research to get rigor analyze, the researcher is using grounded approach (Glaser and Strauss, 1967) to analyze the data. Grounded theory was originally expressed by Barney Glaser and Anselm Strauss in their 1967 book The Discovery of Grounded Theory, with this theory, it is a way of building theory systematically using data obtained from this research. As the key steps in a grounded theory research, the analysis of this research will be drawn following the key steps by using comparative analysis of Strauss and Corbin (1990). Strauss and Corbin (1990) had created a series of data analysis steps for grounded theory that consists of open coding, axial coding, selective coding, and the generation of a conditional matrix. Moreover, Strauss and Corbin (1990) describe some flexible guidelines for coding data when engaging in a Grounded Theory analysis:

For open coding, I will transcribe the data to read over and over, then analyze the data carefully sentence by sentence to match up type of data, if this data is important, the data will be coded. Coded data need to be straightforwardly meaning to the raw data. I will try to make a code at this as much as possible to be ready for the next step.

The next step is axial code. It is a set of data that are put back together in a new way after open coding. I will make connection of each code in the same meaning or grouping as the categories.

The final step is selective coding. After the categories of data is made, I will bring all categories and integrate them to a story, which has the meaningful in this research. Also, I will try to make a relationship of each category. At this

point, I can create the model of this research and also make the proposition or hypothesis that can be needed to test in the future.

3. In this research study, the research is a using multiple case designs approach to find the answer.

However, for qualitative research to get rigor analyze, the researcher is using grounded approach to analyze the data. Strauss and Corbin (1990) had created a series of data analysis steps for grounded theory that consists of open coding, axial coding, selective coding, and the generation of a conditional matrix. Therefore, I would describe the coding analysis for each variable.

3.1. Social impact

As the results of this research, for human capital, I have found that there are two key main factors, which are knowledge and personality. Thus, I present data from the five social entrepreneurs to show, in a structured manner, how I reached the themes from the first-order coding and second-order coding. I provides representative quotations supporting each of our second-order coding. I also used quotations in the text so as to provide a clear understanding of my analysis. Therefore, I present knowledge factor that consist of skill, experience, education, and training and personality factor that consist of passion, vision, flexibility, and beliefs.

3.1.1.Knowledge

As the value of knowledge, social entrepreneur needs to create and plan for entrepreneurial activity to solve the social problem and also to create a better organizational performance. As Dee et al. (2001) has researched, it has found that social entrepreneurs need to have a knowledge to look for the opportunity and analyze how to find the customer's need to satisfy by using social innovative way. Therefore, I present knowledge factor that consist of skill, experience, education, and training.

Education:The first coding that I have found from interviewing the social entrepreneur. As I have mentioned above, I found that 4 social entrepreneurs were at least gradated in undergraduate level. 2 of these graduated from the United States. Other 2 were graduated in Thai university. Even though I found that one social entrepreneurs was graduated only lower secondary level, however, this social entrepreneurs has gained the education by learning to many places, but he has never got a degree. He received only the certificate after he finished the course. As the result, education is one of the element that can build up to the knowledge. Additionally, key informants provided the following comments:

SE1. He said that "I went to every place such Department of Skill Development, Chiang Mai University and other places that could provide him to learn how to massage."

SE2. "I studied English major for undergraduate level. I believe that it will help him in the future. And it did help me because I can write business plan and summit to place for scholarship, so I can learn about processing coffee. Then, I can go back home help to solve the problem in Akha hill tribe."

Knowledge	Details
Experience	
SE2	the member in volunteer club to help other people
SE3	using the experience to find the way of helping people in the tribe even to design and make a suggestion on the product
SE4	study abroad and use to work with a peace corporation know how to make a business that can operate to help solving society problem

Table .1. Summary of knowledge

Skill. A skill is the learned ability to carry out a task with pre-determined results often within a given amount of time, energy, or both. In other words, the abilities that one possesses. So, key informants provided the following comments:

SE1. "I have learned how to massage many places, so I was doing this for many years. Because of lifelong learning, I have the skill to massage, so I can teach other people to learn how to massage."

SE2. "Before I do not know how to process coffee beans, after I have tried and fail many times, so when I see it I can recognize that if this coffee beans coffee is taste this and that."

Knowledge	Details

Knowledge	Details
Skill	
SE1	learn how to massage many places for many years lifelong learning earning the skill to massage
SE2	try and fail many times until know the right way to process the coffee

Table .2. Summary of knowledge

Training is teaching, or developing in oneself, any skills and knowledge that relate to specific useful competencies. Training has specific goals of improving one's capability, capacity, productivity and performance. So key informants provided following comments:

SE1. "If there is any training, free or not free, I would go there to experience it because I have to improve myself. There are many things to learn. Not only will me but all employees go training."

SE5. "I believe training is very important. To take care old person, I will go for training and keep learning of how I can efficiently take care of these person."

Knowledge	Details
Training	
SE1	any training, free or not free, go there to experience it because I have to improve myself many things to learn all employees go training
SE5	training is very important go for training and keep learning of how efficiently take care of these person

Table. 3. Summary of knowledge

As the result, skill, training, experience, and education are key antecedent for knowledge of social entrepreneur on human capital.

3.1.2.Personality

As the character-based approach, it is composed of the personality structure and the human capital of an entrepreneur. In this research paper, I will limit the discussion on the entrepreneurial characteristics model that can bring up the business to success. Successful entrepreneurs have common characteristics, which are divided into three clusters; achievement, planning, and power (Buiza, 2012; Ruangkrit & Thechatakerng, 2015). Therefore, I present personality factor that consist of achievement, planning, and power cluster that found in this research paper.

Passion. It is how social entrepreneurs feel love to do something. The social entrepreneurial activity could have the contribution to the society. Key informants has provided the following comments:

SE2. "I really love on what I do. I can help to have solve my society problem."

SE1. "I believe that massage can help people in the society. If poor people who want to massage, but have no money, so I can help and give a massage for free. Moreover, I can relieve the stress by doing a massage."

Personality	Details
Passion	
SE2	love on what I do help to have solve my society problem
SE1	believe that massage can help people in the society help and give a massage for free to relieve the stress

Table. 4. Summary of personality

Vision. Here is the following of key informants comments that can be construct of this factor:

SE2. "I think the most power for doing socially enterprise is the idea, not money."

SE1. "On my plan in the future, I want to help other handicap people to have a better of living. Right now, I have contact to deaf association to propose of how I can help deaf people."

Personality	Details
Vision	
SE2	the idea, not just money for doing this business
SE1	to help other handicap people to have a better of living

Table .5. Summary of personality

Flexibility. It is the extent to which a person can cope with changes in circumstances and think about problems and tasks in novel, creative ways. So, in order to create social innovative activity, social entrepreneur need feel free to adapt correspondent to the social problem. Key informants

provided the following comments:

SE2. "Because of being a social entrepreneur, I need to know what the problem of the society is, so I can look for or find what activity that could help people in the tribe. I will not strict on just one thing, so I will keep changing until I meet to the purpose."

SE5. "I have to be flexibility including all of the employee because our job is helping the old person. Sometimes, I have to change the plan in order to help efficiently."

Personality	Details
Flexibility	
SE2	looking for or find the right activity to help people in the tribe not strict on just one plan keep changing until meet the goal
SE5	to be flexibility including all of the employee because our job is helping the old person sometimes changing the plan in order to help efficiently

Table .6. Summary of personality

Belief. It is the state of mind in which a person thinks something to be the case, with or without there being empirical evidence to prove that something is the case with factual certainty. In other words, belief is when someone thinks something is reality, true, when they have no absolute verified foundation for their certainty of the truth or realness of something. For social entrepreneur, they believe in the god to do the right thing or to take care of people who have disadvantage. Here is the key informants' comments as following:

SE3. "I used to be in the profit business. Profit is not helping everyone to improve their quality of life. In the Christianity religious, people need to share of something good, so I follow in the of Christianity teaching. I have a beliefs that doing this business will help other to become improve quality of living."

SE2. "Because I used to be a Buddhist novice, I have learned dharma every day. I was also volunteer to Non-profit organization to help other people. Because of Buddhist teaching, it helps me to understand how to become a social entrepreneur."

SE4. "As a Christian organization, people who work here, they work by their heart, not work for money."

Personality	Details
Belief	
SE3	sharing and believing with the heart of helping others believe in Christianity teaching to improve quality of living
SE2	used to be a Buddhist novice using dharma learning in life Buddhist teaching
SE4	work by their heart not work for money

Table .7. Summary of personality

As the result, vision, flexibility, passion, and belief are the antecedent for human capital in order to create social entrepreneurship.

3.2. Social entrepreneurship

By definition of social entrepreneurship, it is "a multi-dimensional construct involving the expression of entrepreneurially virtuous behavior to achieve the social mission, a coherent unity of purpose and action in the face of moral complexity, the ability to recognize social value-creating opportunities and key decision-making characteristics of innovativeness, proactiveness and risk-taking" (Mort et al., 2003, p. 76). As the result, this research has found six construct factors that can lead to social impact creation. There are innovativeness, proactiveness, risk-taking, opportunity seeking, passionate, and information seeking. Thus, I present data from the five social entrepreneurs to show, in a structured manner, how I reached the themes from the first-order coding and second-order coding. I provides representative quotations supporting each of our second-order coding. I also used quotations in the text so as to provide a clear understanding of our analysis. Therefore, I present each of these factors as well as key informant provided the comments.

Risk-taking. Being a social entrepreneur is just like other entrepreneur in the profit business. There is high risk and high return. However, this return has to come with two things: profit and social impact. This is the key informants' comments that provided as following:

SE1. He said that "when I do a business, I need to be brave on doing something and also dare to invest of something. Coming to Chiang Mai, it is a challenge for me because it is a big city, so it is hard to do and to find a job, but there is

always a chance, if you never give up."

SE2. He also mentioned that "being a social entrepreneur is just like other entrepreneur. There is a risk to do something. I move to do business here in Chiang Mai. It is risky for me but I never give up until I find the place to open the coffee shop in the basement of this apartment."

SE3. And SE4. They shared the same comments that "because economy has gone down, our business is not doing well for exporting goods. To help people in tribe and handicrafts community, it is challenge for us to doing the business with making profit and social purpose at same time. We have to open the local shop, which I never know that it is going to be succeeded or not, but we try our best to do business with two purposes."

Social entrepreneurship	Details
Risk-taking	
SE1	need to be brave on doing something dare to invest of something challenge for me coming to a big city, so it is hard to do and to find a job never give up
SE2	a risk to do something risky for me to move to a big city never give up
SE3 and SE4	challenge for us to doing the business with making profit and social purpose at same time never know that it is going to be succeeded or not, but trying our best to do business with two purposes

Table .8. Summary of social entrepreneurship

Innovativeness. It is how a firm's propensity and capability to rapidly incorporate change in business practices through creation and/or adoption of new ideas, that add value in the form of increased competiveness and sustainability. For social entrepreneur, they try to find social innovative activity to solve the society problem. Here is the key informants' comments that support to innovativeness.

SE2. "I want to find the difference way of coffee bean process, so I have to go study in the United States. I was writing a business plan. I summit it to organization that can provide the scholarship for me to go to study. Then, when I come back, I still try to find the way of making its own coffee taste, so I can have differentiate the product to the market. Also, I could pass on this knowledge to other people in the tribe. Now, I can process coffee beans in difference taste."

SE1. "I am a handicap person. Learning how massage is a difficult. Compare to person who is not a handicap, it would easier for them to learn how to massage because they can see it, but I cannot. So, I have to find the way how to learn the massage in its own way. Every time, I go to study massage, I will be the model for other people, so teacher is teaching, he can understand what teacher is teaching. As the result, I could use this way to teach other handicap person who want to learn how to massage."

Social entrepreneurship	Details
Innovativeness	
SE2	to find the difference way of coffee bean process to find the way of making its own coffee taste differentiate the product to the market able to process coffee beans in difference taste
SE1	to find the way how to learn the massage in its own way come up with the new idea of learning how to massage come up with the new idea of how to teach other handicap person who want to learn how to massage

Table .9. Summary of social entrepreneurshipProactiveness. The most valuable social entrepreneurs are the ones who are proactive. By definition, this means they control situations by causing things to happen rather than waiting to respond after things happen. Social entrepreneurs who are proactive don't sit around waiting for answers to appear; they stand up, put one foot in front of the other, and find the answers. They don't wait for someone to hand them an instruction manual. Proactive people are constantly moving forward, looking to the future, and making things happen. They're actively engaged, not passively observing. Being proactive is a way of thinking and acting. For this reason, here is some key informants' comments that support to proactiveness.

SE2. He mention that "Because I want to solve the problem of the tribe, I know that we grow coffee, but the problem is

how to distribute them, so I was the very first for moving this forward to find the way to solve the problem. That is why I have to write a business plan to get scholarship to go aboard and learning how to make the value added for coffee beans."

SE1. In addition, he support that "because I want to make a better living, not just selling the lottery. I found that massage is a good job. It can help people in many ways. Even though it is hard to learn for me, I have to do it, so I was also very first person for doing this job."

Social entrepreneurship	Details
Proactiveness	
SE2	try to find a way to solve the problem of the tribe write a business plan to get scholarship to go aboard and learning how to make the value added for coffee beans
SE1	to make a better living, not just selling the lottery hard to learn for me, but have to do it the first person for doing this job

Table. 10. Summary of social entrepreneurship

Information seeking. It is the process or activity of attempting to obtain information in both human and technological contexts. Information seeking is related to, but different from, information retrieval. Here is some comments that support of how social entrepreneurs is a information seeker.

SE1. "I look for information and doing some research before I do something. Just like to look for scholarship, I kept searching who I will offer the scholarship until I finally succeeded."

SE2. "I also kept searching for a place to learn more and more of learning how to massage. Even to look for the fund to help my business, I was seeking if there was available funding, so I was acting it very fast by having my assistant help."

SE5. "Because of running a business, I need to have a starting budget, not just the idea, so I have to look for a place to receive the funding. I had to write the business plan and attend to the business plan competition that Thai Social Enterprise Office has provided. And I got the third place. However, because my project has the greater impact to the society, Thai Social Enterprise Office has offered the funding for starting up the business."

Social entrepreneurship	Details
Information seeking	
SE1	look for information and doing some research keep searching for the scholarship provider
SE2	keep searching for a place to learn more and more of learning how to massage to look for the fund to help my business acting it very fast
SE5	to look for a place to receive the funding to start up the business to write the business plan and attend to the business plan competition that Thai Social Enterprise Office

Table .11. Summary of social entrepreneurship

Opportunity seeking. One of the thing that defines a social entrepreneur is his/her ability to search for potential opportunities. Because that is what being a social entrepreneur is all about: finding potential problems and opportunities, and providing real, tangible solutions to these problems. Identifying or discovering an opportunity comes naturally to them, and it is actually a big part of being a social entrepreneur. Here is some comments that support the idea of being an opportunity seeker.

SE1. "Chiang Mai is the biggest province in the Northern part of Thailand. There is always a room for business. Because I have a story to tell and can create the differentiation on the product, I choose to do the business here. In fact, Chiang Mai location is not far from Chiang Rai."

SE2. "I moved here because it is my wife's home. At first, I was thinking what I am going to do for a living, with the skill I have, massage is only skill. Chiang Mai is the tourist place and many tourist like to do the massage. At that time, I was looking for a job in the massage shop. Because I am a blind person, nobody recruits me for working. That is how I become an entrepreneur."

Social entrepreneurship	Details
Opportunity seeking	
SE2	always a room for business for a big city story to tell and can create the differentiation on the product
SE1	the tourist place and many tourist like to do the massage failing to find a job cannot be employee anywhere else become an entrepreneur

Table.12. Summary of social entrepreneurship

Passionate. Entrepreneurial passion is a motivational construct characterized by positive emotional arousal, internal drive and engagement with personally meaningful work that is prominent to the self-identify of the social entrepreneur. Social entrepreneurs who convey passion are more persuasive, motivated, have larger social networks and more social capital. As a result, they have more income, sales revenue and growth in sales and earnings compared with entrepreneurs who are less passionate. Passion is therefore is critical to a social entrepreneur's success. Here is some comments that support the idea of passionate.

SE2. "If you want to be a social entrepreneur, you need to really love to do it. It feels really attach to it. You really need to have a crush on it, which I always have."

SE1. "I really love to do massage and I believe this job will able to help people. Also, I can teach and pass on this skill to other blind person."

Social entrepreneurship	Details
Passionate	
SE2	need to really love to do it feeling really attach to it need to have a crush on it
SE1	really love to do massage believe this job able to help people

Table.13. Summary of social entrepreneurship

Social impact

As the results of this research, for social impact, I have found that there is a key main factor of how they measure. Thus, I present data from the five social entrepreneurs to show, in a structured manner, how I reached the themes from the first-order coding and second-order coding. I provides representative quotations supporting each of our second-order coding. I also used quotations in the text so as to provide a clear understanding of our analysis. Therefore, I present the result as following.

To measure the social impact, I found that all social entrepreneurs have confirmed that their social businesses have the impact to the society. These social businesses can solve the social problem by looking at income of people increase, so they can sustain themselves. Here is some comments that support quantitative measurement.

SE1. "I have kept tracking of my blind student after they have finished the massage course. I go to see how they are living with my assistant. I found that some of them have gained the income because they can buy some facility. However, some of them are not really better, but at least they have a skill of massage so that they can use this skill to make a living."

SE2. "I can see that people in the tribe have a car, income increase, and can buy some other facilities. Some of them can create their own business and make a brand of them."

SE3. And SE4. "Because these businesses are the member of World Fair Trade Organization, this organization will come to assess the impact to the society such as an income increase" as I have mentioned earlier.

SE5. "How I measure the impact of my business, I calculated from number of amount of investment, and number of old people that they can help." The owner has mentioned that he was measuring the social impact by using Social Return on Investment (SROI).

Furthermore, another type of measurement, it is hard to measure. All of social entrepreneurs have mentioned that "most people as their target group have improved the quality of living or well-being."

Qualitative measurement	Details
SE1	keep tracking of my blind student after they have finished the massage course to see how they are living to gain more the income
SE2	better life and better in living with all facilities create their own business and able to build a brand

SE3 and SE4	using the World Fair Trade Organization assessment
SE5	social return on investment (SROI)

Table .14. Summary of social impact measurement

3.3.Discussion

The finding of this research study is how human capital drive to social entrepreneurship. The results show that knowledge is the key point important that drives to social entrepreneurship. Knowledge as in this research study contains skill, education, training, and experience. These are factors that create the knowledge for social entrepreneur so that they can drive to the social entrepreneurship activity. It is correspond with Dee et al. (2001). They have found that social entrepreneurs need to have a knowledge to look for the opportunity and analyze how to find the customer's need to satisfy by using social innovative way. In addition, Guclu et al. (2002) has mentioned on their research that inspired idea is the important factor for operating the venture and also, knowledge is another important factor for success.

Another interesting finding, the results show that personality is also the key important for social entrepreneur. It consists of vision, passion, flexibility, and belief. Thus, personality may influence the intentions and the manner in which the individual acts (Koe Hwee Nga & Shamuganathan, 2010). It could be expected that social entrepreneurs often possess certain distinct personality characteristics which define their behaviors/actions. Personality traits are partly developed by innate nurturing, socialization and education. These tacit traits are also formed values/beliefs held and play an important role in driving social entrepreneurial decision making. Thus, personality traits may influence the intentions and the manner in which the individual acts (Koe Hwee Nga & Shamuganathan, 2010).

For social entrepreneurship, I have found three more factor that can be used to measure, which are passionate, information seeking, and opportunity seeking. It is correspondent to Buiza (2012) and Ruangkrit & Thechatakerng (2015). They agree that successful entrepreneurs have common characteristics, which are divided into three clusters; achievement, planning and power. Achievement cluster consists of opportunity seeker, commitment to the work contract, persistence, risk taking, and demand for efficiency and quality. Planning cluster consists of goal setting, information seeker, and systematic planning and monitoring. Power cluster consists of persuasion of networking and self-confidence.

Finally, social impact can be measured by looking at income of people increase and improving the quality of living or well-being. However, social impact is hard to measure (Cook et al., 2003; Economist, 2006; Seelos and Mair, 2005). As this research study, the result show that the impact can be seen as the society is increasing on income or profit. Also, the results show that improving the quality of living or well-being is hard to measure, but we can recognize and see how they have improved their quality of living. Robert and Woods (2005) mention that social entrepreneurship is building the venture that connect between business and philanthropic, environmental problem, and to fill the gap of income and employment difficulties.

3.4.Implications

The implications of this study for scholars and practitioners are many. First, although research is expanding on social entrepreneurship, limited research is available on social impact creation; therefore, this study contributes to the scholarly community by expanding on the existing limited research on the topic. Second, the study tested the scope and generalizability of an existing theoretical framework and provided additional insight about human capital of social entrepreneurs that consequence to social impact creation. Furthermore, because Thailand is an infancy experience of social entrepreneurship, by researching social entrepreneurs operating in the Thailand, the researcher expanded ongoing research in the field of social entrepreneurship. Third, this study followed recommendations from scholars who called for the use of qualitative methods to increase existing quantitative research, by studying the human capital of social entrepreneurs, studying how human capital drive to social entrepreneurship and how social entrepreneurship describe the experience of creating social impact (Mair et al., 2012; Sharir & Lerner, 2006; Zahra et al., 2009). Therefore, the study results will contribute to scholarly research by enlightening organization and management scholars about how social entrepreneurs relieve social problems.

3.5.Limitation

The major limitation of this study is the apparently small

size of the sample due to the relatively small size of the population comprising social entrepreneurs who have been recognized by Thai Social Enterprise Office. Moreover, the research is only taken in Chiang Mai province, Thailand. Furthermore, this is qualitative research, so it may not be able to generalize the results of research. Finally, this research study is only exploring of how human capital of social entrepreneurs that consequence to the social impact.

3.6.Recommendations for future research

The recommendations for further research are in two broad categories: recommendations from the data and the research design, and recommendations from gaps identified in the literature reviewed. For the data and research design, I would recommend for future to gather more data as in quantitative to confirm the model. The research design should be designed in quantitative research. More data are needed to confirm the model. In addition, another future research that I would recommend is to find the gap in the literature review to extend the boundary of social entrepreneurship, which this research has mainly focused on human capital, to make it more academic and practical.

