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A Study on Classifying Business Innovation in Construction Firms

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Abstract: *Business innovation is a critical issue that construction enterprises cannot avoid in their pursuit of sustainable growth. However, theoretical research in academia has not effectively guided practice, and existing studies have not explored the development logic of business innovation in construction enterprises from a configuration perspective. This work defines the concept of business innovation in construction enterprises and categorizes it into types based on three dimensions: technological empowerment, characteristics of the industrial chain, and industry attributes. Using a quantitative content analysis approach, combined with existing innovation classification frameworks and specific industry practices, this study comprehensively classifies and analyzes business innovation in construction enterprises, revealing the characteristics and trends of different types of innovation.*

Key words: *Construction enterprises, Business innovation, Content analysis*

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I. INTRODUCTION

Classification plays a vital role in business research and serves as a fundamental basis for comprehending the innovation in construction enterprises. Through the study of classification, we can delve deeper into theoretical aspects such as the meanings, causes, and impacts of the categorized elements. The involvement and withdrawal from business activities are directly linked to the operational scope of a company, with innovation occurring at every stage of the business execution process [1]. Firms have the flexibility to opt for various business development models at different times to cater to their specific requirements [2]. Additionally, there is a call from scholars to align the classification of product or process innovations with the particular context of the industry [3]. For instance, in the financial sector, banking innovation can be categorized into asset-related, liability-related, and intermediary business innovations, reflecting the unique characteristics of the industry.

Construction companies typically make deliberate adjustments or changes to their existing operations. Nonetheless, some of these firms have a murky understanding of the innovation process [4]. By merely following the mainstream or imitating others without deep thought, they struggle to gain meaningful insights into the development of innovative businesses. Most current studies examine corporate innovation and business transformation in isolation using case studies, failing to thoroughly dissect the essence of business innovation in the construction sector. Consequently, the proposed classifications only offer a partial view of business innovation, and discussions on the topic are fragmented. Additionally, Chinese construction companies seldom disclose information about business changes, and when they do, it's often in qualitative terms. Rarely do companies quantitatively report detailed innovations, revenue shares, or other key metrics, lacking proper processes or indicators to measure business innovation in practice. Since innovation output should not be measured the same way as ordinary production, prematurely relying on financial metrics like sales, profit margins, and Return on Investment (ROI) could even hinder a company's ability to reach its innovation objectives [5].

This work draws existing work and focuses on construction firms. It considers the practical context of construction production and the role of technology in empowering these businesses. By integrating existing approaches to classifying business innovation with relevant theories, the paper categorizes the types of innovation in construction enterprises based on three key aspects: technological empowerment, characteristics of the industrial chain, and industry-specific attributes. Utilizing quantitative analysis methods, the paper sheds light on the distinct features and trends of innovation across various business sectors. This offers a more detailed perspective on the types of innovation occurring within construction enterprises. The ultimate goal is to provide thorough theoretical guidance for the practical implementation of business innovation in the construction industry. The remaining chapters of this paper are arranged as follows: Section II introduces related work, Section III details the selection of samples and data processing, Section IV is the statistical results analysis, and Section V concludes.

II. Related work

Economists and business leaders have recognized that the efficiency and effectiveness of the global construction industry are crucial to the economic and social recovery following the global financial crisis. Recently, scholars' interest in construction industry innovation has surged again [6], with innovation models for construction enterprises constructed from various perspectives. Among them, the following three innovation models for construction enterprises are of utmost importance.

(1) Winch's Construction Innovation Process Model Winch's model divides the construction innovation process into two dynamic processes: the top-down absorption-implementation process and the bottom-up problem-solving-learning process [7]. Winch's constructed innovation process model clearly demonstrates the connections between the three levels of environment, enterprise, and project in construction innovation.

(2) Gann and Salter's Project-based Enterprise Innovation Model Starting from the perspective of project-based enterprises, Gann and Salter discuss the process by which construction enterprises form and utilize technological capabilities [8]. As a typical project-based enterprise, construction enterprises need to manage two processes simultaneously: project processes and business processes. Business processes are continuous and repetitive, while project processes are temporary and unique. Therefore, only by integrating project and internal business processes can project-based enterprises effectively utilize and reproduce technological capabilities.