Conclusion

The research is significant in the study of social entrepreneurship particularly because the researcher used the lens of multiple case designs analysis. The study involved the collection, analysis, and interpretation of the key informants' experiences regarding social impact creation from their perspective as social entrepreneurs. Research on social entrepreneurship is increasing, as is the scale and impact of social entrepreneurs in solving social problems. The researcher discussed the contributions of this research to the limited existing literature on social impact creation. The study also tested the scope and generalizability of an existing theoretical framework and provided additional insight about human capital of social entrepreneurs that consequence to social impact creation. Because social entrepreneurship research is in its infancy, this study is positioned to contribute significantly to the growing body of knowledge and is intended to benefit both academic and practitioner communities.

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Identifying Key Problems and Constraints in the Development of Innovative Activities in Technology Parks

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KEYWORDS

Technology park;
Innovation financing;
Public-private Partnership;
International cooperation;
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ABSTRACT

The study examines the potential for adapting successful elements of the Chinese technology park development model to the Republic of Belarus. The objective of the study is to identify factors reducing the effectiveness of Belarusian technology parks and identify areas for improvement, taking into account international experience. The paper consists of an introduction, which outlines the objective, hypothesis, and relevance of the topic. The main section presents an analysis of the institutional, financial, and organizational barriers to the operation of Belarusian technology parks; and a comparative study of the Chinese model, which demonstrates high performance. The results of the study demonstrate that eliminating the identified limitations and adapting individual mechanisms of Chinese practice can improve the effectiveness of technology parks and strengthen their role in the national innovation system.

ВВЕДЕНИЕ

Развитие инновационной инфраструктуры становится ключевым условием повышения конкурентоспособности национальной экономики, ускорения технологического обновления и формирования устойчивых источников экономического роста. В современных условиях именно технопарки выступают базовыми элементами инновационной экосистемы, обеспечивая трансфер технологий, поддержку высокотехнологичных компаний, создание рабочих мест и интеграцию науки, образования и бизнеса. Однако эффективность технопарков существенно зависит от качества институциональной среды, уровня финансирования, степени вовлечённости частного сектора и способности формировать благоприятные условия для инновационной деятельности.

В Республике Беларусь технопарковое движение находится в стадии становления. Несмотря на наличие сформированной сети научно-технологических парков, большинство из них сталкивается с ограничениями, связанными с недостаточным финансированием, слабой материально-технической базой, ограниченным спектром услуг, дефицитом квалифицированных кадров и недостаточной интеграцией в международные инновационные цепочки. Преобладание государственных инициатив при создании технопарков, отсутствие единой стратегии развития и слабая координация между участниками инновационной системы дополнительно сдерживают их потенциал.

В то же время Китай демонстрирует один из самых успешных в мире примеров развития технопарков и инновационных кластеров. Китайские индустриальные и научно-технологические парки стали драйверами модернизации экономики, обеспечив приток инвестиций, развитие высокотехнологичных отраслей и формирование устойчивых международных связей. Масштабность, разнообразие моделей, гибкость механизмов управления и активное участие частного сектора делают китайский опыт особенно ценным для стран, стремящихся ускорить инновационное развитие.

Сравнение белорусской и китайской практики выявляет существенный институциональный и технологический разрыв, который ограничивает возможности прямого заимствования моделей, но одновременно подчёркивает

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необходимость адаптации успешных элементов китайского подхода к национальным условиям. В условиях растущей конкуренции за инвестиции и человеческий капитал, а также необходимости повышения эффективности использования инновационных фондов, задача совершенствования деятельности белорусских технопарков приобретает стратегическое значение.

Актуальность исследования определяется необходимостью выявления ключевых проблем и ограничений, препятствующих развитию технопарков в Беларуси, анализа факторов, влияющих на их эффективность, и определения направлений адаптации международного опыта, прежде всего китайского, к национальной инновационной системе. Решение этих задач позволит повысить результативность технопарков, усилить их вклад в инновационное развитие регионов и обеспечить формирование устойчивой инновационной экосистемы.

Цель исследования – выявить ключевые проблемы и ограничения, препятствующие эффективному развитию технопарков в Республике Беларусь и в Китае, и обосновать направления их совершенствования с учётом успешных элементов китайской модели технопаркового развития.

Гипотеза исследования заключается в том, что повышение эффективности белорусских технопарков возможно при условии устранения институциональных, финансовых и организационных ограничений, а также адаптации отдельных механизмов китайской практики – диверсификации источников финансирования, усиления роли частного сектора, расширения международной кооперации и формирования специализированных инновационных кластеров. Объект исследования – технопарки как элементы национальной инновационной инфраструктуры. Предмет исследования – институциональные, организационно-экономические и управленческие механизмы функционирования технопарков, определяющие их эффективность и возможности развития в национальном и международном контексте.

1.Существует ряд препятствий, сталкиваясь с которыми технопарки не оказывают в полной мере содействие развитию инновационной инфраструктуры.

Во-первых, в Беларуси парковое движение находится на начальном этапе. Помимо широко известного китайско–белорусского индустриального парка «Великий камень», в стране создана сеть из семнадцати технопарков, созданных в основном совместными усилиями университетов и региональных властей. К 1 июня 2025 года в Беларуси насчитывалось четырнадцать научно-технических парков, двенадцать из которых функционировали как государственные учреждения, а два - в частной собственности. Однако их прогресс сдерживается рядом сохраняющихся недостатков: техническая инфраструктура часто остается устаревшей, требуется значительное повышение квалификации персонала, а доля действительно высокотехнологичной продукции по-прежнему невелика. Спектр услуг, доступных компаниям-резидентам, ограничен, практика управления инновациями недостаточно развита, и большинство парков продолжают ориентировать свою деятельность на внутренний рынок, сохраняя при этом лишь слабые позиции на международном уровне [1, с. 37].

Китай, напротив, давно завоевал и продолжает удерживать лидирующие позиции в мировом развитии промышленных и технологических парков. В стране насчитывается более семи тысяч таких площадок, расположенных в каждой провинции и организованных в самых разнообразных форматах. К ним относятся зоны технико-экономического развития, промышленные кластеры, парки высоких технологий, пилотные зоны свободной торговли, зоны трансграничного сотрудничества и экспортоориентированные производственные территории. Этот контраст подчеркивает настоятельную необходимость для белорусских регионов расширять собственную инновационную инфраструктуру, запускать новые специализированные платформы, расширять существующие парки и значительно повышать качество и масштабы своей деятельности.

Недостаточное освоение инновационного фонда. «В 2024 году было использовано 100 % средств республиканского инновационного фонда, однако были

не до конца задействованы ресурсы местных фондов: в Гродненской области реализовано 33,6 % средств, в Минской – 26,1 %, в Брестской – 63,5 %» [2]. Бюджеты большинства технопарков в Беларуси формируются за счет государственных средств, что не всегда позволяет обеспечить достаточное финансирование для всех необходимых проектов. К тому же, неразвитая система венчурного финансирования, недостаточный уровень доверия к белорусским стартапам и отсутствие механизмов стимулирования для частных инвесторов затрудняют привлечение средств в технопарки. Беларусь пока не получила широкого доступа к международным фондам для поддержки инноваций, что ограничивает возможности финансирования технопарков [3, с. 35].

Недостаточное финансирование. Инновационные инициативы могут получить финансовую поддержку только в том случае, если они удовлетворяют четко определенному набору требований. Прежде всего, планируемый технологический процесс должен обеспечивать уровень добавленной стоимости на одного сотрудника, который как минимум соответствует, а в идеале превосходит средние показатели, характерные для соответствующего сектора в Европейском Союзе. Кроме того, проект должен демонстрировать ярко выраженную экспортную направленность, подтверждая свою способность конкурировать за пределами внутреннего рынка [3, с. 35]. В Беларуси инициатива создания технопарков принадлежит, в подавляющем большинстве случаев, государству (государственной власти и государственным организациям), а не как в соответствии с мировым опытом частным субъектам – физическим лицам организациям [4, с. 173].

Рисунок 1 – Динамика объемов финансирования технопарков в Республике Беларусь за 2010-2024 гг.
Источник: [5].

2. Данные, представленные на рисунке, ясно указывают на то, что существующая сеть технопарков в Беларуси была создана в основном за счет государственных инвестиций, в основном за счет средств местных и национальных централизованных инновационных фондов.

Заметный сдвиг произошел в 2018 году, когда технопарки получили право создавать собственные фонды инновационного развития. Эти средства формируются из половины подоходного налога, уплачиваемого компаниями-резидентами, или из половины единого налога, уплачиваемого резидентами, работающими по упрощенной системе налогообложения, и накопленные ресурсы могут быть направлены, среди прочего, на капитальные затраты, такие как модернизация оборудования, расширение лабораторий или приобретение оборудования. современное оборудование.

Только в 2024 году на укрепление материально-технической базы научно-технических парков из государственного бюджета было выделено более 134 миллионов рублей. Эти инвестиции приносят ощутимую отдачу: каждый рубль бюджетной поддержки соответствует стоимости продукции, произведенной компаниями-резидентами, примерно на 7,4 рубля [6]. Однако в долгосрочной перспективе правительство, как правило, воздерживается от покрытия повседневных эксплуатационных расходов технопарков, сосредоточившись вместо этого на управлении, стратегическом планировании и координации приоритетов развития.

Белорусская модель заметно отличается от многих международных практик. В большинстве случаев создание технопарков в стране инициируется государственными органами или аффилированными с государством организациями, и это происхождение четко отражается в структуре финансирования. Государственные средства остаются доминирующим источником для создания инфраструктуры, даже несмотря на то, что часть этих ресурсов официально регистрируется в статистике как внебюджетное финансирование. На самом деле строительство и

расширение объектов технопарка по-прежнему в значительной степени зависит от государственного бюджета, который остается основным фактором формирования и роста национальной инновационной экосистемы.

Отсутствие единой государственной стратегии по развитию технопарков приводит к разрозненности действий разных министерств и ведомств, что затрудняет консолидацию ресурсов и координацию усилий. Слабая коммуникация между технопарками, научно-исследовательскими институтами, бизнес-инкубаторами и образовательными учреждениями препятствует обмену информацией, созданию синергии и объединению усилий. Отсутствие четкой специализации технопарков ограничивает их возможности для концентрации ресурсов на определенных областях и привлечения специалистов с уникальными компетенциями [3, с. 35].

Партнерские отношения с университетами играют центральную роль в функционировании технопарков. Во многих странах высшие учебные заведения активно участвуют в обучении предпринимателей, организации образовательных программ, подготовке специалистов для компаний-резидентов и формировании научно-исследовательской базы, на которой растет инновационный бизнес. В Беларуси это взаимодействие особенно сильно в тех технопарках, которые были созданы на базе университетов, где сотрудничество между академическими структурами и предприятиями-резидентами обычно является наиболее тесным и последовательным.

Отсутствие квалифицированных кадров. В Беларуси наблюдается дефицит высококвалифицированных специалистов в области науки, технологий и инноваций, особенно в перспективных отраслях (IT, биомедицина, зеленая энергетика). Недостаточное сотрудничество между технопарками и учебными заведениями приводит к тому, что выпускники вузов не всегда имеют достаточный практический опыт и трудятся не по специальности. Отсутствует достаточное количество программ переподготовки и повышения квалификации для специалистов, что ограничивает возможности для их профессионального роста и адаптации к требованиям инновационной экономики.

3. Несовершенство законодательной базы:

процесс регистрации новых компаний в технопарках может быть длительным и сложным, что отпугивает потенциальных резидентов. Недостаточная правовая защита интеллектуальной собственности и инвестиций создает неопределенность и риски для резидентов технопарков. Таким образом, законодательная база не всегда предоставляет достаточные стимулы для разработки и коммерциализации инноваций, что снижает мотивацию резидентов к активной деятельности.

За последние несколько лет белорусское правительство приложило значительные усилия для формирования правовой среды, направленной на стимулирование долгосрочного инновационного роста. Несмотря на достигнутый прогресс, согласованная и специализированная нормативно-правовая база, регулирующая деятельность технопарков, еще не создана. В результате многие парки в настоящее время объединяют проекты, которые резко отличаются как по технологической направленности, так и по стратегическому назначению, создавая пространства, которые часто напоминают скорее набор офисных и производственных помещений, чем полноценную среду, поощряющую сотрудничество, эксперименты и спонтанный обмен идеями.

Китай представляет собой контрастный пример. В этой стране нет единого общенационального закона, регулирующего деятельность технопарков, однако решения об их создании принимаются на уровне Государственного совета, в то время как региональные власти адаптируют операционные модели с помощью местного законодательства, отражающего конкретные экономические и географические условия. Поскольку китайские парки глубоко интегрированы в глобальные производственные и исследовательские сети, их практика формируется в соответствии с международными стандартами. Для Беларуси этот опыт подчеркивает важность приведения национального законодательства в соответствие с общепринятыми глобальными подходами, включая элементы, заимствованные из китайской модели, с целью повышения прозрачности, предсказуемости и международной ориентации отечественных промышленных и исследовательских парков. Интеграция белорусских парков в существующие сети

Экономического пояса Шелкового пути, разработка скоординированных программ сотрудничества и расширение услуг для иностранных резидентов, в частности, помощь в ознакомлении с местными нормативными актами и деловой практикой, могли бы значительно укрепить их глобальное участие [1, с. 37].

Другой постоянной проблемой является ограниченная доступность эффективных механизмов поддержки. Стартапы, работающие в технопарках, часто сталкиваются с ограниченным доступом к финансовым инструментам, что замедляет темпы запуска и масштабирования инновационных проектов. Услуги по маркетингу и продвижению не всегда достаточно развиты, что затрудняет компаниям-резидентам выход на новые рынки и повышение узнаваемости бренда. Кроме того, сотрудничество с международными организациями, университетами и частными компаниями остается неравномерным, что сокращает возможности для обмена знаниями, притока инвестиций и технологического сотрудничества.

По данным Государственного комитета по науке и технологиям Беларуси, отечественные технопарки уже дают положительные результаты, особенно в плане создания рабочих мест и получения дохода. В то же время дальнейшее расширение может быть ограничено ограниченными ресурсами для развития инфраструктуры и проблемами привлечения малых и средних предприятий. Со временем и накопленным опытом эти барьеры могут быть постепенно преодолены. Укрепление государственной инновационной политики и совершенствование инструментов поддержки будут необходимы для того, чтобы технопарки в полной мере реализовали свой потенциал в качестве катализаторов технологического прогресса и более широкого социально-экономического развития.

Ограничениями для установления более глубоких связей Беларуси и Китая остаются существенный институциональный и технологический разрыв между странами, а также значительные различия в области инновационного развития. Это приводит, с одной стороны, к неготовности белорусских субъектов к участию в качестве резидентов и инвесторов в китайских индустриальных парках, а с другой – сдерживает развитие инновационного взаимодействия на рыночной основе с ориентацией на технологии V и VI технологических укладов. Кроме этого, невысокая емкость белорусских рынков товаров, услуг, технологий предопределяет возможность ориентации китайских производителей на европейский или евразийский рынки. Однако в этом случае Китай может рассматривать иные варианты сотрудничества, например, со странами ЕАЭС, где уровень технологичности экономики выше укладов. Кроме этого, невысокая емкость белорусских рынков товаров, услуг, технологий предопределяет возможность ориентации китайских производителей на европейский или евразийский рынки. Однако в этом случае Китай может рассматривать иные варианты сотрудничества, например, со странами ЕАЭС, где уровень технологичности экономики выше [1, с. 37].

Отсутствие отлаженной системы взаимодействия между инновационными структурами и университетами. Фирмы-арендаторы в технопарке должны получить возможность формального и неформального сотрудничества с научными сотрудниками и преподавателями вузов, льготный доступ к научным и технологическим разработкам, информационным и библиотечным ресурсам. Для университетов тесное взаимодействие с арендаторами технопарка – это возможность приблизить содержание и цели программ обучения к потребностям перспективных нанимателей и для повышения шансов на трудоустройство выпускников, что способствует укреплению репутации и престижа вуза.

В Беларуси же отношения между инновационными структурами и вузами пока имеют выраженную учебную окраску, а контакты в области научных исследований и разработок носят чаще разовый и очень избирательный характер. Широкое сотрудничество технопарков, научно-исследовательских и опытно-конструкторских объединений с ключевыми предприятиями промышленного комплекса будет способствовать налаживанию гибких сетевых взаимосвязей и их расширению, а также поступательному развитию высокотехнологичных производств. В мировой практике между университетами и фирмами-резидентами технопарков или парков высоких технологий, устанавливаются партнерские взаимоотношения, которые носят взаимовыгодный характер.

Для компаний, которые предпочитают размещаться в технопарках, преимущества выходят далеко за рамки предоставления офисных или лабораторных помещений.

Резиденты получают доступ как к формальным партнерским отношениям, так и к повседневному неформальному взаимодействию с университетскими исследователями и преподавателями, получают приоритетное представление о новых научных и технологических разработках и могут полагаться на академические информационные системы, библиотеки и исследовательскую инфраструктуру. Для университетов такая близость к бизнесу обеспечивает ценную обратную связь: образовательные программы могут быть скорректированы с учетом реальных потребностей отрасли, стажировки становится легче организовывать, а выпускники выходят на рынок труда с большими перспективами. Этот взаимный обмен в конечном счете укрепляет репутацию высших учебных заведений и усиливает их роль как ключевых участников экономического развития. Однако в Беларуси сотрудничество между университетами и инновационными предприятиями по-прежнему сосредоточено в первую очередь на образовании, в то время как совместные научно-исследовательские проекты возникают спорадически и остаются весьма избирательными [7, с. 391].

Еще одним препятствием для расширения деятельности технопарков является их ограниченная интеграция с региональными экономиками. Хотя местные органы власти выступают в качестве учредителей трех белорусских технопарков, потенциал межрегионального сотрудничества остается в значительной степени неиспользованным. Между белорусскими регионами и провинциями Китая подписано более ста соглашений, однако подлинное сотрудничество между самими технопарками практически не налажено. Единственными заметными примерами являются соглашения, заключенные администрацией Свободной экономической зоны «Брест» с Национальной зоной промышленного развития высоких технологий Сяогань в провинции Хубэй и районом высоких технологий Бэнбу в провинции Аньхой. В то же время региональные администрации не обладают независимыми полномочиями по формированию инновационной политики и, главным образом, по реализации национальных стратегий. Это институциональное ограничение сужает сферу поддержки, которую они могут предложить технопаркам, в том числе на международной арене, и ослабляет стимулы местных органов власти к углублению сотрудничества с помощью этих платформ.

В последние годы влияние торговой войны между США и Китаем и всплеск возвращения домой также привели к быстрому росту населения в районах, прилегающих к научным паркам, а инфраструктуры будет недостаточно из-за большого роста населения. Если общее планирование в области охраны окружающей среды будет проигнорировано, это повлияет на устойчивое развитие поселений [8].

Хотя сотрудничество в создании совместных технопарков сулит заметные экономические преимущества, превращение этой модели в стабильный канал межрегионального партнерства между Беларусью и Китаем остается сложной задачей. Прогрессу продолжает препятствовать ряд сохраняющихся барьеров, в том числе неравномерное участие предприятий, законодательные положения, которым по-прежнему не хватает ясности, и отсутствие хорошо отработанных механизмов управления и координации совместных парковых инициатив. Эти факторы делают процесс налаживания долгосрочного сотрудничества более сложным, чем предполагалось изначально.

На современном этапе Беларусь в основном завершила формирование своей сети технопарков, однако ее структура по нескольким существенным параметрам отличается от мировой практики. Университетские парки занимают гораздо большую долю, чем это обычно бывает на международном уровне, и инициатива по созданию новых площадок чаще всего исходит от государственных органов и общественных организаций, а не от частных инвесторов. Это объясняет, почему развитие такой инфраструктуры в значительной степени зависит от бюджетного финансирования. Технопарки уже стали важным компонентом современной экономической системы, но их долгосрочная эффективность будет зависеть от нескольких условий: надежных инструментов финансовой поддержки, слаженного взаимодействия всех участников инновационной экосистемы, наличия сильного резерва квалифицированных специалистов в регионах, более высокой готовности промышленных предприятий к внедрению инноваций. новые технологии и продолжающееся совершенствование законодательной базы, регулирующей инновационную инфраструктуру в Беларуси.

Заключение

Анализ показал, что, несмотря на формирование сети технопарков в Беларуси, их эффективность остаётся ограниченной из-за институциональных, финансовых, организационных и кадровых барьеров. Преобладание государственной инициативы, недостаточная материально-техническая база, слабая интеграция с университетами и промышленностью, узкий спектр услуг и несовершенство нормативно-правовой базы препятствуют превращению технопарков в полноценные центры инновационного развития.

Сравнение с китайской моделью подтвердило наличие значительного разрыва, но одновременно выявило направления, которые могут быть адаптированы к белорусским условиям. Китайский опыт демонстрирует, что высокая результативность технопарков достигается благодаря диверсификации источников финансирования, активному участию частного сектора, гибким механизмам управления, чёткой специализации, глубокой интеграции с университетами и международной кооперацией.

Повышение эффективности белорусских технопарков возможно при реализации комплекса мер: совершенствовании нормативно-правовой базы и формировании единой стратегии развития; расширении механизмов привлечения частных инвестиций и венчурного капитала; модернизации организационно-экономических моделей управления; укреплении связей с университетами и промышленностью; развитии кадрового потенциала; а также интеграции в международные инновационные сети, включая сотрудничество с китайскими индустриальными зонами. Реализация этих направлений позволит технопаркам стать значимым инструментом инновационного роста и повысить устойчивость национальной инновационной системы

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Выявление ключевых проблем и ограничений в развитии инновационной деятельности технопарков

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Аннотация: Республике Беларусь, и оценивается возможность адаптации успешных элементов китайской модели технопаркового развития. Цель исследования — выявить факторы, снижающие эффективность белорусских технопарков, и определить направления их совершенствования с учётом международного опыта. Структурно работа состоит из введения, где формируется цель, гипотеза и актуальность темы, в основной части представлен анализ институциональных, финансовых и организационных барьеров в деятельности белорусских технопарков; сравнительное исследование китайской модели, демонстрирующей высокую результативность. Результаты исследования показывают, что устранение выявленных ограничений и адаптация отдельных механизмов китайской практики способны повысить эффективность технопарков и укрепить их роль в национальной инновационной системе.

Ключевые слова: технопарк; инновационная инфраструктура; институциональные ограничения; финансирование инноваций; государственно-частное партнёрство; международная кооперация; инновационная политика; кластеризация; трансфер технологий; развитие регионов.

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Exploring the Integration Path of Intangible Cultural Heritage Revitalization and Commercial Innovation: A Case Study of the "Rhythm of Dye: Blind Collection" Tie-Dye Blind Box Project

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KEYWORDS

Intangible Cultural Heritage;

Tie-dye;

Blind Box Economy;

Cultural Capital Transformation;

Business Model Innovation;

ABSTRACT

Against the backdrop of cultural industry innovation and consumption upgrading, the revitalization of Intangible Cultural Heritage (ICH) faces a transitional need from "protective inheritance" to "innovative development." Taking the "Dye-Charm Blind Collection" tie-dye blind box project as a case study and employing qualitative research methods, this paper systematically explores innovative pathways for integrating ICH with the blind box economy. The research finds that the project achieves the commercial transformation of tie-dye cultural capital through a three-dimensional innovation system encompassing "product reconstruction (cultural symbols + functional extension + experience design), technological empowerment (process optimization + digital design + standardized production), and ecosystem construction (online-offline integration + domestic-overseas markets + experience-sales synergy)." Practice demonstrates that the project has not only achieved significant economic benefits (projected revenue of 1.7 million RMB for 2025, with a repurchase rate of 40%) but also generated positive social impacts in areas such as rural revitalization and cultural dissemination. This study proposes that ICH revitalization should, based on Cultural Capital Theory and Scene Consumption Theory, construct a sustainable development model of "culture-commerce-society" synergistic symbiosis, providing theoretical reference and practical guidance for the innovative development of ICH.

INTRODUCTION

As a vital carrier of the excellent traditional Chinese culture, the protection and inheritance of Intangible Cultural Heritage (ICH) has always received significant national attention [1]. However, within the macro-context of globalization, digitalization, and shifting consumption cultures, many ICH skills are facing a survival crisis characterized by "generational breaks in transmission, product-market disconnect, and market contraction" [2 – 4]. Sole reliance on salvage documentation and static preservation can no longer sustain their vitality. Exploring pathways for revitalization through "protection in development and inheritance in innovation" has become a shared concern for both academia and industry [5,6]. Tie-dye, a representative of China's traditional textile dyeing and printing techniques, was inscribed on the National List of Intangible Cultural Heritage in 2006 [7]. Its core technique of resist-dyeing through tying and binding with threads produces natural, infinitely varied visual beauty, carrying rich regional culture, folk beliefs, and aesthetic philosophy [8]. However, similar to many traditional handicrafts, tie-dye is trapped in challenges such as outdated product forms, an aging consumer base, and a fragmented, small-scale industry [9,10]. Therefore, researching how tie-dye techniques can integrate into contemporary life through creative transformation and innovative development holds significance not only for supplementing ICH protection theory but also for offering concrete references for cultural industry practice.

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1.Research Methods and Case Selection

This study adopts a qualitative case study method, employing participatory observation, in-depth interviews, and document analysis to conduct longitudinal tracking of the "Dye-Charm Blind Collection" project. This case possesses typicality and foresight: Firstly, it directly confronts the core inheritance challenges of tie-dye skills; Secondly, it innovatively integrates the "blind box," a highly representative new consumption model; Thirdly, it has established a complete value chain from R&D and production to marketing, achieved preliminary market validation and social resonance, and thus meets the mature conditions for in-depth study.

2.Analysis of Development Dilemmas and Market Opportunities for ICH Tie-Dye

2.1.Multidimensional Dilemmas: Systemic Challenges in Inheritance, Product, and Market

The contemporary survival dilemma of tie-dye skills is a systemic issue, primarily manifested in three dimensions:

2.1.1.Inheritance and Dissemination Dilemma: Singular Channels and Audience Disconnect.

The inheritance of tie-dye skills has long relied on "oral transmission and personal demonstration" within families or master-apprentice relationships, along with local festival exhibitions, resulting in a limited dissemination radius. In today's world dominated by digital media for information dissemination, this traditional model struggles to reach the younger generation, the future mainstay of consumption. Surveys indicate that youth aged 18-30 predominantly hold stereotypical perceptions of tie-dye as "tourist souvenirs" or "outdated handicrafts," lacking understanding of its cultural depth and craft aesthetics, leading to weak emotional connection. Consequently, the inheritor group is aging severely, facing a shortage of successors.

2.1.2.Product Innovation Dilemma: Fixed Forms and Context Disconnect.

Most tie-dye products currently circulating in the market remain traditional categories like scarves, clothing, and wall hangings, with design styles tending towards formulaic patterns, often emphasizing "ethnic style" or "retro feel." This creates a significant gap with the aesthetic preferences (e.g., simplicity, personalization) and usage scenarios (e.g., office, social gifting) of modern urban life. Intense homogenized competition, coupled with a lack of functional extension and emotional added value, means these products can only maintain limited premium pricing relying on "handmade" or "ICH" labels, resulting in a low market ceiling.

2.1.3.Industrial Development Dilemma: Non-standardized Production and Cost Paradox.

Tie-dye production mostly relies on family workshops or small-scale studios. Production processes, dye formulations, and quality control depend heavily on artisan experience, lacking standardized systems, which leads to inconsistent product quality. Simultaneously, purely handmade production is inefficient with high labor costs, causing product pricing to be generally high (common clothing items often priced above 200 RMB), exceeding the psychological expectations for daily mass consumption. This creates an awkward situation of being "praised but not purchased," hindering industrial scaling and branding development.

Dilemma Dimension	Specific Manifestations	Innovative Countermeasures
Inheritance & Dissemination	Singular channels, audience disconnect	Blind Box Carriers + Social Dissemination to Reach Young Demographics
Product Innovation	Fixed forms, context disconnect	Cultural symbol translation + functional extension, adapting to modern scenarios
Industrial Development	Non-standardized production, high costs	Technological optimization + standardized production, reducing costs
Market Expansion	Domestic limitations, low	Cross-border cultural narrative

	international recognition	+ platform synergy, expanding overseas markets
Data Source	Industry research and literature review	Project practice summary

Table.1. Comparative Analysis of Tie-Dye Industry Development Dilemmas and "Dye-Charm Blind Collection" Innovative Countermeasures

2.2. Literature Review and Research Gap

In recent years, cross-disciplinary research on the revitalization of intangible cultural heritage and commercial innovation has become a prominent topic in the field of cultural industries. Existing studies have laid a theoretical foundation for this paper, yet there remains considerable scope for further expansion. Since the 18th National Congress of the Communist Party of China, promoting the creative transformation and innovative development of excellent traditional Chinese culture has become a crucial direction. ICH, as a vivid witness of Chinese civilization, is being integrated into modern life through commercialized innovation, becoming a cultural driving force for high-quality economic and social development.

In foundational theoretical research on ICH revitalization, "productive protection" was an early core paradigm. Gao [11] proposed that ICH protection needs to maintain the living inheritance of skills in production practice, avoiding static preservation. However, this theory does not clarify the path connecting production with market demand, making it difficult to solve the disconnect between traditional skills and contemporary consumption. Li [12] further proposed the concept of "innovative development," emphasizing that ICH should integrate into modern life scenarios, achieving value regeneration through design innovation and functional reconstruction. However, her research focuses more on macro-level conceptual interpretation, lacking operational frameworks for specific industry integration. Liu and Leng [13] defined China's ICH protection approach of "productive protection" as a unique Chinese path, highlighting its practice-oriented nature, but the discussion on commercial mechanisms remains relatively weak.

At the level of research on practical actors and pathways for ICH revitalization, scholars focus on multi-agent collaboration and cross-border integration trends. Research indicates that diverse actors including veteran artisans, new-generation inheritors, cultural and creative platforms, and commercial enterprises work together, opening new paths for ICH inheritance and innovation. Among them, new-generation inheritors, with their acute market perception, are adept at combining modern elements with ICH skills; cultural and creative platforms play a bridging role, connecting market demand, designers, and artisans. For instance, "Wang's Handicraft" integrates Miao embroidery and other skills with blind box formats, creating popular innovative products; commercial enterprises promote ICH industrialization through digital technology empowerment and industry chain integration. In terms of specific pathways, ICH commercial innovation has formed four main directions: product iteration, category expansion, IP creation, and technology empowerment. These involve updating product content and form, broadening application scenarios, shaping cultural IPs, and leveraging cutting-edge technologies to transform ICH from traditional crafts into marketable products. Wang and Cao [14], from a design perspective, pointed out that the key to ICH revitalization lies in translating traditional symbols through modern design language to enhance contemporary aesthetic value, but did not address emerging forms like "ICH + new consumption models." Liu and Zhang [15] explored the application of AI and big data in ICH inheritance, arguing that digital technologies can optimize production efficiency and expand dissemination scope, but did not delve deeply into the synergistic mechanism between technology and business logic.

In studies related to blind box economics and cultural consumption, Zhang and Yang [16] argues, based on the consumption psychology of Generation Z, that the "unpredictability" and "collectibility" of blind boxes align with the emotional needs and social demands of young consumers, thereby offering a novel medium for the dissemination of cultural products. According to the 2025 China Digital Entertainment Industry IP Development Report, blind box products have driven a year-on-year growth of 62.8% in the market size of cultural and creative derivatives, with emotional experience consumption among Generation Z rising to 68.05%, reflecting a trend toward greater specialization, segmentation, and emotional engagement in the cultural and creative market. Cases such as the derivative blind boxes of the 15th National Games

mascot demonstrate that blind box products integrating traditional cultural elements possess strong market appeal, with their core competitiveness stemming from the emotional value attached to the unboxing process and the collectible nature of the products. However, existing research has predominantly focused on analyzing blind box marketing models or describing individual cases, leaving a gap in exploring the deep integration mechanisms between blind boxes and intangible cultural heritage (ICH) crafts, as well as a lack of systematic investigation into the full-chain commercial logic of the "ICH + blind box" model.

Regarding the application of theoretical tools, Bourdieu's Cultural Capital Theory provides an important analytical perspective for ICH value transformation. This theory divides cultural capital into three forms: embodied, objectified, and institutionalized, offering theoretical support for interpreting the transformation process of ICH from skill inheritance to commercial product [17]. Chen and Yan [18] explored innovative pathways for ICH revitalization from a scene consumption perspective, while Zhou and Xiao [19] analyzed the commercial transformation mechanism of ICH based on Cultural Capital Theory. However, existing research has yet to combine these perspectives to systematically explain the adaptation logic between ICH and the emerging consumption scene of blind boxes.

In summary, existing research exhibits three notable gaps: Firstly, most studies on ICH revitalization focus on single actors or single paths, lacking systematic analysis of multi-agent collaboration and multi-dimensional innovation, particularly neglecting the deep integration mechanism between new consumption models and ICH. Secondly, for emerging forms like "ICH + blind box," a complete academic discussion encompassing product design, technological support, and business model construction has not yet been formed, and research on their emotional consumption logic and cultural dissemination value remains insufficient. Thirdly, existing research often emphasizes macro-level concepts or single-case descriptions, lacking deep integration between theoretical tools and empirical cases, making it difficult to form replicable generic models. Based on this, this paper takes the "Dye-Charm Blind Collection" tie-dye blind box project as a case study to systematically explore innovative pathways for integrating ICH with the blind box economy, aiming to fill the gaps in existing research.

3.The Three-Dimensional Innovation Practice System of the "Dye-Charm Blind Collection" Project

The project has constructed a three-in-one integrated innovation system with product innovation as the front-end carrier, technological innovation as the middle-platform support, and model innovation as the back-end engine.

3.1.Product Innovation: From "Single Handicraft" to "Diverse Experience System"

The project completely transcends the physical definition of tie-dye as merely "fabric decoration," redefining it as a "cultural experience medium" that is collectible, experiential, and usable. Based on Symbolic Interaction Theory, the products achieve deep interactive identification between consumers and ICH culture through a triple construction of "visual symbols + functional symbols + knowledge symbols." This process also represents the activation of tie-dye cultural capital from a "tacit" to an "explicit" state.

3.1.1.Core Product Line: The "Xiaosheng" Series — Contemporary Translation of Cultural Symbols.

This series takes the traditional Chinese zodiac culture as its IP core and undergoes in-depth design transformation. The team collaborates with intangible cultural heritage inheritors to match the morphological characteristics and symbolic meanings of zodiac animals with traditional tie-dye techniques such as "spiral binding," "folding binding," and "clamp dyeing." For example, the "Tiger" design employs bold, angular binding to convey the animal's power, while the "Rabbit" design utilizes delicate "dot binding" to capture its agility. Each design undergoes over 12 rounds of pattern refinement and color calibration. The product innovatively incorporates capsules of natural plant-based fragrance, using slow-release technology to ensure the scent lasts for 6–8 months. This transforms the item from a static visual artwork into a multifunctional "ambiance product" that combines decoration, aroma, and symbolic blessing, seamlessly integrating into modern life scenarios such as car interiors, home spaces, and offices. The included "ICH Knowledge Card," which explains zodiac culture and tie-dye techniques in youth-oriented language, seamlessly bridges the gap between consumption and education.

3.1.2.Experience Product Line: "Player's Fun" Series – Lowering Barriers through Participatory Creation.

To address the challenge of "high threshold for ICH experience," the project developed DIY kits containing pre-treated fabric, safe plant dyes, simple tools, and HD video tutorials. Users with no prior experience can complete a unique tie-dye piece within 2-3 hours. By organizing "hidden pattern challenge contests" and establishing a "work sharing platform," the project extends one-time purchases into continuous creative interaction and community exchange, significantly enhancing user stickiness and brand loyalty. This series has gained high recognition among young consumer groups.

3.1.3.Derivative Product Line: Contextual Expansion and B2B Customization.

Centered on contexts like home, office, and gifts, products such as tie-dye notebooks, bedding, and tea mats were developed, leaning towards simple and modern styles. Simultaneously, collaborations with wedding companies for customized wedding favors and with enterprises for corporate gifts successfully tapped into the B2B bulk purchase market, broadening revenue streams.

3.2.Technological Innovation: Process Revolution and Efficiency Enhancement Empowered by Technology

Adhering to the principle of "upholding authenticity while pursuing innovation," the project leverages modern technology to tackle industrial pain points while preserving the core handmade charm and eco-friendly philosophy of tie-dye. According to Technology Integration Theory, the project achieves complementary integration between traditional craftsmanship and modern technology, maintaining the core authenticity of tie-dye skills ("upholding authenticity") while addressing efficiency and cost issues through technological optimization ("pursuing innovation").

3.2.1.Process Optimization: Overcoming Efficiency and Environmental Bottlenecks.

Addressing the low dye utilization rate (only about 60%) and lengthy duration of traditional immersion dyeing, the team developed a "Precision Dyeing System using Atomized Dyes." This system uses ultrasonic atomization equipment to convert plant dyes into micron-sized particles for even adsorption onto tied fabric, increasing dye utilization to over 92% (based on in-house R&D process tests). The dyeing time per batch was reduced from 24 hours to 5 hours, with richer color gradations. For color fixation, an innovative approach using plant mordants combined with low-temperature gradient drying technology was adopted, achieving color fastness above Grade 4. Products show no significant fading after 50 standard washes, far exceeding industry averages.

3.2.2.Digital Design R&D: AI-Assistance and Personalized Customization.

Collaborating with a tech company, an AI-assisted pattern design system was developed. This system, trained on thousands of classic tie-dye pattern datasets, can quickly generate new pattern proposals blending traditional charm with modern sensibility based on color trends and user preference keywords. The system also offers a simple customization interface for consumers. Users can input elements like name initials or commemorative dates to generate a preview of a unique pattern, achieving "a thousand patterns for a thousand faces" and flexible design, pushing ICH from "batch reproduction" towards "personal expression."

3.2.3.Standardized Production Management: Building a Quality Control System.

Standard Operating Procedures (SOP) and intelligent monitoring equipment were introduced at key production stages for precise control of parameters like dye concentration, temperature, and time. A full-process quality traceability system from raw material intake to finished product delivery was established, ensuring stability and consistency in product quality, laying the foundation for branding and scaling.

3.3.Model Innovation: Constructing an Omni-Channel Ecosystem Integrating Online-Offline and Domestic-Overseas

The project abandoned single sales channels, constructing a three-dimensional, interconnected business ecosystem that drives traffic mutually. Based on Value Network Theory, this ecosystem connects diverse actors including inheritors, consumers, rural communities, and overseas markets, forming a network system for value co-creation and sharing, breaking through the limitations of the linear value chain in traditional ICH industries.

3.3.1.Online Matrix: Content-Driven Strategy and Social Diffusion.

On platforms such as Douyin and Xiaohongshu, live-streaming sessions featuring "ICH inheritors + influencers" deeply demonstrate the tie-dye craftsmanship and product narratives, transforming the production process into a viewable and interactive "content commodity." Initiatives such as the hashtag challenge "#OpenABlindBoxLearnICH#" encourage users to create unboxing and DIY process videos, forming a substantial pool of user-generated content (UGC). This approach achieves low-cost, high-trust social diffusion. The online store and reservation system are seamlessly integrated, effectively channeling online traffic to offline experiential activities.

3.3.2.Offline Touchpoints: Immersive Experience and Spatial Empowerment.

In cultural and creative districts of major cities, experiential stores named "Rhythm of Dye" have been established, creating integrated cultural complexes that combine exhibition, hands-on workshops, retail, and salon activities. Concurrently, through partnerships with rural areas in Yunnan and Sichuan, which are the origins of tie-dye craftsmanship, "ICH Study Bases" have been set up. These bases facilitate the development of "ICH-Themed Tours," directing consumers toward the cultural source. This approach has established a positive cycle of "urban traffic generation and rural benefit," effectively linking metropolitan engagement with regional cultural sustainability.

3.3.3.Cross-Border Expansion: Cultural Storytelling and Platform Synergy.

The overseas promotion strategy adheres to the principle of "Culture First." On platforms such as Instagram and TikTok, short videos are used to narrate the historical background, philosophical concepts, and intricate craftsmanship of tie-dye, shaping a brand image for Chinese culture that is premium, distinctive, and profound. On the sales front, leveraging e-commerce platforms like Amazon and AliExpress, the brand offers a "Complete Cultural Product Package" that includes an English-language cultural handbook. Furthermore, collaborations with overseas Chinese Cultural Centers and museums to host workshops have effectively established an overseas conversion pathway from "cultural awareness" to "product purchase."

4. Comprehensive Evaluation of Project Implementation Outcomes

4.1.Economic Benefits: Diversified Revenue and Rapid Growth

The project has established a healthy financial model. C-end retail (blind boxes, derivatives) contributes the main revenue, with a repurchase rate reaching 40% (project Q1 2024 sales data). The core "Xiao Sheng" series maintains stable monthly sales exceeding 3,000 units. B-end customization and cross-border sales have become new growth engines. Total revenue for 2025 is projected to surpass 1.7 million RMB (based on industry growth rates and project channel expansion plans), with net profit margin maintained above 25%. The first round of financing has been initiated, with reasonable valuation and a clear equity structure, preparing sufficient capital for subsequent expansion.

4.2.Social Benefits: Empowering Rural Areas and Promoting Employment

The project practices the principle of "Business for Good." Its self-owned workshop in Dali provides stable employment for 15 local artisans, whose average monthly income exceeds the local average by 30% (project HR statistics). Through an order-based agriculture model, long-term procurement agreements have been signed with over 50 households cultivating dye plants, increasing their average annual income by more than ¥10,000 (data from partner

household surveys). The intangible cultural heritage (ICH) study programs have stimulated local consumption in catering and accommodation, injecting new tourism-driven momentum into rural revitalization. Furthermore, the project's public welfare training courses have cumulatively trained over 200 individuals, including rural women and persons with disabilities (project charity activity records), fostering inclusive transmission of traditional craftsmanship.

4.3.Cultural Benefits: Revitalizing Inheritance and International Dissemination

The most profound impact of the project lies in the activation of cultural value. Through fashionable and engaging reinterpretation, tie-dye has emerged as a symbol of "Guochao" (China-Chic) on social media, captivating young audiences. Over 70% of the project's official account followers are under the age of 35 (platform backend data). More than 80% of consumers reported having "reconnected with tie-dye culture" through the products (consumer survey results). Internationally, the project has become a regular feature in cultural exchange events in countries such as Belarus and Kazakhstan, with products sold in over ten nations. It now serves as a significant vehicle for narrating Chinese stories and conveying Eastern aesthetics.

5. CInsights into Pathways for ICH Revitalization and Commercial Innovation

The success of the "Dye-Charm Blind Collection" project is not accidental. It systematically validates a viable pathway for ICH revitalization, offering profound insights for both theory and practice:

First, value reconstruction is the core premise. The revitalization of intangible cultural heritage (ICH) must go beyond superficial adaptation; it requires a contemporary reinterpretation of its cultural value. By elevating tie-dye from a mere "craft" to a "narrative medium embodying zodiac culture" and an "experiential tool for creating a better life," the project has fundamentally reconstructed its value.

Second, integrated innovation demands systematic advancement. Isolated innovations in products or marketing are seldom sustainable. By synchronizing innovation across three dimensions—product, technology, and model—the project has established an interlocking and mutually reinforcing "innovation matrix," building a robust competitive barrier.

Third, the business model should foster an ecosystem of symbiosis. A successful ICH commercial project should function as a value network connecting inheritors, consumers, rural communities, and international markets. Through online-offline integration, urban-rural interaction, and cross-border dissemination, the project has constructed a multi-stakeholder ecosystem that shares value, ensuring sustainability and social impact.

Fourth, social responsibility and commercial interests can be mutually reinforcing. The project demonstrates that deeply integrating rural revitalization, employment promotion, and environmental stewardship into the business logic not only enhances brand reputation but also secures policy support and community resources, achieving a "dual-drive" of commercial and social value.

The core finding of this study is that the essence of ICH revitalization lies in the contemporary transformation and contextual reconfiguration of cultural capital. The success of the project stems from its symbolic conversion of cultural capital through product innovation, the enhancement of production efficiency of cultural capital through technological innovation, and the expansion of realization scenarios for cultural capital through model innovation. Ultimately, this has forged a synergistic mechanism integrating "cultural value—commercial value—social value," providing a replicable theoretical framework for similar ICH revitalization projects.

Nonetheless, the project faces challenges, such as the ongoing pressure for product iteration, the need to deeply adapt to cultural differences in overseas markets, and balancing scale expansion with artisanal quality. Future exploration could delve deeper into areas like digital collectible development, virtual experience creation, and collaborations with international designers.