(3) Bygballe and Ingemansson's Construction Innovation Structure Model Based on the network approach, Bygballe and Ingemansson analyze the relationship between the project level, enterprise level, and industry level in construction innovation [9]. Innovations at the project level, enterprise level, and industry level have different patterns. Exploratory innovation mainly occurs at the project level, where inter-organizational engineering projects provide opportunities for exploratory innovation in the face of new participants, resources, and activities. Exploitative innovation mainly occurs at the enterprise level, where innovation needs to be "realized" to bring value to the enterprise. Therefore, problem-solving in projects needs to be transformed through learning and organization into solutions that can be applied to future projects, meaning that innovation has become an "implementable reality" and "an inherent premise and thinking structure incorporated into organizational practice." Exploitative innovation also frequently occurs at the industry level, where the adoption and realization of innovation depend on how various solutions coordinate with each other and the acceptance of the participants in the construction network. Therefore, it is necessary to make the network around the enterprise accept and adapt to innovation. The advanced aspect of this model lies in their revelation of the different patterns of innovation at the project level, enterprise level, and industry level, as well as the feedback loops between the three levels in construction innovation..

III. Selection of Samples and Data Processing

3.1 Sample Selection

To gather quantitative data on the business innovation practices of construction firms, this study uses content analysis to extract information from the "Annual Reports" issued by A-share listed construction companies in China. To ensure the reliability of the research findings, the sample includes Chinese listed construction companies from 2012 to 2022. After organization, the final dataset comprises 101 listed construction companies and 717 company-year observations. According to the nature of ownership of the listed companies, the sample consists of 40 state-owned construction enterprises, making up 39.6%, and 61 private construction enterprises (including those with foreign investment), accounting for 60.4%. Geographically, the case companies are spread across 19 provinces and cities in China, with the top five being Beijing (21.78%), Guangdong Province (17.82%), Shanghai (12.87%), Zhejiang Province (11.88%), and Jiangsu Province (8.91%).

3.2 Category Construction and Coding

Business innovation in construction enterprises can be categorized into three types: technology empowerment, vertical extension of the industrial chain, and horizontal expansion within the industry. Drawing on the three-dimensional framework for classifying business innovation, this study meticulously reviews the "Annual Reports" of the sample companies and further enhances the coding system. With the reliability of each category ensured, manual coding is performed in the style of "report number—specific business innovation content." The study uses the business distribution from the previous year as a reference point, compares the "Annual Reports" from two consecutive years, and identifies the relevant business changes. To maintain the integrity of the coding results, if an analysis unit includes different types of business innovation content, the statistical frequency for the corresponding category is incremented. In line with the definition of business innovation, if a company experiences business contraction or even withdrawal during the observation period, the relevant coding is also added. Ultimately, a coding table for the analysis units of construction enterprise business innovation content is created, as presented in Table 1.

Table 1 Coding for Analysis Units of Business Innovation Content in Construction Enterprises

Number	CCAY	Business Innovation Analysis Unit	Coding
1	000090-2013	The urban renewal plan (draft) for Tianjian Industrial Park area has been approved by the Shenzhen Municipal Planning and Land Resources Committee, and the company is actively advancing the demolition efforts.	1-1
2	000498-2013	1. The increase in the company's R&D investment in 2013 is primarily due to the establishment of the "Shandong Provincial Asphalt Pavement Recycling Engineering Technology Research Center", and the company has also taken on the "Promotion and Application of On-site Hot Recycling Technology and Equipment for Asphalt Pavement" project managed by the Western Traffic Construction Science and Technology Project Management Center of the Ministry of Transport.	2-1
		2. The company's investment in trunk highway maintenance during the "Eleventh Five-Year Plan" period has significantly increased compared to the "Tenth Five-Year Plan" period, with the market space for road and bridge maintenance construction, primarily shifting to road upgrading and daily maintenance, gradually expanding.	2-2
		3. In response to market demand, the company has newly established an equipment manufacturing company, and during the reporting period, it secured 10 equipment manufacturing and hanging basket, mobile formwork rental projects, with a contract value of 55 million yuan. | 2-3	2-3
…	……	……	……
716	605303-2022	1. The company has achieved leading research and development results in the resource recycling of garden waste, providing scientific and technological support for smart ecological construction.	716-1
		2. The company has formed a complete industrial chain covering "pre-planning consultation, planning and design, mid-investment construction and development, and post-operation services". | 716-2	716-2
		3. The company is actively expanding its layout in new infrastructure areas such as smart gardens, smart forestry, smart water conservancy, and comprehensive national land management, as well as in agro-tourism and industrial operation fields, exploring new markets.	716-3
		4. During the reporting period, the company newly obtained 10 patents including “A Comprehensive Treatment Method for Saline-Alkali Soil” and expanded its special ecological environment governance and restoration business.	716-4
717	605598-2022	-	-