In summary, the case study demonstrates that the revitalization and transmission of ICH is a systematic endeavor requiring the synergistic application of cultural insight, design creativity, technological application, and business acumen. It outlines a vision where ICH, while respecting its authenticity, can be revitalized in modern societal life through thoughtful commercial design, achieving a multi-faceted win for cultural preservation, industrial development, and social well-being.

Conclusion

From the practice of "Dye-Charm Blind Collection," we see that tradition is not a burden for progress but a source of innovation. Enabling ICH to "live" in the present, "flourish" in daily life, and "walk" towards the world requires not only sentiment but also a set of scientific methods and business models that transform cultural wisdom into modern value. This is perhaps the most solid and charming step in promoting the creative transformation and innovative development of China's excellent traditional culture.

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A Study on the Protection Strategies of Historical Buildings in Longshengzhuang Commercial Area, Inner Mongolia, Based on Comprehensive Value Grading

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KEYWORDS

Historical buildings and shops;

Comprehensive value classification;

Protection strategies;

Longshengzhuang:

ABSTRACT

Commercial historical buildings, as products of the fusion of commercial activities and historical culture, possess unique architectural styles and profound historical connotations. They are not only a key component of cultural heritage but also witnesses to urban history and culture. This paper takes the historical buildings of Longshengzhuang Commercial Area as its research object, constructing a comprehensive value evaluation system for these buildings based on seven indicators: historical value, scientific value, artistic value, commercial value, social value, surrounding spatial environment, and surrounding cultural environment. The system evaluates and delineates the protection levels of the Longshengzhuang Commercial Area historical buildings, proposing graded protection measures from three dimensions: overall protection strategy, protection objectives, and specific measures.

INTRODUCTION

The "Guiding Opinions on Strengthening the Protection and Inheritance of Historical and Cultural Heritage in Urban and Rural Construction" clearly states that "a graded protection system should be established for historical buildings." The basis of this graded protection system is a comprehensive and integrated assessment of the value of historical buildings, but currently there is a lack of a sound comprehensive value assessment system to support this work. Different historical buildings also have significant differences in cultural value, degree of damage, and protection measures, which brings certain difficulties to the protection work [1]. The earliest domestic research on the comprehensive evaluation of historical buildings can be traced back to Zhu Guangya [2]'s comprehensive evaluation of Suzhou historical buildings. Subsequently, different scholars have continuously optimized and improved the different types of heritage [2-3], protection processes [4-5], protection carriers [6-7], evaluation methods [8-9], and evaluation standards [10-11]. As a product of the integration of commercial activities and historical culture, the historical buildings of shops have unique architectural styles and profound historical connotations. They are not only a key component of historical and cultural heritage, but also witnesses of urban history and culture, and have irreplaceable significance in urban development, but they have received little attention from the academic community, and research on the comprehensive value evaluation of historical buildings of shops is also blank. Therefore, this paper takes the historical buildings of Longshengzhuang Commercial Building in Inner Mongolia as the research object, scientifically evaluates their comprehensive value, classifies them into protection levels according to their comprehensive value, and proposes targeted hierarchical protection strategies, which have certain reference value for the local government's scientific decision-making and precise implementation of protection policies for historical buildings of commercial buildings.

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1. Current Status of Historical Commercial Buildings in Longshengzhuang

1.1. Current Quality of Historical Commercial Buildings

Based on the damage to the building exteriors, structural characteristics, and maintenance conditions, the current quality of the 192 existing historical commercial buildings in Longshengzhuang was categorized into three levels: good, average, and poor, and statistical analysis was conducted, as shown in Table 1. Overall, the quality of the 192 existing historical commercial buildings in Longshengzhuang is not optimistic, generally being poor. Due to the outflow of local residents, some historical commercial buildings have been left unattended and have fallen into disrepair, resulting in collapses or even demolition. Furthermore, these historical commercial buildings are wooden structures, and after years of weathering, their columns and beams have developed cracks and decay, seriously affecting the structural safety of the buildings. In addition, some villagers failed to follow reasonable structural design principles when carrying out construction, renovation, and expansion work, resulting in unreasonable building structures and unstable connections, further exacerbating the decline in building quality.

Classification	Features	Proportion	Image
Good quality	The building's exterior showed no obvious damage, its structure was stable, and it had not been altered or expanded.	7.3%	
Poor quality	The building's exterior was partially damaged, but the overall structure was preserved.	35.9 %	
of poor quality ;of low quality	The building is dilapidated and has significant structural safety hazards, making repairs extremely difficult.	56.8 %	

Table.1. Classification of the Current Quality of Historical Buildings in Longshengzhuang Commercial Area

1.2. Current Status of Protection of Historic Commercial Buildings

Based on maintenance frequency and methods, the 192 existing historical commercial buildings in Long Sheng Zhuang are divided into four levels: well-preserved,moderately preserved, poorly preserved, and unpreserved, as shown in Table 2. Overall, the preservation status of the historical commercial buildings in Longshengzhuang is worrying, generally considered poor. None of the existing historical commercial buildings are regularly maintained using the original structure, materials, and techniques; only 3.65% of residents have carried out structural reinforcement, wall painting, and roof tile replacement; 79.69% of residents only perform unprotected repairs when problems arise; and 16.66% of residents have no protective measures, allowing the buildings to deteriorate. This indicates that the local government does not prioritize the preservation of historical buildings, and while most residents do repair them, they lack awareness of the importance of protecting them.

Classification	Features	Proportion
Good protection	Regular maintenance should be carried out on the building according to its original structure, raw materials, and processes to maintain its appearance and functionality.	0%
General protection	The building is not maintained regularly according to its original structure, materials, and techniques, but repairs such as structural reinforcement, wall repainting, and roof tile replacement are carried out.	3.65%
Poor protection	Maintenance is performed irregularly, only when issues such as water leakage or power outages occur, and does not provide protection for the building itself.	79.69%

unprotectedness	No maintenance, no protection for the building, and it is left to be damaged.	16.66%

Table.2. Classification of the Current Status of the Protection of Historical Buildings in Longshengzhuang Commercial Area

2. Construction of a comprehensive value evaluation system

2.1. Statistical analysis and screening of indicator factors

The relevant standards, international charters, and academic research [12-15] involved in the current evaluation of architectural heritage were summarized. The data were statistically analyzed and screened from the perspectives of the building's intrinsic value and external environment. Similar indicators and factors in the literature were integrated to form a comprehensive value evaluation system for commercial historical buildings, which consists of 7 primary indicators (historical value, scientific value, artistic value, commercial value, social value, surrounding spatial environment, and surrounding cultural environment) and 42 corresponding secondary indicators, as shown in Table 3.

2.2. Determining the weight of comprehensive value indicators

To ensure the credibility of the evaluation system, this study consulted several experts and scholars with some understanding of Longshengzhuang, including university teachers, cultural relic preservation workers, government officials, and respected local residents. A total of 25 questionnaires were distributed, and 21 valid questionnaires were collected. The results of the questionnaires were used to construct a judgment matrix using the weighted geometric mean method and passed a consistency check, as shown in Table 3.

target layer	Primary indicators and weights	Secondary indicators and weights
The Comprehensive Value of Commercial Historic Buildings	historical value (0.2256)	historical age (0.0569)
		completeness of historical records (0.0236)
		integrity of building (0.0393)
		post-construction alteration degree (0.0432)
		characteristic reflectance (0.0327)
		Historical event relevance (0.0163)
		preservation degree of ancillary relics (0.0136)
	Scientific Value (0.1253)	Structural technical features (0.0519)
		Construction process characteristics (0.0397)
		Local material characteristics (0.0337)
	artistic value (0.1413)	Local cultural characteristics (0.0284)
		Spatial layout effect (0.0335)
		architectural space characteristics (0.0315)
		architectural detail decoration (0.0327)
		architectural style typical (0.0152)
	commercial value (0.2009)	Commercial function (0.0315)
		exploring potential,developing potential (0.0306)
		Property status (0.0210)
		commercial space utilization (0.0661)
		Business scale (0.0517)
	social value (0.1209)	reflecting folk customs (0.0137)
		social emotional attachment (0.0186)
		Vitality of public space (0.0148)
		local identity (0.0357)
		diversity of public space (0.0207)
		group cohesiveness (0.0174)
	Surrounding spatial environment (0.1024)	Location conditions of the building (0.0129)
		coordination of surrounding building forms (0.0138)
		The Characteristic of Surrounding Space Layout (0.0109)

		integrity of the surrounding architectural style (0.0173)
		Infrastructure completeness (0.0156)
		spatial environmental variability (0.0186)
		Age of Surrounding Buildings (0.0133)
	The surrounding environment (0.0836)	The richness of related folk customs and cultural activities (0.0128)
		Population size and structure (0.0115)
		The degree of residents' cognition of historical buildings (0.0131)
		Residents' willingness to protect historical buildings (0.0108)
		The Protection Mode of Historical Buildings by the Residents (0.0096)
		Frequency of neighborhood interactions among surrounding residents (0.0085)
		Average income level of surrounding residents (0.0076)
		Average educational level of surrounding residents (0.0097)

Table.3. Comprehensive Value Evaluation Table of Historical Commercial Buildings

2.3. Evaluation system scoring criteria

The qualitative results are transformed into quantitatively evaluable indicators using the fuzzy evaluation method. In order to eliminate the influence of different dimensions, all evaluation indicators are divided into different levels for evaluation, and a four-level scoring method (0-1, 2-4, 5-7, 8-10) is adopted.

Evaluation factor	score			
	8-10	5-7	2-4	0-1
historical age	The Ming Dynasty and earlier periods	Qing Dynasty	the Republic of China (1912-1949)	New China is established
completeness of historical records	There are detailed records.	There are rough records.	Some records exist.	ahistoric
integrity of building exterior	Very complete	Relatively complete	Generally complete	bug,imperfect
post-construction alteration degree	Unchanged	Minor changes	Major changes	Significant changes
characteristic reflectance	Very strong	Relatively strong	Generally strong	Not strong
Historical event relevance	Very relevant	Compare	general relevance	
preservation degree of ancillary relics	beyond compare	Better	Generally good	bad
Structural technical features	Very distinctive	More distinctive	Generally distinctive	without colour
Construction process characteristics	Very distinctive	More distinctive	Generally distinctive	without colour
Local material characteristics	Very distinctive	More distinctive	Generally distinctive	without colour
Local cultural characteristics	Very strong	Relatively strong	Generally strong	Not strong
Spatial layout effect	Very strong	Relatively strong	Generally strong	Not strong
architectural space characteris	Very strong	Relatively strong	Generally strong	Not strong

tics				
architectural detail decoration	Very strong	Relatively strong	Generally strong	Not strong
architectural style typical	Very strong	Relatively strong	Generally strong	Not strong
Commercial function	Very strong	Relatively strong	Generally strong	Not strong
exploring potential,developing potential	Very strong	Relatively strong	Generally strong	Not strong
Property status	country	unit or collective	personal	not quite clear
建筑空间利用率	Very strong	Relatively strong	Generally strong	Not strong
Business scale	More than 200 square meters	150-200s quare meters	100-150s quare meters	Under 100 square meters
reflecting folk customs	Very strong	Relatively strong	Generally strong	Not strong
social emotional attachment	Very strong	Relatively strong	Generally strong	Not strong
Vitality of public space	Very strong	Relatively strong	Generally strong	Not strong
local identity	Very strong	Relatively strong	Generally strong	Not strong
diversity of public space	Very strong	Relatively strong	Generally strong	Not strong
group cohesiveness	Very strong	Relatively strong	Generally strong	Not strong
Location of the building	Very strong	Relatively strong	Generally strong	Not strong
coordination of the architectural style of the surrounding buildings	Very strong	Relatively strong	Generally strong	Not strong
The Characteristic of Surrounding Space Layout	Very strong	Relatively strong	Generally strong	Not strong
integrity of the surrounding building style	Very strong	Relatively strong	Generally strong	Not strong
Infrastructure completeness	Very perfect	perfect	General improvement	faultiness
spatial environmental variability	No changes	Minor changes	General changes	Significant change
Age of Surrounding Buildings	The Republic of China and before	1949-1980	1980-2000	After 2000
Folk Custom and Cultural Activity Richness	Very strong	Relatively strong	Generally strong	Not strong
Surrounding population scale	300More than one person	200-300	100-200	Under 100 people
The awareness of historical buildings among the surrounding residents	Very high	high	Generally high	No high

Residents' willingness to protect historical buildings	Very strong	strong	Generally strong	No strong
Resident's Protection Mode of Historic Buildings	Very familiar	Familiar	Generally familiar	No familiar
Frequency of neighborhood interactions among surrounding residents	Very frequent	Frequent	Frequently	Not frequent
Average income level of surrounding residents	More than 3000 yuan	2000-3000 yuan	1000-2000 yuan	Under 1000 yuan
Average educational level of surrounding residents	Bachelor's degree or above	junior college	senior school	High school and below

Table.4. Table of Indicator Scores for Comprehensive Value Evaluation System of Historical Buildings

2.4. Comprehensive Value Grading of Historic Commercial Buildings

Each historic commercial building was scored according to the indicator scoring table and classified into four levels of protection: I, II, III, and IV.

order of evaluation	Evaluation score	Commercial Historic Building Number
Historic buildings of Grade I	75 < score ⩽ 100	A12、A21
Historic buildings of Grade Ⅱ	50 < score ⩽ 75	A22、A41、A54、A55、A75、A76、A77、F5、I12、L8、L11、L66
Historic buildings of Grade Ⅲ	25 < score ⩽ 50	A17、A24、A52、A84、E64、J45、K5、L10、L65、L67、L68、L69
Historic buildings of GradeⅣ	0 ⩽ score ⩽ 25	A1、A2、A3、A9、A10、A11、A16、A19、A20、A25、A39、A40、A42、A46、A50、A51、A57、A58、A59、A60、A61、A63、A64、A65、A66、A67、A68、A69、A71、A72、A73、A74、A79、A80、A82、A83、A85、A87、A88、F3、F6、F15、F16、F17、F18、F19、F20、F21、F22、F23、F24、F28、F33、F34、F35、F36、F37、F38、F40、F41、F47、I41、I42、I43、J46、J47、J48、J71、J72、J73、J74、K1、K2、K3、K7、K12、L1、L2、L3、L4、L5、L6、L7、L9、L12、L13、L14、L15、L16、L17、L18、L19、L20、L21、L22、L23、L24、L25、L26、L27、L28、L29、L30、L31、L32、L33、L39、L40、L41、L42、L43、L44、L45、L48、L49、L54、L57、L58、L59、L60、L61、L62、L63、L64、L70、L71、L72、L73、L74、L75、L76、L77、L79、L80、L82、L83、L84、L85、L87、L88、L89、L90、L91、L93、L95

Table.5. Comprehensive Value Grading Table for Historic Buildings

2.5. Historical building classification protection strategy

For different historical building grades of Longshengzhuang shops, specific protection measures are proposed from three aspects: overall strategy, protection objectives and specific measures.

grade	wholistic strategy	protected object	concrete measure
First-class historical building	Strict protection and preservation of the original appearance	Ensure the integrity of the original appearance, structure, materials, and historical information of the historic building.	All renovation, expansion, or demolition activities are strictly prohibited except for necessary maintenance and repairs. The original state of the building shall be preserved. A professional maintenance team shall be established to conduct regular structural inspections, repairs, and upkeep, ensuring the building's safety and stability. Real-time monitoring of the surrounding environment is required to prevent damage from external factors such as pollution and vibrations. Grade I protected historical buildings shall be incorporated into legal protection frameworks, with a stringent regulatory mechanism established to rigorously combat illegal activities.
Secondary historical buildings	moderate repair and functional activation	On the basis of protecting the style and core value of the historic building, the building should be restored and functionally transformed to improve its use value.	Develop a detailed restoration plan to meticulously repair the damaged sections of the building while preserving its overall architectural character. Implement appropriate functional adaptations—such as converting it into a museum, library, or cultural center—without compromising its historical integrity. Revitalize the building through community engagement by encouraging residents to participate in conservation and utilization activities. Organize cultural events and lectures to transform the historic structure into a vibrant community hub. Provide technical support and training to enhance the professional standards of restoration and preservation efforts.
Grade III historic building	Preserve the landscape and renew moderately	On the basis of maintaining the features of the historic architecture, the building should be updated and transformed moderately to meet the needs of modern life.	Identify the distinctive features of historical buildings, including architectural styles, colors, and materials. During renovation and upgrading, implement a design review mechanism to ensure projects harmonize with the historical architecture's character, preventing damage to its overall aesthetic. Encourage diverse functional uses such as commercial, office, and residential spaces to enhance the buildings' multifunctionality and vitality. Promote public participation through methods like open bidding and community discussions, while establishing a supervision system to guarantee compliance with renovation standards.
Level 4 historical building	Flexibility in the use of architectural style	On the basis of maintaining the continuity of historical features, the historical buildings should be used and developed more flexibly to promote the inheritance and innovation of culture.	Develop a style continuity plan to ensure new construction or renovation projects harmonize with historical buildings in terms of style, scale, and color, creating a unified architectural character. Encourage innovative functional uses such as creative industries, art studios, and homestays to promote the integration of historical buildings with modern life. Provide policy support and incentives, including tax benefits and financial subsidies, to encourage private capital participation in the preservation and utilization of historical buildings. Strengthen the cultural heritage and educational functions of historical buildings through

			cultural activities, exhibitions, and educational programs, thereby enhancing public historical and cultural literacy.

Table.6. Table of Classified Protection Measures for Historic Commercial Buildings

Conclusion

Historical commercial buildings serve as tangible witnesses to economic development, acting not only as venues for trade but also as important platforms for cultural exchange, thus possessing unique historical value. Conducting comprehensive value assessments of these buildings, assigning them different protection levels, and proposing tailored protection strategies allows for protection work to be tailored to the specific architecture, which is of profound significance for the scientific formulation and precise implementation of protection policies for various types of historical buildings.

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The Organizational-Economic Mechanism for Enhancing Technoparks' Participation in Innovation Development in China and Belarus

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KEYWORDS

Innovation;

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ABSTRACT

The issue of cooperation between the Republic of Belarus and China in the field of innovation is currently becoming increasingly relevant. The study examines the factors and conditions for effective operation of technology parks in China and Belarus, considering state regulation, focus on developing external markets, lobbying for budgetary spending on R&D, implementing preferential policies, and maintaining genuine communication with leading universities. This article explores the potential for collaboration between the Republic of Belarus and the People's Republic of China in establishing industrial parks, drawing on successful international technology park models such as the "Great Stone" and "Silk Road" initiatives.

INTRODUCTION

One of the key priorities in the foreign economic strategy of the Republic of Belarus is to further develop trade and economic cooperation with the People's Republic of China. "Establishing innovation infrastructure entities stands as one of the most effective tools for fostering innovative entrepreneurship and the knowledge-based economy as a whole" [1, p. 37]. This perspective directly highlights the pivotal role of Belarusian tech parks, which serve as key platforms for technology transfer, startup support, and accelerating the commercialization of scientific innovations. In fact, technology parks are becoming the key infrastructure players that drive the entire innovation cycle—from idea to market launch.

In Belarus, the term "technopark" refers to a specialized organizational structure that typically employs no more than a hundred people, with its primary mission being to foster entrepreneurship growth in the scientific, technological, and innovation sectors.These organizations provide a structured ecosystem where both corporate entities and individual entrepreneurs recognized as residents can complete the full innovation cycle – from initial R&D to final implementation and market integration of new technologies. A startup specializing in advanced materials could develop prototypes of innovative composite materials within such a tech park before transitioning to industrial-scale production.

1.A study on Belarusian technology park operations

By early June 2025, Belarus had established a network of fourteen officially recognized science and technology parks: twelve state-owned and two privately operated [2, p. 59].

Показатели	2019 г.	2020 г.	2021 г.	2022 г.	2023 г.	2024 г.	2025 г.
Количество субъектов инновационной инфраструктуры, в том числе:	25	25	26	24	24	23	21
научно-технологические парки	14	14	14	14	14	16	14
центры трансфера	8	7	7	5	6	5	5

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технологий							
Количество иных организаций, имеющих статус субъекта инновационной инфраструктуры	1	1	1	1	1	2	2

Table.1. Number of innovation infrastructure entities in the Republic of Belarus from 2019 to 2025

Source: [2], [3], [4].

This network functions as a distributed innovation infrastructure, with each entity shaped by its specialized focus and local economic context. Private tech parks typically emphasize flexible residency policies or specialized technology sectors, while government-backed parks are often closely integrated with regional development initiatives or universities.

If we examine these parks based on the number of registered residents, we observe significant variation in the number of active residents. The largest science and technology parks are those with over twenty-five active residents, such as the Minsk City Technopark, Brest Science and Technology Park, and the Politechnical Park of BNTU. These parks often serve as regional hubs with extensive laboratory facilities and partnerships with major research institutes. The second tier includes parks that can accommodate between ten and twenty-five registered residents. This category includes the Coral Technopark in Gomel, the Russian Agency for Development and Investment Attraction, Mogilev Technopark, the Inkata Technopark, the small business incubator of the "Law and Order" legal group, and the Minsk Regional Technopark. These facilities support growing companies by providing essential services such as patent consulting, early-stage funding networks, and shared office space infrastructure. A cluster of small tech parks operates, each hosting up to ten residents, such as the Science-The Vitebsk State Technological University's technology park, a counterpart facility to the Polotsk State University, the "Tekhnolab" educational, scientific, and industrial center in Grodno, the "UNITECHPROM BGU" park, and the "Gorki" park. The BGUIR Technopark and Scientific-Technical Park, which are often focused on establishing subsidiaries in early stages and experienced production.

According to data from the Belarusian Institute of System Analysis and Information Support in the Scientific and Technical Sector [4], as of January 1, 2025, the total number of registered residents across all technology parks in the Republic of Belarus reached 276 organizations, marking an increase of 11 compared to the previous year. Meanwhile, the growth in the number of residents was accompanied by a significantly more dynamic increase in employment: the total workforce of resident organizations in technology parks increased by approximately 1,100 people, or about 20% compared to 2023, reaching around 6,400 employees [2], [3], [4].

This surge reflects not just a rise in the number of companies, but also a significant expansion in their operational scale. For instance, a software development firm based in Minsk City Technopark could double its development team to meet export demands, while a biotech startup in Grodno might hire new lab staff after securing venture capital funding. These details demonstrate how Belarusian tech parks are evolving from basic incubators into sophisticated innovation ecosystems. They not only drive regional development and sustain high-value-added employment, but also strengthen the country's competitive edge in global technology markets.

Economic data confirms this trend. Official statistics show that "the output volume of products manufactured by technology park residents increased by over 20% year-on-year, reaching approximately 1 billion rubles. The total value of products exported by these residents reached around 460 million rubles, accounting for 46% of the total output. Compared to 2023, this figure has risen by 29%." [3] These metrics demonstrate that the expansion of technology parks is reflected not only in increased resident numbers, but also in a substantial enhancement of their production and export capabilities, establishing them as a key driver of Belarus' high-tech economy.

1.1.Policy and Funding Dynamics in Belarus

In 2024, China's leadership initiated a new initiative to reevaluate the operational principles of science parks, calling for a fundamental overhaul of their regulatory framework. In line with this directive, the National Science and Technology Commission has developed a comprehensive set of guidelines designed to verify that park residents are genuinely committed to innovation. These recommendations also included standardized contracts regulating innovation activities and formalized reporting formats for tracking the use of funds from the Innovation Development Fund. This change reflects broader policy objectives: enhancing

accountability, transparency, and efficiency within the innovation ecosystem. Under the previous system, a small robotics company could receive government funding without demonstrating clear milestones or measurable results, which the new rules aim to address [3].

In the first half of 2024, MGT LLC emerged as the primary driver of employment growth among technology park residents, creating or upgrading 198 jobs. This expansion reflects not only rising demand for specialized skills but also demonstrates the ability to attract local engineering talent that might otherwise seek employment abroad. MGT LLC has attracted a large number of technical university graduates from Minsk by offering competitive terms to keep them in the country [3].

Beyond employment trends, the technology transfer sector demonstrated notable yet uneven dynamics. Supported by the Technology Transfer Center (TTC), eight agreements for transferring or acquiring rights to scientific, technical, or innovative achievements were signed between January and June 2024, totaling 14,200 rubles. This figure stands in stark contrast to 2023, when 11 such transactions amounted to 177,200 rubles [2, p. 63]. While 2024 saw fewer deals and lower total value, this shift indicates a focus on smaller, potentially more targeted early-stage transfers. For example, a university lab might license an algorithm or prototype to a young startup testing its market viability.

Funding reflects a complex situation. In the first half of 2024 alone, 47.6 million rubles from state funds were allocated to strengthen the physical and technical infrastructure supporting innovative enterprises. Of this amount, 44.6 million came from local innovation funds, a mere 0.2 million from the Republican Centralized Innovation Fund (RKIF), and 2.8 million from the republican budget. To gauge this scale, compare it with the funding allocation at the end of 2023: a total of 107.3 million rubles, with 104 million sourced from local sources, 2.5 million from the Republican Innovation Fund (RKIF), and 0.8 million from the republican budget. The funding structure underscores the crucial role of local authorities in enhancing innovation readiness – for instance, financing the reconstruction of shared laboratory spaces or equipping coworking spaces with cutting-edge prototyping tools [3].

It's worth noting that these investments deliver substantial returns. At the beginning of 2024, every ruble of government funding translated to 8.9 rubles in products developed by the technology park's residents, up from 7.6 rubles a year earlier [4]. This figure serves as a rough gauge of the multiplier effect of government spending on innovation. Imagine a small bioinformatics company that, thanks to subsidized equipment upgrades, secures a major data analysis contract for a pharmaceutical client – these examples help illustrate the improved ratio.

The diverse range of activities among the technology park's residents is truly impressive. Their work spans instrumentation engineering, precision mechanical systems, electronic design, cutting-edge IT services, software development, medical technologies and pharmaceuticals, fundamental and applied research and development, optical systems,Laser devices, energy solutions, energy-saving strategies, and cutting-edge bio-and nanotechnologies. For instance, one resident might develop specialized optical sensors for autonomous vehicles, while another focuses on creating software to manage smart energy grids.

1.2.The "Great Stone" Industrial Park

The "Great Stone" Industrial Park stands as a key driver of Belarus' innovative potential. Located near Minsk, this expansive international business hub spans over 11,000 hectares, featuring a sleek modern design and meticulously planned eco-friendly infrastructure. Beyond its impressive scale and aesthetic appeal, the "Great Stone" operates under a special legal framework designed to attract global investors through simplified regulations and attractive tax incentives. Its core mission is to serve as a bridge for economic partnership between Belarus and China – a vision realized through joint production capacities, collaborative research initiatives, and integrated logistics hubs designed to steer trade along the modern Silk Road.

The development of the China-Belarus "Great Stone" Industrial Park demonstrates Belarus 'gradual establishment of a core hub for high-tech investments and international supply chains. This park serves not only as a business incubation platform but also as a strategic tool for the country's integration into global economic systems. This is precisely why academic literature emphasizes that "particularly, it enables Belarus to develop as a mediator between the West and the East, while enhancing its appeal to foreign investment" [3]. This statement directly reflects the strategic role of the "Great Stone" as a pivotal element in Belarus' foreign economic policy and underscores its significance in shaping a new model of international

cooperation.

The functions of the "Great Stone" are as follows:

developing joint economic cooperation between China and Belarus; establishing nationally competitive technologies; creating jobs for highly skilled professionals; attracting foreign direct investment; fostering a favorable investment climate in Belarus; and encouraging indigenous innovation.

The establishment of the massive China-Belarus industrial park "Great Stone" inevitably sparks debates about whether Russia can create a similar joint venture with China on its own soil. This question is hardly academic; both countries have already accumulated substantial cooperation experience, as evidenced by projects like China's "Silk Road" High-Tech Park in Fengdong and Russia's "Skolkovo" Innovation Center. It's easy to envision a new Russian-Chinese complex being developed in Russia's Far East. This facility will serve as a vital bridge for investment flows from Northeast Asia and a launchpad for high-tech startups built on the foundations of research clusters in Moscow or Novosibirsk.

2.China's Technoparks: A Study in Progress

China's leadership in the global technopark movement is no accident. Through decades of policy and strategic planning, the country has developed a vast and diverse landscape of over 7,000 industrial parks spread across all provinces and regions – from Guangdong's factories to Sichuan's inland industrial hubs. These are not homogeneous spaces, but a kaleidoscope of development zones: high-tech districts focused on advanced manufacturing, free trade pilot zones testing policy reforms, border cooperation enclaves designed to streamline cross-border trade, export processing zones linked to coastal ports, and much more [1].

China's ambitions for these zones were clearly defined in a key government directive: the "Several Opinions of the State Council on Promoting the High-Quality Development of National Technology Parks" (State Council Document No.7-r, July 13,2020). This comprehensive policy statement serves not merely as a dry administrative document, but rather as a master plan for state-led innovation. It outlines comprehensive ideological frameworks, a set of guiding principles, and a series of development goals aimed at transforming these national technology parks into engines of economic modernization by 2035. For policymakers in Beijing, these zones serve as tools for redistributing high-value-added domestic production, advancing cutting-edge research, and safeguarding China's technological sovereignty amid growing global competition [7].

By 2024, China's national technology park system had maintained a state of near-constant growth and evolution. While no single authoritative report comprehensively captures all aspects of this expansion, local and industry reports paint a vivid picture: new parks are emerging at breakneck speed, the number of resident companies keeps growing, R&D budgets are increasing, and patent applications are surging. The Chinese model isn't static—it's designed for perpetual motion. In areas like the Pearl River Delta, municipal governments are offering free lab space to biotech startups, while local universities are overhauling their engineering programs to meet industry demands.

Figure.1. Development indicators of major technology parks in China in 2024. Source: [8].

The results speak for themselves. According to CGTN, the combined net profit of China's top 500 tech park enterprises surged nearly 5% in 2024, surpassing the 4.5 trillion yuan mark [4]. This isn't just a testament to corporate efficiency—it reflects a meticulously crafted ecosystem designed to sustain profitability, from generous subsidies to tax incentives and seamless logistics networks. While it is often mentioned that there are over 169 "national-level" science parks, this figure hardly reflects the underlying complexity. Each of these high-tech zones serves as a regional growth hub, specifically designed as a cluster where research institutes, factories, venture capital, and government incentives come together to transform ideas into market-ready technologies [7].

What truly sets the Chinese approach apart is its governance structure. Unlike many Western science parks that often operate with significant autonomy for the private sector, China's technology parks are under strict state oversight. This centralized model isn't just bureaucratic control per se, but a meticulously designed system that fosters collaboration

between local governments, universities, research institutes, major manufacturers, and small tech startups. Imagine a tech hub in Tianjin where the municipal government funds AI training programs, a local university establishes an applied robotics lab, and manufacturers commit to implementing these systems in production – all under a unified policy framework.

The primary objective of establishing China's new high-tech development zones is to create an innovation-driven regional infrastructure that can transform theoretical research into practical technological solutions. These zones are typically located in the country's largest and most strategically important cities – Beijing, Shanghai, Guangzhou, Tianjin, Wuhan – where clusters of leading universities, research institutions, and technological hubs converge.The convergence of centers and production capabilities unlocks unprecedented collaboration potential. This strategic concentration of intellectual capital isn't accidental—it's a core component of our ecosystem strategy. By integrating top minds into a collaborative framework, we transform their breakthroughs into market-ready export products that meet global demand.

When it comes to government support, China and Belarus employ a wide range of incentives to maintain the competitiveness of their tech parks. In Belarus, these incentives often target specific needs: constructing new facilities, renovating existing infrastructure, co-financing equipment procurement, or offering preferential laboratory space rentals. Tax breaks and low-interest loans help alleviate the financial burden on residents. Regional authorities may introduce their own individual incentives, providing local support and aligning with economic development strategies.

In contrast, the Chinese model heavily relies on R&D-driven support. Companies operating in China's tech parks often enjoy full tax incentives during their growth phase, after which a reduced corporate income tax rate takes effect. Partial reimbursement of R&D costs has become standard practice, making innovation a more risk-tolerant proposition for businesses of all sizes. Imagine a startup in Shenzhen developing cutting-edge semiconductor technologies: in its first few years, it might not pay corporate income tax, instead receiving grants to hire additional engineers and purchase production equipment.

While Belarus is heavily investing in physical infrastructure for innovation – including modern laboratories, coworking spaces, and production facilities – China is equally committed to funding real-world R&D that will bring commercially viable ideas to life in these spaces. This divergence reveals contrasting philosophies: Belarus views technology parks as vital infrastructure for national development, while China sees them as integrated policy tools to advance strategic industries to global frontiers.

The core of China's tech park development strategy rests on an undeniable truth: the state serves as both a catalyst and guarantor for economic transformation, aiming to establish the country not merely as a participant in the global economy, but as a technological superpower that sets the rules.

"The implementation of the 'Belt and Road' strategy will not only help China better utilize its substantial foreign exchange reserves and boost economic development and cooperation along the 'Belt and Road', but also encourage China and the Republic of Belarus to jointly establish technology parks – which currently represent one of the most significant and promising focal points for bilateral cooperation" [6].

3.A comparative analysis of park operations in Belarus and China

The technological gap between Belarus and China creates opportunities for active innovation collaboration, particularly in joint educational and scientific initiatives, including through:

engaging Belarusian scientists and research institutions in executing China's international scientific and technological cooperation programs; designating Belarus as a co-sponsor for Chinese initiatives under national and regional science and technology programs and projects; attracting Chinese partners to undertake Belarusian scientific research projects establishing joint regional universities, laboratories, and research centers for cutting-edge studies to undertake unique projects.

In this context, priority areas such as technology transfer, establishing high-tech manufacturing facilities, and integrating Belarusian companies into China's regional innovation clusters gain particular significance. This is precisely why academic literature emphasizes that "the aforementioned initiatives can be viewed as preparatory steps for Belarus' more proactive innovation policies in China's regions, leveraging the potential of industrial parks"

[1]. This means that current initiatives—from developing the "Great Stone" to participating in China's regional programs—are laying the groundwork for Belarus to establish a more systematic presence in China's innovation ecosystem, while also expanding opportunities for Belarusian companies in the high-tech sector.

The ongoing efforts to improve working conditions at t he China-Belarus "Great Stone" Industrial Park and attra ct more high-tech Chinese tenants naturally point to bro ader prospects: the potential to establish joint Belarusian -Chinese agro-industrial complexes both on Belarusian s oil and in Chinese provinces. These promising agropark s could serve as powerful engines for cross-border food production innovations,unlocking collaboration opportuni -ties—particularly in organic farming, an area where Be larus has established significant competitive advantages across multiple regions. Consider, for instance, the farm ers in Mogilev who pioneered the export of organic dai ry products under a joint brand, or Chinese partners im plementing precision irrigation systems that boost yields while conserving water.

Such enterprises could serve as fertile ground for collaborative market development, which is not only expanding but also evolving as consumer demand for eco-friendly, certified organic products grows across both domestic and international markets. In this sense, agroparks would go beyond being mere processing and distribution hubs. They could become innovation laboratories for developing new production models, branding strategies, and export logistics chains tailored to environmentally conscious consumers across the country, from Moscow to Shanghai.

For Belarus, adopting this approach is not merely about diversifying exports; it represents a strategic shift that will benefit fromA thorough examination of China's industrial park management legislation. One of the most remarkable aspects of China's industrial park policy is its willingness to experiment: pilot zones serve as testing grounds for regulatory innovations, administrative streamlining, and fiscal incentives before these practices are rolled out nationwide. For Belarusian regions exploring the creation of their own joint science and technology parks, this model serves as an attractive example. By encouraging local experimentation in commercialization and public-private partnerships, Belarus could establish a more sophisticated and flexible innovation framework that aligns with market dynamics rather than resisting them.

These parks could go beyond being mere industrial space rentals. They could evolve into hubs for collaborative technological advancement, leveraging international research initiatives and commercial spin-offs. Imagine the Gomel Agro-Industrial Park conducting field trials of pest-resistant grain varieties co-developed with Chinese laboratories, or the Vitebsk Research Center adapting China's food industry automation systems to Belarusian production lines. Beyond technology transfer, these parks will foster cultural and institutional ties that transform one-off projects into enduring partnerships spanning decades.

To realize this vision, Belarus must expand its interregional cooperation framework. The key lies in forging stronger and more dynamic partnerships at the level of industrial, scientific, and technological parks – these hubs could serve as gateways to broader foreign economic integration. Such cooperation would not only strengthen Belarus's position in Chinese markets but also transform the nature of bilateral trade by replacing raw material flows with value-added and technology-intensive exchanges.

This transformation requires Belarusian regions to actively engage in international networks and specialized associations – membership that could provide access to standard-setting bodies, best practices, and cutting-edge research collaborations. Establishing new agro-industrial parks that leverage the natural and logistical strengths of specific Belarusian regions could further strengthen these connections, creating a solid local foundation for global engagement.

Equally important is learning from China's industrial parks: their strict adherence to international standards, effective use of tax incentives, and ability to establish flexible and productive partnerships with manufacturers, universities, and research centers. Belarusian policymakers could, for instance, establish pilot training exchanges enabling Belarusian specialists to work in Chinese industrial parks, or develop joint educational programs that introduce students to the regulatory frameworks and technological ecosystems of both nations.

Ultimately, developing such a network of cross-border innovation hubs will require Belarus to elevate its overall innovation capacity. This means moving beyond empty slogans and actively fostering the growth of small and medium-sized enterprises (SMEs) with innovative business models. It also involves boosting the proportion of

organizations that invest heavily in R&D, while expanding the production of high-quality innovative products tailored for both domestic and export markets.

Conclusion

Belarus's innovative infrastructure is developing steadily, as evidenced by the growing number of tech park residents, rising employment, and expanding business sectors.

Belarusian tech parks are strengthening their role as innovation hubs by delivering end-to-end innovation support—from R&D to commercialization—and showcasing growing manufacturing and export capabilities.

State policy is becoming more results-oriented, as evidenced by the updating of regulatory frameworks, standardization of innovation requirements for projects, and strengthened oversight of innovation fund utilization.

The Great Stone Industrial Park serves as a cornerstone of Belarusian-Chinese collaboration, driving investment attraction, creating high-tech jobs, and integrating Belarus into global value-added chains.

China's experience in establishing technology parks serves as a valuable model for adaptation, while expanding cooperation with China unlocks new opportunities for Belarusian companies in high-tech sectors and technology transfer.

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A Study of the Development of a Dual System of Vocational Education in Modern Society

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KEYWORDS

Dual-qualification teachers;

Integration of education and production;

Vocational education:

ABSTRACT

With the deepening integration of education and production, as well as the transformation and modernization of industrial sectors, the development of a corps of "dual-skilled" teachers in vocational education has become a key tool for improving the quality of training technical specialists and qualified personnel. This article examines practical issues such as institutional barriers, weak interaction between educational institutions and enterprises, and the lagging assessment system. The authors analyze the causes of these barriers from the perspective of policy implementation, incentive mechanisms, and professional development, proposing a three-dimensional strategy including standardized certification, the creation of professional communities, and a comprehensive incentive system. This ensures the necessary human resource support for the high-quality development of vocational education.

ВВЕДЕНИЕ

В «Программе реформирования национальной системы профессионального образования» (2019) и «Мнениях о углублении реформы строительства современной системы профессионального образования» (2022) четко поставлена задача укрепления корпуса «двухквалификационных» преподавателей и углубления взаимосвязи образовательной и производственной цепочек. Согласно данным Министерства образования, в 2024 году доля «двухквалификационных» преподавателей в профессиональных учебных заведениях составила около 53%, однако сохраняются структурные диспропорции: 76% штатных преподавателей не имеют более чем 3-летнего опыта работы на предприятиях [1], а доля высококвалифицированных специалистов с предприятий среди внештатных преподавателей составляет менее 15% [2]. Основываясь на опыте нового развития, в данной статье проводится системный анализ практических трудностей и путей совершенствования «двухквалификационной» системы, что может послужить теоретической основой для оптимизации данной деятельности.

1.Проблемы системы «двухквалификацион-ных» преподавателей профессионального образования

1.1.Кризис идентичности и разрыв в компетенциях: от «двойного сертификата» к «двойным способностям»

Ключевая проблема: система аттестации фокусируется на формальном наличии «двух сертификатов», в то время как практические навыки преподавателей не соответствуют требованиям производства. Это создает разрыв между «формальной квалификацией» и «реальными профессиональными компетенциями» (таблица 1).

Индекс	Данные	Литература

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Индекс	Данные	Литература
Практические возможности остаются на уровне «демонстрационной эксплуатации».	63% учитель	[3]
Учителя моложе 45 лет могут руководить реальными корпоративными проектами	только 28%	[4]

Таблица.1.Разрыв между квалификацией и компетенциями

1.2.Проблема формализации взаимодействия между образовательными учреждениями и предприятиями

Ключевая проблема: взаимодействие между учебными заведениями и предприятиями носит формальный характер, а дисбаланс в распределении ресурсов между городскими и районными образовательными учреждениями усугубляет низкую эффективность сотрудничества (таблица 2).

Индекс	Размер	Литература
Доля временных внештатных преподавателей в районных образовательных учреждениях (без закрепленного рабочего места)	65%	[5]
Разрыв в «проектном сотрудничестве» между районными и городскими образовательными учреждениями	42%	
Уровень плагиата в производственных дневниках преподавателей	38%	[6]
Доля стажировок на административных должностях, предоставляемых предприятиями (уровень вовлечённости в ключевые направления деятельности - нулевой)	73%	[7]

Таблица.2.Дисбаланс в распределении ресурсов

1.3.Ограниченность системы оценки и мотивации: проблема "одномерного" подхода

Ключевая проблема: отсутствие комплексной системы оценки и недостаточная мотивация приводят к тому, что преподаватели уделяют больше внимания формальным сертификатам, чем реальным профессиональным компетенциям (таблица 3).

Индекс	Данные	Литература
Учебные заведения без специализированной системы аттестации для «двухквалификационных» преподавателей	85%	[7]
Разрыв в эффективности между «двухквалификационными» и обычными преподавателями	Недостаточный 5%	[8]
Влияние производственного опыта на карьерный рост преподавателей	Ниже 10%	

Таблица.2.Показатели квалификации

2.Анализ причин: тройное ограничение системы, интересов и культуры

2.1.«Поверхностное» исполнение политики

Несмотря на то, что «Программа реформирования системы подготовки "двухквалификационных" преподавателей профессионального образования в новую эпоху» (2019) четко предусматривает требования к производственной практике, на местном уровне отсутствуют детализированные механизмы реализации. Проблема особенно остро проявляется в районных образовательных учреждениях: исследование Хэбэйского педагогического университета показало, что 83% учебных заведений при сертификации «двухквалификационных» преподавателей заменяют требование «опыта работы на предприятии» на «отраслевые сертификаты» из-за отсутствия сотрудничества с предприятиями [5].

Такая политика «холостой работы» напрямую ведет к разрыву между теорией и практикой. Данные Чжэнчжоуского железнодорожного института (2020) свидетельствуют, что преподаватели, прошедшие стажировку в районных предприятиях, демонстрируют лишь 61% эффективности своих городских коллег в руководстве студенческими проектами [6].

2.2.Асимметричное взаимодействие интересов учебных заведений и предприятий

Преприятия демонстрируют низкую заинтересованность в участии из-за дисбаланса между затратами и выгодами: подготовка одного «двухквалификационного» преподавателя требует инвестиций в размере 120-150 тыс. юаней, при этом положительный эффект для предприятия минимален, что приводит к нежеланию вкладывать ресурсы в данный процесс.

Со своей стороны, профессиональные учебные заведения сталкиваются с ограничениями штатного расписания, и не могут предложить конкурентную зарплату высококвалифицированным специалистам. Это создает противоречие: «школы нуждаются в практиках, предприятия – в прибыли» [9].

2.3.Социокультурные стереотипы в отношении профессионального образования

Общественное признание «двухквалификационных» преподавателей остается ниже, чем у педагогов общего образования. Согласно опросам, 68% родителей считают, что преподаватели профессионального образования «уступают вузовским в теории и мастерам-практикам в навыках» [3].

Внутри учебных заведений также сохраняется скрытое предубеждение «в пользу дипломов, а не компетенций», что снижает профессиональную самооценку преподавателей. Только 41% педагогов рассматривают статус «двухквалификационного» преподавателя как долгосрочную карьерную цель [4].

3.Стратегии обеспечения качественного развития

3.1.Создание замкнутой системы «стандарты – сертификация – отсев» для укрепления профессиональной идентичности

Разработка «Стандартов компетенций двухквалификационных преподавателей профессионального образования (2025)» с включением в ключевые показатели:опыт реализации корпоративных проектов;результаты технологических разработок [7].