*CCAY：Company Code and Publication Year

3.3 Validity and Reliability Verification

(1) Validity Testing

Validity refers to the accuracy of measurement. Firstly, a classification framework was constructed in conjunction with the production characteristics of construction enterprises and the actual content of the text to be analyzed, which has inherent logic and high surface validity. Secondly, clear and distinct definitions were provided for the categories to be measured, with examples explaining the meanings and coding rules for each category, indicating high construct validity. Lastly, the three types of business innovation - technology empowerment, vertical extension of the industrial chain, and horizontal expansion within the industry - are explicit content, and the data sources are authentic and reliable, allowing for objective standards to judge them; furthermore, the sub-categories of the three types of business innovation were set, which are more conducive to improving the accuracy and effectiveness of coding.

(2) Reliability Testing

The purpose of reliability assessment is to ensure that, given the same coding rules and the same text, the process of data generation can be repeated by other researchers. The reliability of content analysis includes two main types: firstly, longitudinal reliability, or stability reliability, which indicates that each time the coder applies the same classification criteria to the same content at different times, the analysis results should be consistent or identical; and secondly, horizontal reliability, or inter-coder reliability, which indicates the degree to which independent coders assess the characteristics of information or artifacts and reach the same conclusion.

Percentage consistency is chosen as the reliability index to calculate the degree of consistency between two coders or between the same coder’s two coding sessions. Percentage consistency is the number of units coded consistently divided by the total number of units coded, calculated as follows:

$$PA_o = \frac{A}{n} \tag{1}$$

where PA_o represents the observed consistency ratio, A denotes the number of units coded consistently in the two coding sessions, and n represents the total number of units coded. The numerical range of the calculation results is from 0 (complete inconsistency) to 1 (complete consistency). Generally, when the PA_o index is within the range of [0.8, 0.9], it indicates that the consistency of coding has passed the test [10,11].

IV. Statistical Results Analysis

4.1 Analysis of the Overall Situation

Listed construction enterprises usually have more abundant internal and external resources and stronger creative capabilities, and the large-scale engineering projects they involve help to promote business innovation. Based on the year, the overall situation of business innovation for listed construction enterprises is statistically analyzed, and the results are shown in Fig. 1.