Реализуется система динамической сертификации с переаттестацией каждые 3 года и минимальным уровнем отсева 15% (с учетом опыта немецкой дуальной системы).Пилотный проект в Хэнане показал увеличение участия преподавателей в производственной практике на 47% после внедрения данного механизма [8].

3.2.Формирование двойных сообществ «город-отрасль» для углубления взаимодействия образования и производства

Городские кластеры : Создание 500 городских образовательно-производственных объединений на базе промышленных парков с моделями:

√ «Стажировка преподавателей на предприятиях + решение технологических задач» (например, объединение 12 профессиональных колледжей в зоне развития Чжуншань для подготовки преподавателей интеллектуального производства).

Для районов со слабым взаимодействием: адаптация модели «3 входа/3 выхода» Чжэнчжоуского железнодорожного института: Преподаватели на технических должностях (120 дней/год), Корпоративные наставники в аудиториях (40% практических занятий),

Совместные курсы (напр., «Техобслуживание ж/д сигнализации») [6].Результаты:рост коммерциализации патентов на 230%;трудоустройство по специальности – 92%.

Отраслевые альянсы : Формирование 100 отраслевых образовательно-производственных

сообществ (машиностроение, ИТ) с участием лидеров рынка для:разработки программ подготовки двухквалификационных преподавателей;реализации модели : «зачисление = найм, обучение = работа» [3].

Ключевые преимущества стратегий:Стандартизация → Повышение качества преподавательского состава;Гибкие модели → Адаптация к региональным условиям;Ориентация на результат → Измеримые показатели эффективности.

3.3.Инновационный механизм «развивающей оценки + рыночного стимулирования»

Создать трехмерную систему оценки "преподавательские способности + техническое обслуживание + социальное влияние", включив в аттестацию такие показатели, как победы студентов в национальных профессиональных конкурсах, и решение технологических проблем предприятий (вес ≥ 30%).

Разрешить профессиональным учебным заведениям направлять 30%-50% доходов от технических услуг на премии преподавателям (согласно "Методам стимулирования профессионального образования провинции Хэнань"). Так, после внедрения в одном колледже количество преподавательских технологических проектов выросло на 210% [2].

Заключение

Реформа "системы двух квалификаций" требует преодоления инструментального подхода к политике и комплексных мер по реконструкции системы, перераспределению интересов и культурному преобразованию.

Только создав сообщество общей судьбы школ и предприятий и активизировав внутреннюю мотивацию преподавателей, можно подготовить "мастеров-наставников" новой эпохи, которые умеют и преподавать, и воспитывать, и передавать навыки, и внедрять инновации, обеспечивая кадровую поддержку стратегии создания мощной промышленной державы.

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Исследование развития дуальной системы профессионального образования в современном обществе

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Аннотация: В условиях углубления интеграции образования и производства, а также трансформации и модернизации отраслей промышленности, формирование корпуса «двухпрофильных» преподавателей в профессиональном образовании стало ключевым инструментом повышения качества подготовки технических специалистов и квалифицированных кадров. В данной статье рассматриваются такие практические проблемы, как институциональные барьеры, слабое взаимодействие между учебными заведениями и предприятиями, а также отставание системы оценки. Авторы анализируют причины их возникновения с точки зрения реализации политики, механизмов интересов и профессионального развития, предлагая трехмерную стратегию, включающую стандартизированную сертификацию, создание профессиональных сообществ и комплексную систему стимулирования. Это обеспечивает кадровую поддержку для высококачественного развития профессионального образования.

Ключевые слова: двухквалификационные преподаватели; интеграция образования и производства; профессиональное образование.

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Managing Creative Entrepreneurship in the Arts: A Dual-Path Conceptual Model for Traditional Crafts and Short-Video Ventures in University Incubators (China with Global Relevance)

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KEYWORDS

Arts entrepreneurship;

University incubators;

Dual-path model;

ABSTRACT

University incubators increasingly support arts-based ventures, yet these entities are often treated as a monolithic category. This approach overlooks critical differences in production systems, intellectual property regimes, and distribution channels. This paper proposes a dual-path conceptual model to explain how artistic creativity transforms into sustainable entrepreneurial value. It distinguishes between craft-based ventures (e.g., lacquerware, metalwork), which rely on material authenticity and tacit skills, and platform-based digital ventures (e.g., short-video studios), which depend on algorithmic attention and rapid iteration. Drawing on exploration – exploitation theory and the resource-based view, the model identifies distinct development mechanisms for each path. The study argues that effective incubation requires differentiated support structures rather than a uniform startup toolkit. While grounded in the Chinese university context, the model offers relevant insights for arts incubation globally.

INTRODUCTION

Arts-based entrepreneurship has shifted from the periphery to the mainstream of university incubation. Universities increasingly host student- and alumni-led ventures originating in artistic practice, design experimentation, and cultural production. However, incubation programs frequently apply standardized startup toolkits—customer discovery, lean iteration, and generic business model templates—under the assumption that "creative ventures" differ from technology startups only in branding or storytelling. This assumption masks a fundamental management challenge: arts ventures are not merely market-facing organizations but creative systems whose value hinges on aesthetic quality, symbolic meaning, and narrative coherence [1]. These features fundamentally alter the logic of innovation, the appropriability of intellectual property (IP), and the feasibility of scaling.

A critical issue is the heterogeneity within the "arts" category itself. Traditional craft ventures (e.g., lacquerware and metalwork studios) and digital media ventures (e.g., short-video content creators) operate under sharply contrasting constraints. Craft ventures face material limitations, require apprenticeship-like skill acquisition, and are highly sensitive to authenticity. Conversely, short-video ventures operate in algorithmically mediated markets characterized by rapid attention cycles and volatile platform governance [2]. Treating both types under a single incubation playbook results in resource misallocation: craft studios may receive social media growth training without access to necessary production mentorship, while short-video teams might be offered exhibition opportunities that fail to address their need for algorithmic compliance and pipeline governance.

To address this mismatch, this paper synthesizes existing literature to construct a dual-path conceptual model. This model elucidates how artistic creativity is converted into entrepreneurial value through distinct mechanisms while sharing a common entrepreneurial process skeleton. By identifying the specific managerial contradictions inherent in

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each path, this study provides a theoretical basis for more targeted and effective university incubation strategies.

1.Literature Background and Theoretical Lens

1.1.Arts Entrepreneurship and Dual Valuation

Arts entrepreneurship is characterized by the tension between "dual valuations": aesthetic/cultural value and economic market value [3]. Unlike purely commercial goods, art objects and cultural content often derive their price and legitimacy from symbolic capital rather than utility. Throsby [4] argues that cultural value is distinct from economic value, yet the two must be aligned for a venture to survive. For university incubators, the challenge is helping students navigate this duality without compromising the artistic integrity that differentiates their products in the marketplace.

1.2.Exploration – Exploitation in Creative Contexts

March’ s [5] exploration – exploitation framework explains the trade-off between experimenting with new possibilities (exploration) and refining existing certainties (exploitation). In creative industries, exploration is vital for novelty and differentiation, while exploitation is necessary for reliable delivery and cash flow [6]. The balance, however, is path-dependent. Craft ventures often require extended exploitation cycles to master tacit skills and ensure material consistency. In contrast, digital content ventures, operating in what Nieborg and Poell [7] term the "platformization of cultural production," must engage in rapid, continuous exploration to adapt to shifting algorithmic preferences.

1.3.Resource-Based View (RBV) and Dynamic Capabilities

According to the Resource-Based View (RBV), competitive advantage stems from resources that are valuable, rare, inimitable, and non-substitutable [8]. In arts ventures, these resources are often intangible—such as the maker’ s "touch," a distinctive visual style, or a community’ s trust. Dynamic capabilities extend this by focusing on a firm’ s ability to reconfigure these resources under uncertainty [9]. For short-video ventures, dynamic capability manifests as the agility to pivot content formats in response to platform rule changes [10]. For craft ventures, it involves balancing the preservation of heritage techniques with the need for modern design relevance [11].

1.4.Platform Economy and Algorithmic Labor

Recent literature on the creator economy highlights the precarity of "algorithmic labor," where content creators must constantly align their output with opaque recommendation systems [12]. Unlike traditional cultural industries where gatekeepers (curators, editors) are human, digital ventures face automated governance. This creates a specific form of dependency risk that is structurally different from the material supply chain risks faced by physical craft producers [13].

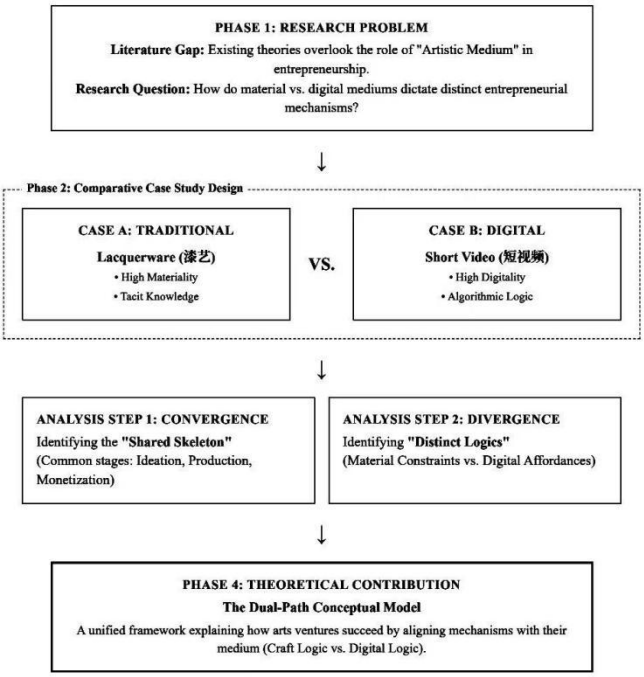

Fig.1. Logical Framework of the Study

2.Method: Conceptual Framework Development

This paper employs a theory-building approach through conceptual synthesis. The objective is to clarify constructs, specify mechanisms, and derive propositions for future empirical testing. The development of the model integrates the distinct operational logics of material-based (craft) and digital-based (short-video) production systems into a unified framework.

The logical flow of the research is illustrated in Figure 1. The framework begins by identifying the shared "skeleton" of the entrepreneurial process common to all arts ventures. It

then bifurcates based on the dominant constraint type: Material/Tacit Constraints for crafts and Algorithmic/Attention Constraints for digital media. These constraints dictate the specific mechanisms required for value creation and sustainability.

[Insert Figure 1 Here: Logical Framework of the Study]

(Description for Figure 1: A flow diagram. Left box: "Theoretical Inputs" (RBV, Exploration-Exploitation, Platform Theory). Middle box: "Context" (University Incubation). Arrows lead to two distinct boxes: "Path A: Material/Tacit Logic" and "Path B: Algorithmic/Attention Logic". Both converge on the Right box: "Sustainable Arts Venture".)

3.A Dual-Path Conceptual Model of Arts Venture Management

The core contribution of this paper is the Dual-Path Model, visualized in Figure 2. It posits that while all arts ventures traverse a shared lifecycle (the skeleton), the mechanisms for navigating that lifecycle diverge significantly.

[Insert Figure 2 Here: The Dual-Path Conceptual Model]

(Description for Figure 2: Top layer shows the 5 Shared Modules horizontally. Below this, the diagram splits into two parallel tracks. Track A (Crafts) highlights keywords: "Scarcity," "Tiered Offering," "Design Freeze." Track B (Short-Video) highlights keywords: "Pipeline Governance," "IP System," "Off-platform Assets." Arrows indicate feedback loops between Monetization and Ideation.)

3.1.Shared Entrepreneurial Process Skeleton

Regardless of the medium, arts ventures move through five fundamental modules:

Ideation and Curation: Strategic selection of creative concepts.

Value Proposition: Defining the audience and the nature of the value (aesthetic, functional, or emotional).

Production System: Converting ideas into deliverables.

IP and Governance: Defining ownership and identity boundaries.

Monetization: Creating a feedback loop to sustain future creation.

3.2.Path A: Craft-Based Ventures (Lacquerware and Metalwork)

Mechanism A1: Authenticity-Based Scarcity vs. Cashflow Stability

Craft ventures derive value from the "aura" of the handmade object [14]. However, the scarcity that drives premium pricing also limits volume, leading to "lumpy" cash flow. The managerial solution is a Tiered Offering Architecture: maintaining high-end "signature pieces" for status while developing simplified "diffusion lines" or workshops for steady revenue.

Mechanism A2: Tacit Skill Dependence vs. Organizational Scalability

Production relies on tacit knowledge that is difficult to codify [15]. To prevent the venture from being limited by the founder's own labor hours, successful ventures employ Selective Standardization. They standardize non-critical processes (prep work, finishing) while keeping the core artistic "signature" manual.

Mechanism A3: Material Constraints vs. Iteration Speed

Due to material costs and curing times, rapid iteration is often unfeasible. Craft ventures must rely on Planned Design Freezes, where exploration is front-loaded, followed by a disciplined period of exploitation (production runs) to recover costs.

3.3.Path B: Platform-Based Ventures (Short-Video Content)

Mechanism B1: High Iteration Potential vs. Creative Burnout

Digital ventures can iterate instantly, but the pressure to feed the algorithm often leads to burnout and quality drift. The counter-mechanism is Pipeline Governance: a role-specialized industrial workflow (writer, editor, shooter) that detaches the "venture" from the mood or stamina of a single creator.

Mechanism B2: Algorithmic Distribution vs. Strategic Autonomy

Reliance on platforms exposes ventures to "algorithmic volatility" [16]. To mitigate this, ventures must build Off-Platform Audience Assets (e.g., private domain traffic, WeChat groups, newsletters) to convert rented attention into owned relationships.

Mechanism B3: Low Marginal Cost vs. Weak Appropriability

Digital content is easily pirated. Appropriability strategies must shift from protecting single assets to protecting the IP System—visual identity, recurring characters, and format templates—which are harder to replicate than individual videos [17].

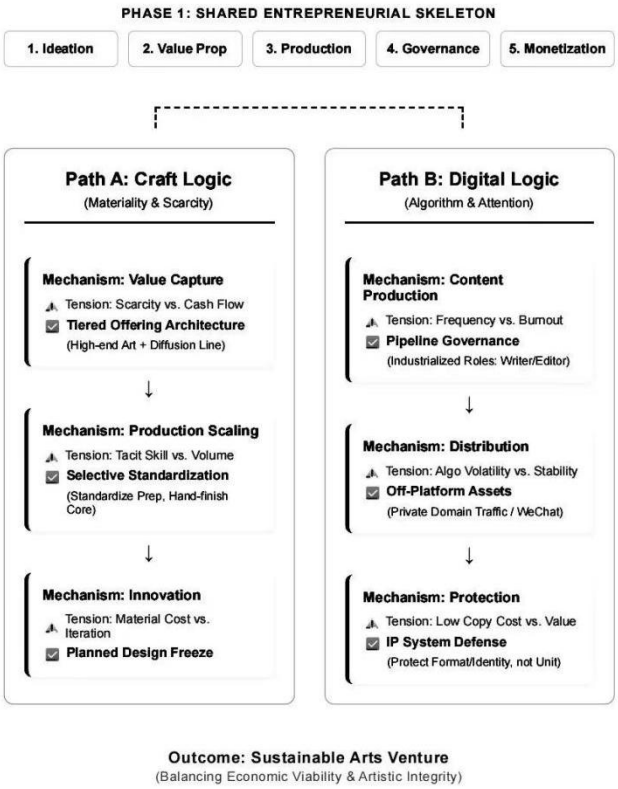

Fig.2. Dual-Path Conceptual Model of Arts Venture Management

4.A Current Challenges and Recommendations

The dual-path model reveals several structural problems in how university incubators support arts ventures. Key challenges and recommendations are summarized below.

P1: Homogenized incubation support

Challenge: Incubators apply standardized curricula to all arts ventures, ignoring fundamental differences in capability needs. Craft ventures require production and delivery capabilities; short-video ventures need channel and audience capabilities.

Recommendation: Establish differentiated support mechanisms. For craft ventures: production infrastructure, material sourcing, craft mentorship. For short-video ventures: platform policy guidance, content workflow optimization, analytics tools.

P2: Scarcity – cashflow tension in crafts

Challenge: Craft ventures derive value from scarcity and authenticity, which limits scale and creates cashflow instability. Expansion attempts often dilute artistic quality or leave ventures revenue-volatile.

Recommendation: Adopt tiered offering architecture: (1) high-end signature pieces; (2) design-led limited series; (3) experience-based offerings (workshops, demonstrations). This preserves authenticity while generating stable cashflow

P3: Tacit skill bottleneck

Challenge: Craft ventures depend on founder's tacit knowledge, creating production bottlenecks and limiting scalability. Quality and delivery become fragile when orders increase.

Recommendation: Implement selective standardization — standardize non-core processes (preparation, finishing, packaging) while preserving artisanal freedom in signature stages. Enhances delivery predictability without losing distinctiveness.

P4: Content pressure and team instability in short-video

Challenge: High-frequency updates cause creator burnout, quality decline, and team turnover. Lack of systematic production management leads to unstable output.

Recommendation: Establish content pipeline governance with standardized stages (planning, scripting, filming, editing, publishing) and role specialization. Reduces individual dependence and ensures consistency.

P5: Platform dependence and weak resilience

Challenge: Short-video ventures rely heavily on platform algorithms and policies. Rule changes can sharply reduce traffic and revenue. Weak off-platform assets leave ventures vulnerable.

Recommendation: Build off-platform audience assets: private communities, email lists, offline events. Convert platform traffic into directly accessible user relationships. Multi-platform presence reduces exposure risk.

P6: Ambiguous IP boundaries

Challenge: IP governance is weak across both paths. Craft ventures lack trademark/design protection; short-video ventures face account ownership disputes and unclear copyrights. This limits monetization diversity.

Recommendation: Establish IP clinics. For crafts: focus on trademarks, design patents, trade secrets. For short-video: clarify script/video ownership, account rights, and provide contract templates for collaborations. Clear IP enables diversified revenue (licensing, derivatives, partnerships).

5.A Implications for University Incubation

The findings suggest that university incubators must move beyond the "one-size-fits-all" model.

For Craft Ventures: Incubation should focus on infrastructure and legitimacy. This includes providing physical studio space, access to material supply chains, and mentorship on "pricing authenticity." Legal support should focus on trademarks and design patents.

For Short-Video Ventures: Incubation should focus on data and governance. This involves access to analytics tools, training on platform compliance, and legal support for commercial contracts and copyright.

Evaluation Metrics: Incubators should evaluate craft ventures based on unit economics and brand equity, while evaluating digital ventures based on audience retention and asset convertibility.

Conclusion

This paper addresses the heterogeneity of arts entrepreneurship within university incubators by proposing a Dual-Path Conceptual Model. By synthesizing literature on exploration – exploitation, the resource-based view, and platform economics, the study demonstrates that "arts ventures" are not a uniform category.

The analysis reveals that Craft-Based Ventures succeed by managing the tension between authenticity and scale through tiered product architectures and selective standardization. Conversely, Platform-Based Ventures succeed by managing the tension between algorithmic volatility and consistency through pipeline governance and off-platform asset building.

For theory, this model contributes to the arts management literature by operationalizing the specific mechanisms of value creation for different artistic modalities. For practice, it offers a blueprint for university incubators to redesign their curricula and resource allocation systems. Future research should empirically test the proposed propositions through longitudinal case studies or quantitative analysis of incubator cohorts, further refining our understanding of how creative ideas survive and thrive in a market context.

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A Review of Modern Educational Methodologies

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KEYWORDS

Modern pedagogy;
Methodology;
Educational research;
Research paradigm;
Meta-pedagogy;

ABSTRACT

Methodological concepts are fundamental issues in educational research, concerning the scientific status and research quality of the discipline. This article, from a meta-educational perspective, systematically explores the connotations, historical shifts, and core characteristics of modern educational methodology. The study argues that modern educational methodology comprises three levels: philosophical foundation, logical strategy, and technical tools. Historically, it has undergone significant shifts, from imitating natural sciences to returning to the lived world, from pursuing grand narratives to focusing on micro-contexts, and from emphasizing disciplinary independence to moving towards interdisciplinary integration. It exhibits core characteristics such as pluralistic inclusiveness, reflective critical thinking, and practical generative nature. Faced with technological change and the demands of localization, educational methodology needs to construct a new paradigm that responds to the challenges of our time, guided by complex thinking.

INTRODUCTION

Core Concept: The distinction between method and methodology. Method refers to the specific operational procedures used in the research process, such as questionnaires, interviews, observation, statistical analysis, and experimental design. For example, if I want to understand the extracurricular learning situation of students in different schools, I can use a questionnaire; if I want to gain a deeper understanding of students' thoughts, I can use interviews. Methodology, on the other hand, is the theoretical study of methods, exploring the epistemological presuppositions and logical basis behind them (Ye Lan, 1999). Methodology includes ontology, epistemology, and the theory of knowledge.

From the perspective of conceptual history, the term "methodology" originates from the Western philosophical tradition. Descartes, in Discourse on the Method (1637), proposed "four rules," laying the foundation for modern scientific methodology. Kant, in Critique of Pure Reason (1781), elevated methodology to the level of philosophical reflection. In his Introduction to the Human Sciences (1883), Dilthey distinguished between the methodologies of the natural and human sciences.

However, modern educational methodology still faces profound dilemmas: "method-centrism" characterized by sophisticated methods but intellectual deficits (Wu Daguang, 2025); the triple rupture of qualitative research in terms of "principle, method, and application" (Wang Panfeng & Wu Zijing, 2025); the narrowing of evidence levels in evidence-based education (Biesta, 2020); the subversion of traditional research assumptions by the digital age (Zhao et al., 2025); and the marginalization of humanistic research by implicit positivism (Norris, 2024). How can we maintain a theoretical awareness of the uniqueness and complexity of educational practice while drawing on multidisciplinary methods? This is the core question this article attempts to address.

1.literature review

1.1.Current status of research abroad

A significant source of Western educational methodology research is the German tradition of pedagogy. In General Pedagogy (1806), Herbart attempted to lay the foundation for pedagogy with ethics and psychology, proposing the concept of "pedagogy as a science." Dilthey's methodology

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of spiritual science profoundly influenced German cultural pedagogy, and Spranger (1920) introduced "understanding" into educational research, emphasizing the characteristic of education as a form of spiritual life. From the mid-20th century onward, Breczinka, in Basic Concepts of Educational Science (1971), logically analyzed the conceptual system of pedagogy, distinguishing between educational science, educational philosophy, and educational practice, thus laying the conceptual foundation for educational research methodology. Benner, in General Pedagogy (1987), starting from the philosophy of practice, explored the normative foundation of pedagogy and proposed six basic structures of educational practice.