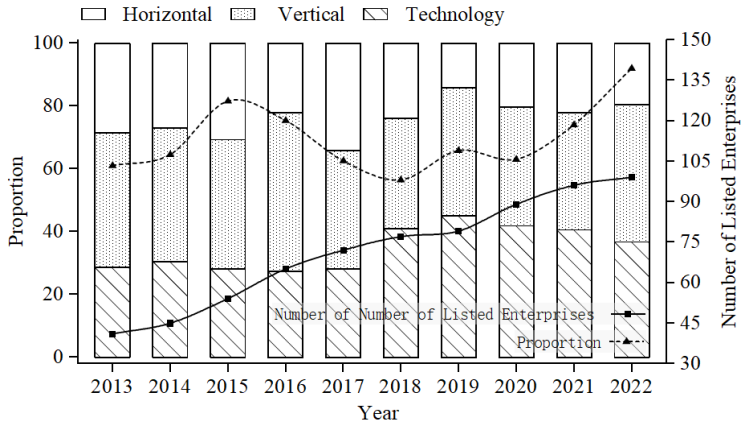
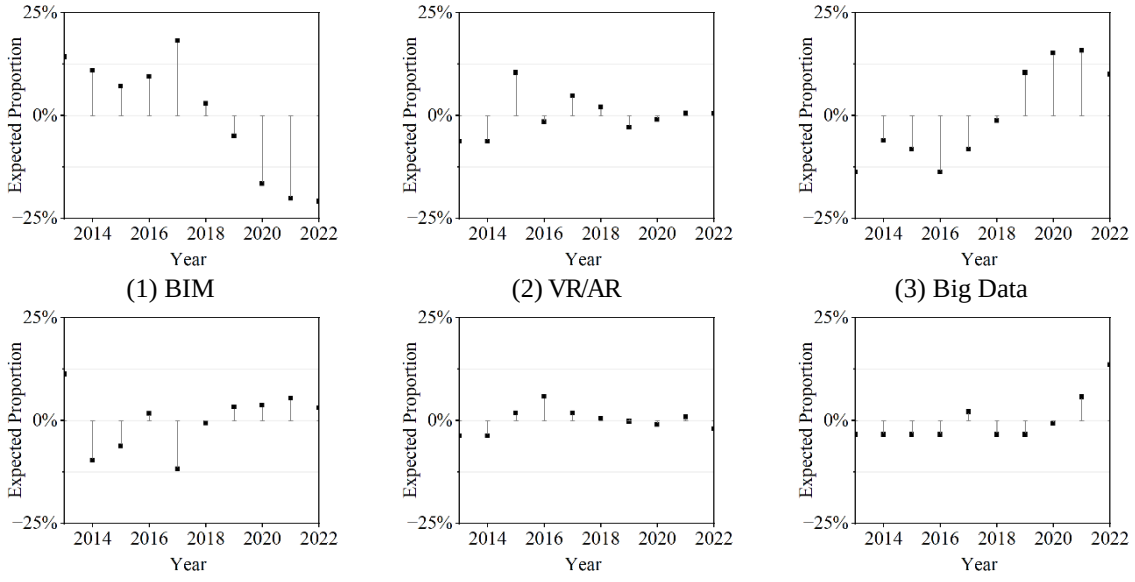


Fig.1 Statistics of Listed Construction Enterprises and Distribution of Business Innovation Types

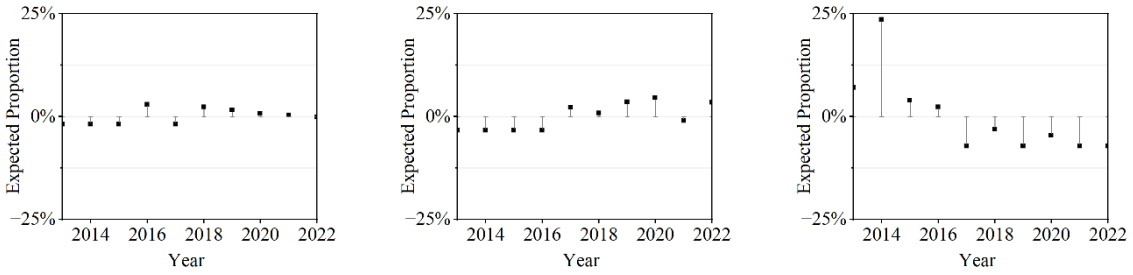
The examination of business innovation quantities and types shows that the overall proportion of business innovation among listed construction companies fluctuates and rises from 61% to 92%. It's evident that in 2015, business innovation peaked due to the spread of digital technology applications and the expansion of project financing. Since 2019, the rise of new business areas like industrialized building material equipment production and manufacturing, smart site management, and intelligent installation has led to a gradual increase in the proportion of innovation among companies. Attention to horizontal expansion of industry business innovation has notably decreased since 2017, with a proportion below 20%. The proportion of vertical extension of the industrial chain remains stable overall, hovering between 35% and 50%. The proportion of technological empowerment business innovation has seen a significant rise since 2018, exceeding 40%.