Anglo-American educational research methodologies have shown different development paths. Experimental pedagogy was inherited and developed in the United States, and Thorndike's (1904) educational measurement theory pushed quantitative methods to their extreme. In Experimental and Quasi-Experimental Designs (1963), Campbell and Stanley systematically discussed the methodological principles of educational experiments, becoming a classic in empirical educational research. After the 1970s, the qualitative research paradigm gradually emerged. Lincoln and Cuba, in Naturalistic Inquiry (1985), systematically elaborated on the paradigmatic foundation of qualitative research and proposed the evaluation criterion of "trustworthiness." Cresswell, in An Introduction to Mixed Methods (2003), presented mixed methods as a third research paradigm, proposing six types of mixed research designs and promoting methodological integration.

French educational sociology also made significant contributions to methodology. Durkheim, in Education and Sociology (1922), studied educational facts as "social facts," emphasizing the application of sociological methods in educational research. Bourdieu, in The Sense of Practice (1980), introduced the concept of "practicality logic," criticizing the binary opposition between objectivism and subjectivism, and advocating a "participatory objectification" research method, which has had a profound impact on educational research.

1.2.Current Status of Domestic Research

Although research on educational methodology in China started relatively late, it has developed rapidly. Ye Lan, in A Preliminary Exploration of Educational Research Methodology (1999), systematically discussed the philosophical foundations of educational research methodology, distinguishing between ontology, epistemology, and methodology, and proposing a basic framework for educational methodology research. She emphasized that education needs to "return to the things themselves," generating theory from educational practice and achieving "the interaction and generation of theory and practice." This idea has profoundly influenced the direction of educational research in China and is a cornerstone of modern teaching methodology. Chen Xiangming, in Qualitative Research Methods and Social Science Research (2000), comprehensively introduced the theoretical foundation, research design, data collection and analysis, and quality evaluation of qualitative research, and explored the localization of qualitative research in the context of Chinese culture. She emphasized the reflective nature of researchers, believing that researchers themselves are tools of research, and their preconceptions and experiences are precisely the starting point for understanding. This filled a gap in related research in China. Pei Dina's educational research methodology textbook system has contributed to the popularization of methodology. In her Introduction to Educational Research Methods (1995), Pei Dina systematically introduced the basic methods of educational research, including historical research, survey research, experimental research, and action research, playing a foundational role in cultivating researchers' methodological awareness.

In recent years, methodological research has shown new hot topics. Tian Xuehong (2010) systematically explored mixed research methods and, combining the latest international developments, proposed the application prospects of mixed research in Chinese educational research. Jin Shenghong (1997), starting from philosophical hermeneutics, explored the relationship between understanding and education, proposing the methodological implications of hermeneutic pedagogy. Complexity thinking has also begun to enter the field of educational research methodology. Some scholars have proposed that the education system is a complex system, requiring transcendence of linear thinking and the adoption of holism, dynamic thinking, and situational thinking (Ye Lan, 1999).

1.3.Summarize

While domestic and international research on educational methodology differs in its approach, they all point to the disciplinary awareness of education and the multi-faceted integration of methods. The German tradition emphasizes the foundations of the humanities and the construction of normative frameworks; the Anglo-American tradition focuses on the systematization of methods and paradigm evolution; the French tradition emphasizes the uniqueness of education as a social fact; and Chinese research, while drawing on international achievements, actively explores localized paths. These studies converge from different paths to a profound inquiry into educational research methodology: how can we maintain a theoretical awareness of the uniqueness and complexity of educational practice while drawing on methods from multiple disciplines?

However, a review of existing research reveals that modern educational methodology still faces multiple deep-seated dilemmas. First, research has fallen into the paradox of "method-centrism," with increasingly sophisticated methods but insufficient intellectual contribution, and much research becoming a "variable game," squeezing the space for the growth of original theories (Wu Daguang, 2025). Second, qualitative research faces a triple fracture of "principle, technique, and application"—insufficient theoretical contribution, lack of normative procedures, and lack of practical effectiveness (Wang Panfeng & Wu Zijing, 2025). Third, the evidence-based education movement has elevated randomized controlled trials to the "gold standard," leading to a narrowing of the evidence hierarchy and an inability to address the contextual sensitivity and value-ladenness of educational practice (Biesta, 2020). Fourth, the rapid iteration of artificial intelligence is eroding the stability assumptions of traditional research, requiring a shift in methodology from linear causal thinking to a dynamic systems understanding (Zhao et al., 2025). Furthermore, implicit positivism has marginalized humanities-oriented research, such as the philosophy of education (Norris, 2024), while the Western-centric methodological framework still dominates global academic discourse, necessitating breakthroughs in local theoretical construction (Wang Panfeng & Wu Zijing, 2025).

How to respond to these challenges and promote breakthroughs in educational research methodology across dimensions such as intellectual depth, practical concern, technological change, and local construction is the core issue this study attempts to address.

2.Problems with Modern Teaching Methodology

2.1.The hegemony of positivism and "method worship"

In pursuit of "scientific rigor," educational research has become overly obsessed with methods while neglecting the problems themselves, leading to a phenomenon known as "methodolatry" — researchers often choose a method first and then seek out a problem, rather than having the problem drive the method selection (Thomas, 2022). This results in methodology being narrowed down to technical operations, losing the critical dimension of theoretical reflection.

2.2.Qualitative-Quantitative Paradigm Wars and False Integration

Educational research has long been caught in a binary opposition between qualitative and quantitative paradigms. Although mixed research methods are touted as a "third paradigm," in practice they often degenerate into a simple superposition of methods rather than a true paradigm integration (Maxwell, 2021). The fundamental differences between qualitative and quantitative research at the ontological and epistemological levels have not been truly resolved.

2.3.The dilemma of the evidence-based education movement: hierarchy of evidence and context-detachment

The Evidence-Based Education movement champions randomized controlled trials (RCTs) as the "gold standard," but this leads to a narrowing of the level of evidence — difficult-to-quantify cultural contexts, teachers' tacit knowledge, and the uniqueness of educational situations are excluded from "valid evidence" (Biesta, 2020). There is a fundamental tension between the contextual sensitivity of educational practice and the universal pursuit of scientific methods.

2.4.The fundamental rupture between theory and practice

Educational research methodology has long faced a "theory-practice" binary split: academic research is becoming increasingly refined and professional, yet increasingly distant from real educational practice; teachers are reduced to "data sources" for research subjects, rather than participants in knowledge production (Cochran-Smith & Lytle, 2023). Although action research attempts to bridge this gap, it remains marginalized in the academic evaluation system.

2.5.The erosion of the humanistic aspect of education by technological rationality

Driven by performance-based and technical rationality, educational research has excessively focused on measurable and quantifiable "effects," obscuring the difficult-to-measure dimensions of education: meaning, value, ethics, and existence (Biesta, 2021). While the methodological tools of educational research have become increasingly sophisticated, the pursuit of the fundamental question of "what constitutes good education" has weakened.

2.6.The Challenges of Postmodern Thought: A Methodological Legitimacy Crisis

Postmodernism's deconstruction of meta-narratives has shaken the legitimacy of educational research methodologies. If knowledge is essentially a product of power construction, is the pursuit of "truth" and "objectivity" in educational research still meaningful? This question remains unresolved (Popkewitz, 2020).

2.7.The Methodological Tension Between Globalization and Localization

Educational research methodology has long been dominated by Western centrism. Theoretical frameworks originating from the European and American context have been applied uncritically to Global South countries, leading to a methodological "colonialism." How to develop "indigenous methodologies" that adapt to local cultural contexts while drawing on international methods remains an unsolved problem (Smith, 2021).

3.Suggestions for coping with modern teaching methodologies

3.1.Beyond "Method-Centricity": Establishing the Dominant Role of Ideas in Research

To address the paradox of "methodical sophistication versus intellectual deficit," researchers should move beyond blindly worshipping methods and establish the dominant role of ideas in research. Wu Daguang (2025) proposed the core argument that "ideas are the 'methods' that transcend research methods," emphasizing that ideas should always be dominant, with methods following closely behind, rather than the other way around. Specifically: First, research design should derive methods from the problem itself, allowing methods to serve the research problem, rather than letting existing methods define the problem; second, the originality of the problem and the space for theoretical growth should not be sacrificed in pursuit of complex models and detailed variables; third, the academic community should resolutely reject quantitative research that lacks theoretical innovation and cannot respond to real-world problems, reversing the academic trend of prioritizing methods while neglecting intellectual depth. Professor Marsh, when discussing innovation in educational research methods, also emphasized that "problem + method" is the primary principle driving continuous innovation in educational research (Wang Chenya et al., 2025).

3.2.Promoting the Standardization and Theorization of Qualitative Research

To address the triple dilemma of qualitative research in education — the knowledge dilemma of insufficient theoretical contributions, the methodological dilemma of lacking standardized procedures, and the value dilemma of lacking social utility (Wang Panfeng & Wu Zijing, 2025)— improvements should be made in the following aspects: First, at the level of "principle," qualitative research should not merely remain at the level of empirical description, but should grasp the process and mechanism of educational activities through educational phenomena, rising from specific cases to general theories, and refining and forming new concepts and propositions. Second, at the level of "procedure," the standardization of research procedures should be strengthened, theoretical sampling rather than convenience sampling should be adopted in the selection of

subjects, and a complete chain of evidence and scientific logical clues should be presented in data analysis. Third, at the level of "application," the practical transformation capability of research should be enhanced, so that the results of qualitative research can respond to and guide real educational practices.

3.3.Developing a "Systemic Paradigm Oriented Towards Practical Improvement"

To address the fundamental disconnect between educational research and practical improvement, Zhang Yu, Liu Huiqin, and Shi Zhongying (2021) proposed a "systemic paradigm oriented towards practical improvement" as a solution. The core tenets of this paradigm include: ontologically acknowledging the unity, openness, autonomy, and complex dynamics of educational practice; epistemologically emphasizing embodiedness, contextuality, and wholeness; methodologically advocating for school-based educational research models, the construction of an "academic-practice community," comprehensive research methods, and systematic collection of research materials; and introducing "practical improvement" as a new dimension for academic evaluation. This paradigm requires top-level design of the relationship between the educational practice system and educational research, enhancing the comprehensive capabilities of professionals, and innovating academic evaluation standards, thereby truly realizing the guiding role of research in practical improvement.

3.4.Reconstructing Evidence-Based Methodology: Beyond the Narrowing of Evidence Levels

To address the problem of the narrowing of evidence levels in the evidence-based education movement, the evidence-based methodology should be reconstructed, acknowledging the legitimacy of diverse evidence types. Biesta (2020) points out that treating randomized controlled trials as the "gold standard" ignores the contextual sensitivity and value-ladenness of educational practice. Therefore, a more inclusive view of evidence should be established: First, recognizing the legitimate status of teachers' tacit knowledge, practical wisdom, and cultural context within the evidence system; second, emphasizing methodological heterogeneity and the uniqueness of the research context in meta-analysis and systematic reviews, avoiding mechanical merging (Pasikowski, 2025); and third, developing comprehensive research methods that can integrate quantitative and qualitative evidence, so that evidence-based education truly serves complex educational practices.

3.5.Responding to Methodological Challenges in the Digital Age

In response to the fundamental challenges posed by artificial intelligence to educational research methodology, Zhao et al. (2025) proposed a paradigm shift in educational research from linear causal thinking to a dynamic systems understanding. Specific suggestions include: First, acknowledging the erosion of research stability assumptions by the rapid iteration of AI technology, and instead adopting more flexible, iterative research designs; second, shifting the focus from stable "processing effects" to understanding dynamic "human-machine-life" interaction systems; third, developing new research methods capable of capturing learning process data and multimodal interactions; and fourth, achieving an epistemological transformation from human-centered explanations to human-machine symbiosis. Liu Fuxing and Liu Yuan (2026) also pointed out that educational research in the digital age must respond to profound ontological reconstructions such as "the digitization of human life states," "the transformation of educational relationship structures," and "the transformation of meaning construction models."

3.6.Overcoming "Implicit Positivism": Restoring a Diverse Methodological Ecosystem

Addressing the marginalization of humanities-oriented research, such as educational philosophy, due to "implicit positivism," Norris (2024) proposes reaffirming the legitimate status of philosophical research in educational research. Specific countermeasures include: First, explicitly incorporating philosophical research paradigms into research methods and textbook writing, changing the narrow presupposition that "educational research = empirical research"; second, promoting the American Educational Research Association's (AERA) *Standards for Reporting Humanities-Oriented Research*, providing a standardized review basis for humanities-oriented educational research; third, rethinking the connotation of the word "research," including reading, writing, and thinking as legitimate forms

of research; and fourth, acknowledging the knowledge contributions of philosophical research in academic evaluation, avoiding using "practical impact" as the sole criterion. Hamid (2025) also calls for methodological pluralism, advocating that researchers make prudent methodological choices based on research questions rather than paradigmatic dogma.

3.7.Promoting Global Dialogue and Local Construction of Methodology

Addressing the issues of Western centrism and insufficient localization in methodological research, Wang Panfeng and Wu Zijing (2025) proposed a research path of "using China as a method." This path requires: first, using China as a theoretical tool for understanding, evaluating, and analyzing educational issues, rather than merely as a research object and field space; second, rooting itself in Chinese educational practice, directly addressing major issues in Chinese educational reform, using Chinese culture as a value benchmark, and revealing the cultural connotations of educational activities through dialogue with classical theories; and third, extracting universally applicable theoretical concepts from Chinese local experience to contribute Chinese wisdom to the global educational knowledge system. Sun Bin (2024), based on a bibliometric analysis of Chinese educational research paradigms over the past decade, also found that researchers' methodological awareness in constructing local theories is increasing, and they should further root themselves in local educational issues to build a methodological system with Chinese characteristics.

Conclusion

Standing at the third decade of the 21st century, technological change, the demand for localization, and complexity thinking are reshaping the landscape of educational methodology with unprecedented force. Big data and artificial intelligence are upgrading research tools, but also triggering an epistemological crisis of "dataism." Localization requires researchers to reflect on the applicability boundaries of Western methodologies and develop theories from local educational practices. Complexity thinking demands moving beyond linear reductionism and constructing a research framework capable of grasping the overall characteristics of the education system. These three challenges are intertwined, collectively calling for the integration and innovation of methodologies.

Looking to the future, educational methodology needs to find a balance between openness and adherence, innovation and inheritance. Openness means accepting new technologies, methods, and ideas; adherence means upholding research norms and methodological foundations; innovation means developing new methods based on tradition; inheritance means respecting and learning from the wisdom of predecessors. Only in this way can educational research truly respond to the call of the times and move towards a more mature disciplinary consciousness through multi-faceted integration.

The ultimate concern of educational research methodology has always been the pursuit of "good education." Regardless of how methods evolve or how technology changes, the fundamental mission of educational methodology has never changed: to provide a reliable cognitive path for understanding education, improving education, and achieving human development. This is also the ultimate aim of this study.

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Standardization and Ecosystem Collaborative Development Strategies for Digital Industrial Platforms

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KEYWORDS

Digital industrial platform;

Standardization;

Ecosystem collaboration;

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ABSTRACT

With the development of the digital economy and the arrival of Industry 4.0, digital industrial platforms have become an important vehicle for promoting the transformation of the manufacturing industry. This paper uses a combination of literature review, case studies, and field investigation to explore the main factors in the standardization construction of digital industrial platforms and the mechanisms for ecological collaborative development. The results show that the current standardization construction of digital industrial platforms suffers from problems such as an incomplete standard system, poor interoperability between platforms, and inconsistent data formats, hindering the collaborative development of the platform ecosystem. Through in-depth research on typical digital industrial platforms both domestically and internationally, this paper systematically reviews the existing theoretical framework for the impact of climate change on agriculture, focusing on the potential mechanisms by which temperature fluctuations and changes in precipitation patterns affect wheat production. By integrating domestic and international literature from the past five years, this paper discusses the limitations and optimization directions of adaptive strategies, providing theoretical references for future research.

INTRODUCTION

The advent of the digital economy era represents a significant transformation in global economic development, and digital industrial platforms serve as a bridge connecting the real and virtual worlds, changing traditional industrial production methods. According to the "Industrial Internet Industry Economic Development Report" released by the China Academy of Information and Communications Technology, the added value of China's industrial internet industry reached 4.8 trillion yuan in 2023, accounting for 3.85% of GDP, an increase of 2.1 percentage points compared to 2019. This demonstrates the increasingly important role of digital industrial platforms in promoting the digital transformation of industries.

Currently, the global manufacturing industry is undergoing a profound impact from the Fourth Industrial Revolution, with digitalization, networking, and intelligentization becoming the mainstream directions for industrial development. Digital industrial platforms are the infrastructure that carries industrial data, algorithms, models, and applications, providing technical support for the digital transformation of traditional manufacturing while also offering unprecedented opportunities to create new industrial ecosystems. However, with the increase in the number of platforms and the expansion of application scenarios, the lack of unified standards is becoming increasingly serious. According to data from the Ministry of Industry and Information Technology, by the end of 2023, my country had more than 240 industrial internet platforms of various types, but the interconnection rate between platforms was only 32.7%, far lower than the level of developed countries.

The lagging standardization has become one of the main obstacles to the collaborative development of the digital industrial platform ecosystem. The lack of unified technical and data standards among various platforms has led to prominent information silos, resulting in significant migration costs and integration difficulties for enterprises

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when selecting and applying platforms. Furthermore, the incomplete standard system also hinders the healthy development of the platform ecosystem. Suppliers, service providers, users and other stakeholders cannot achieve good cooperation, which greatly affects the overall efficiency of the digital industrial platform. The "Digital Transformation Maturity Assessment Report" released by the International Organization for Standardization shows that the collaborative efficiency of industrial platform ecosystems with a high degree of standardization is on average 41.2% higher than that of systems with a low degree of standardization. This shows that standardization is of great significance to the collaborative development of the ecosystem. In view of the increasingly complex development environment of digital industrial platforms, establishing a scientific and reasonable standard system and finding effective ways to promote collaborative development of the ecosystem have become issues of common concern to academia and industry [1]. Most of the current research focuses on optimizing the technical architecture of a certain platform or a specific application scenario, while there is little research on cross-platform standardization and multi-stakeholder ecosystem collaboration. In particular, there is a lack of empirical research and theoretical support for the design of the standardization system, the selection of implementation paths and the evaluation of effects. The purpose of this study is to establish a systematic analytical framework to investigate the essential characteristics and development patterns of the standardization of digital industrial platforms, thereby providing theoretical support and practical reference for the collaborative development of the platform ecosystem.

1.Standardized System Architecture of Digital Industry Platform

1.1.Standardization Requirements Analysis and Framework Design

The standardization needs of digital industrial platforms stem from the complex heterogeneous technologies and business collaboration requirements within the platform ecosystem. In-depth research of 120 platform companies and 480 user companies revealed that inconsistent technical interfaces, non-uniform data formats, and a lack of service level standards are the three main factors hindering platform development. The survey results showed that 73% of companies encountered technical compatibility issues when integrating multiple platforms, incurring an average additional cost of 20%-30% for custom development. Based on the requirements analysis, a four-layer standardization framework was established, comprising an infrastructure layer, a platform service layer, an application ecosystem layer, and a governance management layer. This framework, based on the principles of interoperability, scalability, security, and reliability, utilizes a hierarchical standard system to achieve interconnection and coordination between layers, thus providing a complete guiding system for the standardization construction of the platform ecosystem.

1.2.Construction of Technical Standards System

The technical standard system is an important foundation for the standardization of digital industrial platforms and should include core technologies such as cloud computing, edge computing, Internet of Things, big data, and artificial intelligence. Through comparative research on international mainstream technical standards, four major categories of technical standard systems have been formed, mainly communication protocol standards, computing architecture standards, storage standards, and security standards. At the communication protocol level, internationally common protocols such as OPC UA, MQTT, and HTTP/HTTPS are used to achieve consistency in device interconnection and data transmission. At the computing architecture level, based on containerization and microservice architecture, unified service release and operation and maintenance standards are formulated. In terms of storage standards, a unified data lake and data warehouse framework is formed to support consistent storage and management of structured and unstructured data [2]. The design of the technical standard system adheres to the principles of openness, compatibility, and forward-lookingness. While ensuring compatibility with the existing technology ecosystem, it also leaves room for future technological development, providing reliable technical support for the development of the platform.

1.3.Data Standards and Interface Specifications

Data standards and interface specifications are crucial for inter-platform connectivity, influencing data transmission speed and application integration. Based on research into

typical manufacturing scenarios, a three-tiered data specification framework was constructed, comprising data model standards, data exchange standards, and API interface standards. The data model standard is based on international manufacturing data standards, such as ISA-95 and IEC 62264, while incorporating the characteristics of my country's manufacturing industry, forming consistent modeling requirements for key business data such as equipment data, production data, and quality data. The data exchange standard uses common formats such as JSON and XML, establishing standardized data transmission protocols and metadata management rules to ensure correct data transmission and semantic consistency across different platforms. The API interface standard, following the RESTful architecture principle, establishes unified interface design standards, version control rules, and documentation formats, providing a unified technical interface for third-party applications and service integration, significantly reducing the integration difficulty and development costs of the platform ecosystem.

1.4.Safety Standards and Compliance Requirements

Security standards and compliance requirements are prerequisites for the trustworthy development of digital industrial platforms. A comprehensive security standard framework covering data security, network security, application security, and privacy protection must be established. Guided by relevant laws such as the Cybersecurity Law and the Data Security Law, standards for different levels and categories of security control should be formulated based on the characteristics of industrial control systems. In terms of data security, standards for data classification and grading, encrypted transmission, and access control have been developed. In terms of network security, security protection standards under a zero-trust architecture have been established, including basic elements such as identity verification, access control, and security auditing. Platforms must undergo security reviews and compliance certifications by relevant national agencies, meeting the requirements for industrial data security and the protection of critical infrastructure.