4.2 Analysis of Technological Empowerment Business Innovation



(1) BIM (2) VR/AR (3) Big Data

(4) IoT (5) GIS (6) Cloud Computing



(7) UAV (8) AI (9) 3DP

Fig.2 Trend of Popularity of Digital Technology Use

By analyzing the types of technology used in business innovation activities, we can clearly see the preferences of China's construction enterprises in applying cutting-edge technologies, as well as the popular construction methods of listed enterprises' projects at different times and their intensity in promoting business innovation. This paper calculates the expected proportion of different types of digital technologies based on the frequency statistics of digital technology-related terms in content analysis. This proportion is based on the average proportion of a certain type of technology as a benchmark. When the proportion of a certain type of technology at a certain time point is lower than the average proportion of this technology, it is displayed as a negative value, otherwise, it is positive. The changing trends of the popularity of the use of 9 types of digital technologies over time are shown in Fig. 3. From 2013 to 2022, the use of nine types of digital technologies exhibited a clear fluctuating pattern, but the evolutionary trends of these technologies differed significantly. Technologies 1 and 9 showed a relatively clear pattern of initially rising and then declining. Technology 1 has been continuously declining in use in business innovation since 2019, reaching its lowest point in 2022. Technology 9 had a significantly higher expected proportion than the average of the total proportion in 2014, and then rapidly declined, fluctuating within 3%-7% below the average. Technologies 2, 5, and 7 had similar changes, all showing a peak feature in a specific year and then falling back to the average of the total proportion. Technologies 3, 4, 6, and 8 have shown a trend of fluctuating upward above the average usage in recent years.

4.3 Analysis of Business Innovation in the Vertical Extension of Industrial Chain

Using content analysis data from every three years between 2013 and 2022, the proportion of business innovation in front-end related businesses, back-end related businesses, and side-related businesses at four different time points is calculated to summarize the characteristics of business development in the vertical extension of the industrial chain, as illustrated in Fig. 3-5. In Fig.3, A-F represent Engineering Management and Supervision Services, Engineering Software and Information Technology Services, Engineering Consulting Services, Industry Financial Services, Human Resource Dispatching and Training Services, and Engineering Testing Services; In Fig.4, A-E represent Project Investment and Financing, Survey and Design Services, Building Material Production, Building Material Equipment Transportation and Trade, and Equipment Manufacturing, Leasing, and Maintenance; In Fig.5, A-E represent Property Management, Real Estate Development and Operation, Asset Operation and Maintenance, and Demolition and Renovation Services.