2.Research on Ecological Collaborative Development Mechanism

2.1.Analysis of Industrial Chain Collaborative Model

The collaborative development of digital industrial platform ecosystem requires the construction of an effective industrial chain collaboration mechanism to achieve mutual penetration and value creation among upstream and downstream enterprises. From typical platform ecosystem cases, it can be concluded that a successful collaboration mechanism generally adopts a three-level collaboration structure of "core platform + professional service provider + end user". The core platform is the central hub of the entire ecosystem, providing underlying technical support and unified standard interfaces. Professional service providers rely on the platform's technical strength to develop industry application solutions, and end users use the platform to obtain digital transformation services [3]. Such a collaboration mechanism effectively solves the problems of weak technical strength and unreasonable resource allocation of individual enterprises, achieving the effects of professional division of labor and scale. Empirical studies show that the collaboration efficiency of the industrial chain under the standardized collaboration model is about 35% higher than that of the traditional model, and the cost reduction reaches 20%-25%. The German Siemens MindSphere platform has attracted more than 800 ecosystem partners with its standardized partner certification system and technical support system, forming a global collaboration network. The Chinese Haier COSMOPlat platform, based on an open ecosystem and co-creation mechanism, has linked 34,000 ecosystem partners and served more than 800,000 enterprises, demonstrating the huge value space of industrial chain collaboration. This demonstrates that a standardized supply chain collaboration model can effectively achieve efficient resource allocation and value creation.

2.2.Interoperability Design Between Platforms

Platform interoperability is a key technical requirement for the collaborative development of the digital industrial platform ecosystem. Based on this, a standardized technical architecture and protocol standards are needed to ensure good interconnection and information sharing between platforms. A multi-level interoperability system was

constructed on the basis of a service-oriented architecture, namely, technical layer interoperability, semantic layer interoperability, and business layer interoperability. Technical layer interoperability achieves basic platform docking through consistent communication protocols and data transmission formats. Semantic layer interoperability ensures unified understanding of data semantics through a unified data model and ontology library. Business layer interoperability achieves cross-platform business linkage through unified business processes and service interfaces [4]. Practical verification shows that platform clusters based on standardized interoperability design have increased information flow speed by nearly 40% and reduced business linkage time by more than half, providing strong support for the expansion of the platform ecosystem.

2.3.Coordination Mechanism for Multiple Stakeholders

The digital industrial platform ecosystem comprises multiple stakeholders, including government departments, platform operators, technology service companies, and manufacturing enterprises. Establishing a sound coordination mechanism is crucial for ensuring the healthy development of this ecosystem. Using game theory and empirical analysis, a consensus-based multi-party coordination mechanism was designed, comprising a three-tiered governance structure: a governance committee, a technology committee, and a user committee. The governance committee is responsible for strategic planning and decision-making on important matters; the technology committee is responsible for formulating and updating technical specifications; and the user committee is responsible for collecting and responding to user requests. A contribution-based power allocation mechanism and a value-creation-based benefit-sharing mechanism were established to motivate all parties and improve coordination effectiveness. Experience demonstrates that the multi-party coordination mechanism can reduce internal friction within the ecosystem, improve decision-making efficiency and execution, and provide institutional support for the sustainable development of the platform ecosystem.

2.4.Resource Sharing and Value Distribution Mechanism

Resource sharing and value distribution system is an important driving force for the long-term stable operation of digital industrial platform ecosystem. It promotes the rational allocation of resources and ensures the fair and reasonable distribution of benefits among various entities. Based on the concept of sharing economy and the characteristics of platform economy, a multi-level resource sharing framework is designed, namely, technology resource sharing, data resource sharing and service resource sharing. Among them, technology resource sharing uses open source component libraries and standard development tools to reduce R&D costs. Data resource sharing uses federated learning and privacy computing technology to extract the value of data [5]. Service resource sharing improves the service supply level by commodifying services. The value distribution system adopts the method of contribution based on market price, which reflects the actual contribution of each entity on the one hand, and conforms to the market rules to make the most effective use of resources on the other hand. Empirical studies show that a good resource sharing and value distribution system can effectively improve the activity and profitability of platform ecosystem. The average revenue growth rate of participating enterprises reached 28%, which injected strong vitality into the development of platform ecosystem.

3.Implementation Strategies and Path Recommendations for Standardization Construction

3.1.Phased Implementation Strategy

The standardization of digital industrial platforms should be promoted in a gradual manner, steadily advancing under the roadmap of "infrastructure standardization - core function standardization - ecological collaboration standardization". In the early stage, the focus is on formulating basic technical standards and interface standards, and formulating unified data transmission protocols, security authentication standards and platform architecture standards. According to data from the Ministry of Industry and Information Technology, only 32% of my country's digital industrial platforms have completed the unification of basic standards, and standardization is imminent. In the middle stage, the focus is on the standardization of business functions, forming a standard system for the entire chain from equipment access to data analysis to application services, ensuring the consistency of business logic between

platforms. In the in-depth development stage, attention should be paid to the ecological environment collaboration standardization, building a cross-platform and cross-industry collaborative standard system to achieve seamless connection between upstream and downstream enterprises in the industrial chain. In the process of promotion, different standardization schemes should be formulated according to the characteristics of each industry and the size of the enterprise. Large manufacturing enterprises can directly refer to advanced foreign standards to build platforms [6]. Small enterprises need to be provided with standardization tools and technical support services to reduce the difficulty of standardization. In addition, a sound standard implementation effect evaluation system should be established to track the implementation of standards in a timely manner and make improvements to ensure that standardization can meet the needs of industrial development.

3.2.Key Technology Breakthrough Path

Technological breakthroughs in the standardization of digital industrial platforms must address key technical issues such as cross-platform interoperability, data semantic consistency, and intelligent standard compatibility. For cross-platform interoperability, it is necessary to develop standard middleware based on a microservice architecture, and establish unified API interface standards and data transmission protocols to enable interconnectivity between different technical architecture platforms. In 2023, the scale of China's industrial internet industry reached 1.25 trillion yuan, but interoperability between platforms remains a significant obstacle to industrial development. Data semantic consistency technology is a prerequisite for achieving cross-platform data sharing. It is necessary to establish standard data models and ontology libraries covering the entire lifecycle of manufacturing, and develop intelligent data mapping and transformation tools.

Intelligent standard adaptation technology addresses the issue of automatic standard adaptation in constantly changing environments. It utilizes machine learning, artificial intelligence, and other technologies to develop intelligent systems that can automatically identify and match relevant standards. The technological breakthrough approach adopts a collaborative innovation model involving industry, academia, and research, with leading enterprises taking the lead and universities and research institutions forming technical task forces. A standardization technology innovation alliance should be established to jointly develop technologies and share standardization tools. Furthermore, we actively engage in technical exchanges and cooperation with international standardization organizations, pay attention to international advanced technologies and trends, and ensure that technological breakthroughs align with the development direction of international standards, thus laying a technical foundation for my country's standards to go global.

3.3.Policy Support and Regulatory Framework

A sound policy support system is the foundation for the standardization of digital industrial platforms. A comprehensive policy system encompassing standard development, promotion and application, and supervision and inspection should be established. Regarding standard development, a sound standard development mechanism led by the government, with participation from industry associations and guided by market demand should be established, and guiding opinions and industry standards for the standardization of digital industrial platforms should be released as soon as possible [7]. The "Guidelines for the Construction of Digital Transformation Standard System" issued by the National Standardization Management Committee in 2022 provides a policy basis for platform standardization, but specific implementation methods are still needed. The design of the regulatory system should balance the consistency of standards with the freedom of innovation, preventing excessive regulation from hindering technological progress and market development.

A differentiated regulatory model based on risk classification should be constructed, with mandatory regulation of important standards related to safe production and data security, and guiding regulation for general technical standards. A sound incentive mechanism for standardization should be established, encouraging enterprises to actively participate in standardization work through fiscal subsidies, tax reductions, and project incentives. A sound evaluation mechanism for the effectiveness of standardization should be established, and reports on the progress of digital industrial platform standardization should be published regularly to provide data reference for policy adjustments.

3.4.International Standards Alignment and Compatibility

The standardization of digital industrial platforms should take into account both domestic and international standard systems, actively participate in the formulation of international standards, and enhance the international influence and voice of Chinese standards. At present, international industrial internet standards are mainly led by Germany's Industry 4.0 and the US Industrial Internet Consortium. China should increase its communication and exchanges with such international organizations to promote mutual recognition between Chinese standards and international standards. In 2023, China's participation in the formulation of ISO/IEC industrial internet standards increased by 45% compared with 2019, but it still needs to increase its voice in the formulation of core standards. Establish an international standard tracking and analysis mechanism to understand the development trend of international standards in real time and keep domestic standards consistent with advanced international standards. Promote the standardization of digital industrial platforms in countries along the "Belt and Road" and promote the development of digital trade through mutual recognition of standards [8]. Establish and improve the overseas promotion mechanism of Chinese standards and promote the application of Chinese standards in overseas projects during foreign investment and technology export. Deepen cooperation with multinational companies in the formulation of standards and achieve the goal of maximizing the interests of both parties through technology cooperation and standard sharing. In addition, it is necessary to establish a standard compatibility testing and certification system to provide enterprises with standard consistency evaluation services, so that platforms under different standard systems can be interconnected, laying a solid standard foundation for building a globally integrated digital industrial platform ecosystem.

Conclusion

This paper systematically reviews existing research, revealing the complexity of climate change's impacts on agriculture: rising temperatures and precipitation variability affect wheat production systems primarily through biophysical mechanisms (such as shortened crop growth cycles) and socio-economic pathways (such as resource allocation imbalances). While existing theories point to the potential of adaptive technologies, they neglect regional disparities and policy coordination bottlenecks, resulting in limited practical effectiveness.

The value of this study lies in integrating fragmented knowledge and clarifying that future directions should focus on optimizing both the "mechanism-regional" dimensions. For example, developing countries should prioritize building localized early warning models rather than directly applying developed country solutions. This provides a new perspective for theoretical deepening and policy design, but further empirical verification is needed.

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Comparative Analysis of the Institutional and Digital Environments of the Education Industry in China and Belarus

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ABSTRACT

Based on core theories of the education industry, this paper defines the core concepts of the institutional and digital environments of the education industry. It compares and analyzes the differences in the development models of the education industries in China and Belarus in terms of institutional systems and digital ecosystem construction. Combining the practical foundations of the education industry development in both countries, it proposes targeted development suggestions from the perspectives of self-optimization and bilateral cooperation, aiming to provide theoretical reference and practical paths for the high-quality development and international cooperation of the education industries in China and Belarus.

1.Definition and Current Status of the Institutional and Digital Environment of the Education Industry

1.1.Definition of core concepts

The education industry is a special sector that is demand-oriented, follows the laws of educational development, and draws on business management concepts to achieve optimal allocation of educational resources. Its connotation encompasses three core levels: concepts, institutions, and material aspects. Distinguished from ordinary industries, the core characteristics of the education industry are the unity of non-profitability and profitability, and the coexistence of economic and cultural aspects; it is a special field that combines public welfare and industrial attributes.

Based on this, the institutional environment of the education industry refers to the sum of formal and informal institutions supporting the standardized operation of the education industry, including policies and regulations, education management systems, school entry mechanisms, market operation rules, and cost-sharing systems. It forms the underlying architecture for the development of the education industry. The digital environment of the education industry refers to the digital ecosystem formed by the integration of digital technology and the education industry. Its core includes four dimensions: digital education infrastructure, digital education resource supply system, educational digital technology application framework, and educational data governance rules. It is the core support for the transformation and upgrading of the education industry in the knowledge economy era.

1.2.Overview of Current Development Status

Globally, the education industry has become a fundamental industry with a global and leading role in the national economic system, forming two major development trends: First, at the institutional level, countries are generally building a development model that combines government leadership with market participation, stimulating industry vitality through market mechanisms while upholding the public welfare nature of education; second, at the technological level, digital transformation has become the core direction for the development of the education industry, and digital technology is comprehensively reshaping the production, supply, and service models of the education industry. Since China included education in the tertiary

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sector in 1992, and formally established its position as a "leading, comprehensive, and fundamental knowledge industry" at the Third National Education Work Conference in 1999, the education industry system in China has been continuously improved, forming a diversified school-running pattern with public education as the main body and private education developing in tandem. In terms of digital environment construction, China has built the world's largest digital education infrastructure system, with the National Smart Education Platform connecting over 280,000 schools. The supply of digital education resources and the level of technology application rank among the world's best, and digital education has risen to a national strategy. Belarus inherited the Soviet Union's well-developed national education system and possesses high-quality basic and higher education resources, with its academic degrees recognized by over 100 countries worldwide. In terms of the institutional environment, it has consistently upheld the dominant position of state-coordinated public education. In recent years, it has steadily promoted market-oriented reforms in education, introduced cost-sharing mechanisms in non-compulsory education, and actively integrated into the Bologna Process, constructing a dual-track international education system connecting the CIS and the EU. In terms of the digital environment, Belarus has completed basic network coverage of universities nationwide, and the blended learning model has been widely adopted. It has also achieved regional resource sharing through the CIS Digital Education Alliance. However, due to limitations in economic scale and technology industry, there is still considerable room for improvement in the depth of digital infrastructure coverage and the development level of the local digital education industry.

1.3.Digital Development Model of the Education Industry

The institutional and digital environments of the education industry have become crucial driving forces for educational development in contemporary society. Globally, the education industry is undergoing unprecedented transformation, particularly driven by institutional reforms and digital transformation, resulting in diverse development models across countries. Firstly, China's education industry has made significant progress in both its institutional and digital environments, becoming a model for global education industry reform. At the institutional level, China's education industry has formed a diversified school-running model centered on government leadership and market participation. The government not only clarifies the boundaries of the education industry through laws and regulations but also ensures its public welfare nature through policy support and supervision, especially maintaining a bottom line of public welfare in compulsory education. In non-compulsory education, by introducing private education and market mechanisms, China has further expanded the development space and enhanced the vitality of the education industry. Regarding digital education, China has established the world's largest digital education infrastructure. The construction of the National Smart Education Platform and the popularization and application of digital education resources have further promoted the digital transformation of the education industry. Especially in the application of new technologies such as artificial intelligence, big data, and cloud computing, the education industry is gradually shifting from large-scale development to personalized and precise development. However, despite significant progress in China's education industry system and digital environment development, several challenges remain. The uneven distribution of educational resources, particularly in rural and remote areas, remains a major pain point in educational development. While the government has increased investment in digital education infrastructure in rural areas, the overall urban-rural digital education gap persists. Therefore, China needs to further promote the balanced supply of digital education resources to address educational equity. Furthermore, the legal framework and regulations governing education data governance and intellectual property protection need further improvement to ensure the healthy development of digital transformation. For Belarus, its education industry system and digital environment are still in a phase of gradual development. Belarus's education system remains predominantly public, with government-dependent resource allocation and relatively slow market-oriented reforms. Although the Belarusian government has begun promoting market-oriented reforms in education in recent years, encouraging private capital participation, especially in non-compulsory education, the scale and market share of private education remain small, and market vitality has not been fully realized. Compared to China, Belarus lags significantly behind in technological

innovation and digital transformation within its education industry, particularly in digital infrastructure development and the supply of digital education resources, where considerable room for improvement remains. While Belarus has made some progress in the internationalization of education, particularly through the Bologna Process and educational cooperation with CIS countries, which has enhanced its internationalization level, the development of its digital education and international cooperation remain limited to the regional level, and its global perspective has not yet been fully opened.

2.Institutional and Digital Environment Development Models of the Education Industry in China and Belarus

2.1.Development Model of China's Education Industry

At the institutional level, China has formed a development model guided by top-level design, with multi-stakeholder participation, and a balance between public welfare and the market. First, through a series of laws and regulations such as the Law on the Promotion of Private Education, the boundaries and operating rules of the education industry have been clearly defined, providing institutional guarantees for its development. Second, the government-run school model has been broken down, and private education now covers all educational stages, becoming an important component of the education industry. Third, the public welfare nature of compulsory education is upheld, and a cost-sharing mechanism has been established among the government, families, and society in non-compulsory education stages, balancing educational equity and industry benefits. Fourth, China actively aligns with WTO rules on education services trade, making cross-border education services a significant growth point for the education industry.

At the digital level, China has formed a development model characterized by nationally coordinated construction, diversified market supply, and deep technological integration. First, the state has led the achievement of full coverage of digital education infrastructure, with 100% internet access in primary and secondary schools, thus solidifying the hardware foundation for digital education. Second, a digital resource system combining public welfare and market supply has been built, with the national platform offering massive amounts of free resources, and educational technology companies forming a complete digital education industry chain. Third, cutting-edge technologies such as artificial intelligence and big data are widely applied to all scenarios of teaching, evaluation, and management, driving the transformation of the education industry from large-scale to personalized. Fourth, the education data governance system has been gradually improved, and a series of regulations have been introduced to ensure the security and compliant use of education data.

2.2.Development Model of the Education Industry in Belarus

At the institutional level, Belarus has formed a development model characterized by state-led coordination, steady market-oriented progress, and a dual-track approach to internationalization. Firstly, public education holds a dominant position, with the state coordinating education planning, funding, and curriculum design to ensure universal access to basic education and free, inclusive education. Secondly, market-oriented reforms are being implemented gradually, with private education primarily concentrated in vocational training and language education, although its overall scale and market share are relatively low, indicating room for further industrial development. Thirdly, a mature system of school-enterprise cooperation has been established, creating a deeply integrated industry-education talent training mechanism based on domestic industrial needs. Fourthly, internationalization of education follows a dual-track approach, maintaining the integrated education system of the CIS countries while fully integrating into the Bologna Process, demonstrating significant regional characteristics.

At the digital level, Belarus has formed a development model characterized by government-led construction, regional cooperation and sharing, and steady application implementation. First, digital education infrastructure development is primarily government-funded, focusing on universities and urban primary and secondary schools. Infrastructure development in rural areas is still underway, and the level of hardware equalization needs improvement. Second, digital education resources are mainly supplied by the government, with insufficient market-based product supply. Local digital education companies are relatively

small, and a complete industrial ecosystem has not yet been formed. Third, digital technology applications focus on basic teaching scenarios, and blended learning is widely adopted, but the application of cutting-edge technologies such as artificial intelligence in education is still in its early stages. Fourth, digital education development is centered on regional cooperation, with deep participation in the CIS Digital Education Alliance and the introduction of EU digital education standards and technical solutions. Local technology R&D capabilities are relatively weak.

3.Recommendations for the Development of Education Industry Systems and Digital Environment in China and Belarus

3.1.Recommendations for the Optimization and Development of China's Education Industry

First, continuously balance the public welfare nature of the education industry with the boundaries of market-oriented operation. Uphold the bottom line of public welfare in compulsory education, regulate the operation of private schools, improve the cost-sharing mechanism for non-compulsory education, and achieve a unity of non-profitability and profitability. Second, improve the digital governance system for education, accelerate special legislation on education data security and intellectual property rights for digital resources, establish an industry standard system, and regulate the competitive order of the digital education market. Third, promote the balanced supply of digital education resources, increase investment in digital infrastructure in rural and remote areas, and use digital technology to address the problem of uneven educational development. Fourth, deepen the international institutional innovation of the education industry, align with international rules on trade in education services, expand the export of digital education products and services, and enhance the international competitiveness of cross-border education services.

3.2.Recommendations for Optimizing the Development of Belarus's Education Industry

First, improve the market-oriented institutional system of the education industry, learn from China's diversified school reform experience, introduce incentive policies to encourage social capital participation in school operation, relax restrictions on private education access, and form a pattern of complementary development between public and private schools. Second, establish a digital infrastructure investment mechanism for cooperation between the government and social capital, accelerate the coverage of digital education networks in rural areas, and address shortcomings in hardware facilities. Third, cultivate a local digital education industry ecosystem, encourage universities and technology companies to jointly conduct technology research and development and resource development, and create a localized digital education product system. Fourth, expand the space for international cooperation in education, strengthen educational exchanges with Asian countries on the basis of consolidating regional cooperation, optimize the system for training international students, and create a diversified international system.

3.3.Suggestions for the Development of China-Belarus Bilateral Cooperation

First, establish a platform for institutional exchange in the education industry between China and Belarus, and create a regular exchange mechanism among education authorities, universities, and research institutions to share experiences in school reform and education governance, and deepen the mutual recognition of academic qualifications and degrees between the two countries. Second, deepen cooperation in digital education technologies and resources. China will share its mature experience in digital infrastructure and platform construction, and the two countries will jointly build a Chinese-Belarusian bilingual digital education resource database and a joint digital education laboratory. Third, promote collaborative cooperation between universities and enterprises in industry, academia, and research, and encourage universities and educational technology companies in both countries to jointly build cooperative bases in areas such as technology research and development and talent cultivation, achieving complementary advantages. Fourth, create a brand for China-Belarusian student education cooperation, optimize the two-way student training system and scholarship policies, launch joint training programs focusing on key areas of cooperation between the two countries, and promote the high-quality development of the student education industry.

Conclusion

China has accumulated rich experience in institutional innovation and digital transformation of its education sector, particularly in the construction of digital education infrastructure and the widespread application of resources, where it possesses a relatively mature system. Belarus can learn from China's experience, intensifying its market-oriented reforms in the education sector, encouraging the participation of social capital, and promoting the rapid development of private and vocational education. Simultaneously, Belarus should accelerate the construction of digital education infrastructure, especially in rural and remote areas, strengthening government-private partnerships to improve the accessibility and coverage of digital education resources.

Both countries also have significant potential for cooperation in the internationalization of education. China's internationalization process in the education sector is already in-depth, particularly in cross-border education services and international student education, where it has accumulated rich experience. Belarus's education system, on the other hand, has a solid foundation for cooperation with European and CIS countries. China and Belarus can promote in-depth cooperation in digital education by jointly building digital education platforms and sharing educational resources. In terms of international student education, both countries can improve the quality and level of internationalization by optimizing the two-way student training system and strengthening scholarship policies, thereby promoting high-quality development of their respective education sectors.

Both China and Belarus have their own advantages and unique characteristics in the development of their education sectors. China's education industry has taken the lead in market-oriented reforms and digital transformation, but still faces challenges such as educational equity and uneven distribution of digital resources. Belarus, on the other hand, has a strong foundation in international cooperation in education and its public education system, but its marketization and digitalization efforts need improvement. Both countries can further promote the development of their education industries and foster in-depth cooperation and mutual benefit in the field of education by strengthening institutional innovation, deepening cooperation in digital education, and promoting the sharing of educational resources. In the future, with the continued evolution of the global education industry, China and Belarus will undoubtedly play an increasingly important role in the global education landscape, contributing their wisdom and strength to the development of education worldwide.

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