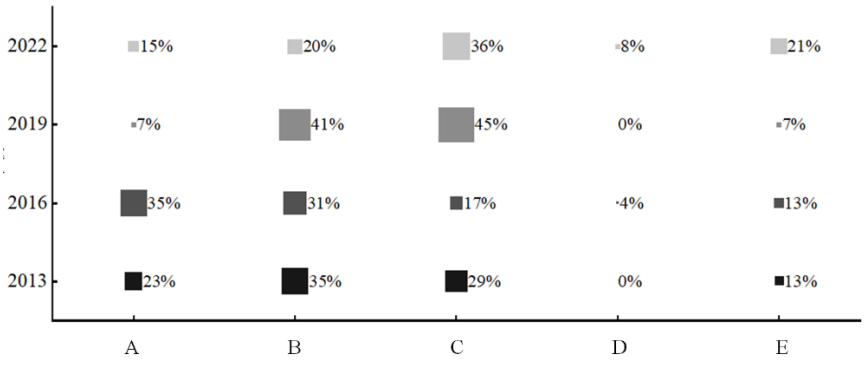


Fig. 3 Development of Front-End Related Business Innovation

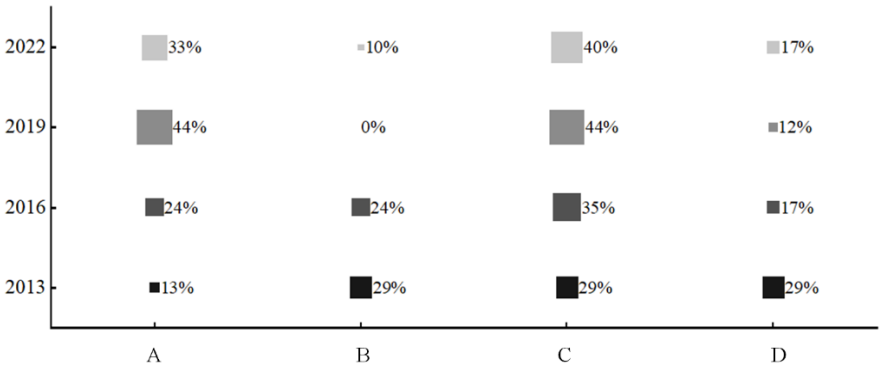


Fig. 4 Development of Back-End Related Business Innovation

From Fig. 6, it can be seen that in the early stage of the development of front-end related business innovation, China's listed construction enterprises mainly extended their services in exploration design and planning, production of building materials, and project investment and financing, accounting for over 80% cumulatively. In the later stage, enterprises gradually shifted their focus from these businesses to equipment manufacturing, leasing, and maintenance in engineering practice to avoid uncontrollable investment and financing risks. The analysis shows that the research and production of building materials are still important ways for construction enterprises to innovate and are also the main means to control project costs. From Fig 7, it can be seen that in the back-end related businesses, property management and asset operation and maintenance are the main choices for enterprises to expand their businesses, which have higher added value in the entire life cycle value chain of the project, showing a trend of increasing year by year. However, the significant decline in profits from real estate development and operation has led enterprises to reduce or even cut off these businesses to maintain the stability of the capital chain.

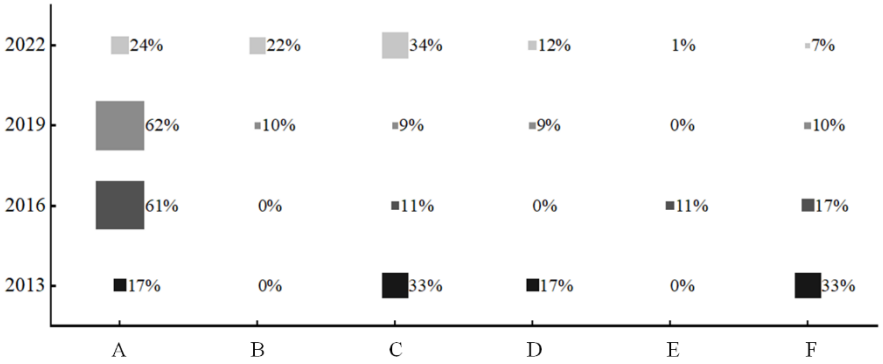


Fig. 5 Development of Side Related Business Innovation

4.4 Analysis of Business Innovation in Cross-Industry Expansion

Industry Horizontal Expansion Business Innovation can be divided into two types: subdivision professional expansion within the industry and cross-industry expansion. Statistics of the proportion of the number of enterprises involved in corresponding businesses to the total number of enterprises in 2013 and 2022 are shown in Fig.6-7.

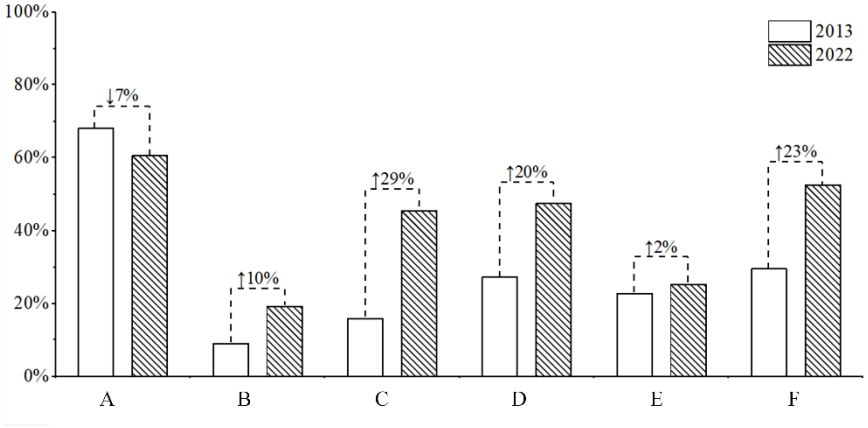


Fig. 6 Proportion of Enterprises Involved in Sub-specialty Engineering Activities

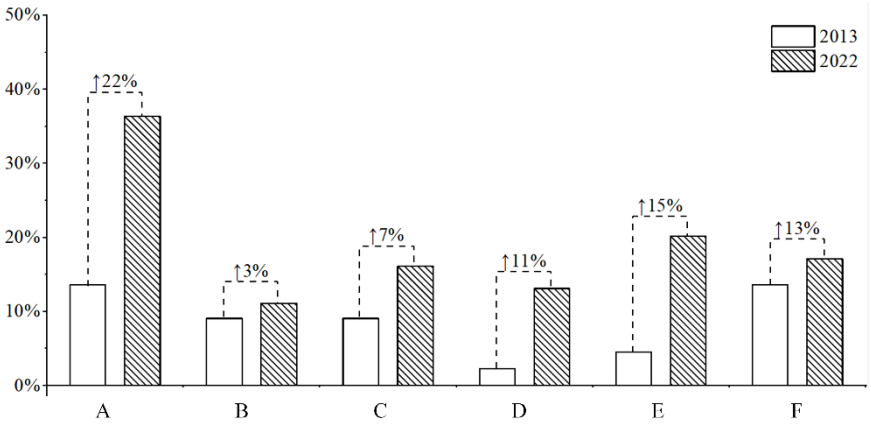


Fig. 7 Proportion of Enterprises Involved in Cross-industry Business Activities

In Fig.6, A-F represent 'Railway, Road, Tunnel, and Bridge Engineering Business', 'Pipeline and Underground Comprehensive Corridor Engineering', 'Energy-saving and Environmental Protection Engineering', 'Electrical Engineering', 'Landscape and Greening Engineering', and 'Mechanical and Electrical Installation Engineering'. In Fig.7, A-F represent 'Environmental Governance', 'Manufacturing', 'Electricity, Heat Production and Supply', 'Wholesale and Retail', 'Cultural Entertainment and Hotel Tourism', and 'Financial Insurance Services'. As shown in Fig 6, among the various sub-specialties surveyed, only railway, road, tunnel, and bridge engineering businesses have seen a decrease in proportion. With the rise of sponge city business in recent years, the proportion of enterprises involved in pipe and underground comprehensive pipe gallery engineering has increased by 10%. Energy conservation and environmental protection engineering, mechanical and electrical installation engineering, and power engineering are the main choices for listed construction enterprises to expand their business within the industry, especially energy conservation and environmental protection engineering, with the proportion of enterprises engaged in this business increasing from 16% in 2013 to 45% in 2022; moreover, the rapid development of China's new energy-related businesses has promoted the growth of the power engineering sector of construction enterprises; finally, the proportion of mechanical and electrical installation engineering has increased by 23%, with various equipment installation activities becoming increasingly active in smart city, smart transportation, smart medical and other construction projects. As shown in Fig 7, the rapid development of environmental protection and restoration technologies has led enterprises to undertake more environmental protection and management projects. With the extension of asset operation business, construction enterprises have gradually incorporated water pollution control, air pollution control, soil pollution control and other activities into their own businesses, with the proportion of enterprises engaged in such business innovations increasing from 14% to 36%, which is more significant in cross-industry expansion. The share of cultural entertainment and hotel tourism services has increased from 5% in 2013 to 20% in 2022.

V. Conclusion

This work employs a quantitative content analysis approach, integrating existing innovation classification frameworks and industry practices, categorizes business innovation in construction enterprises into three types: technology empowerment, vertical extension of the industrial chain, and horizontal expansion of the

industry, and further discusses the innovation characteristics of these three types of business activities. Specifically, the enabling impact of digitalization, industrialization, and green and low-carbon technologies on the business innovation of construction enterprises is not only linked to the trajectory of technological development but also shows a trend of following hotspots. Summarizing the existing experiences, it is observed that industry policies have a more pronounced effect on the innovation of the vertical extension of the industrial chain, with the main focus areas being building material and equipment production, property management, asset operation and maintenance, engineering management, and consulting services. Business innovation in industry horizontal expansion exhibits characteristics of greening and servitization, with ecological civilization construction, new energy, intelligent installation, and cultural tourism offering new profit-generating opportunities for enterprises.

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