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Digital Transformation and Profit Growth: A Configurational Analysis of Regional Dynamics

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ABSTRACT

This study adopts Configuration Theory to explore how diverse combinations of regional factors contribute to profitability, emphasizing the principle of equifinality, which posits that multiple, equally effective configurations can lead to similar outcomes. This study examines the interplay of multiple factors—enterprise informatization, digital infrastructure, e-commerce, technological investment, innovation, hardware, and software—across four key themes: Digital Readiness and Technological Integration, Market and Economic Enablers, Innovation Capacity and Activity, and Foundational Artifacts and Resources. Using data from 31 provinces in China from 2015 to 2022, this study employs fuzzy-set Qualitative Comparative Analysis (fsQCA) to uncover pathways to regional profit growth. The study identifies five distinct configurations contributing to profit growth across China's provinces. In most configurations, e-commerce and technological investment emerge as central drivers. However, in less developed regions, profit growth relies more on improvements in digital infrastructure and hardware, with innovation and enterprise informatization playing a less significant role. The findings also reveal that profit growth requires addressing the weakest elements in the ecosystem—whether digital infrastructure, technological capabilities, or other factors. Strategies tailored to regional conditions must prioritize improving these weaker components to achieve sustained growth, as ignoring them can limit overall success.

Key Words: Configuration Theory, fsQCA, Firm Performance, Innovation Configurations, Emerging Market, Digital Transformation

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Managerial relevance statement: This study challenges traditional growth strategies and reveals that economically developed regions experience diminishing returns from further investments in overdeveloped areas such as digital infrastructure. Instead, optimizing existing systems through data-driven decision-making, operational improvements, and scaling e-commerce operations delivers greater benefits. Conversely, less developed regions experience substantial growth by prioritizing foundational investments in connectivity and hardware rather than prematurely venturing into advanced technologies. The findings dispel the notion that uniform innovation across all factors is essential, showing that targeted investments in weaker components tailored to regional contexts yield the most significant impact. For engineering managers, the research emphasizes strategies to optimize regional growth. In developed regions, enhancing the efficiency of existing systems is key, while less developed areas should focus on building digital connectivity and hardware to integrate businesses into broader markets. Incremental, industry-specific innovations, such as advancing agriculture or modernizing manufacturing, can further support sustainable growth. For policymakers, this study underscores the importance of addressing regional disparities through targeted interventions. Strengthening underdeveloped areas like connectivity and enterprise informatization can significantly improve economic performance. By prioritizing weaker components in regional ecosystems, both developed and less developed regions can maximize returns, achieve balanced growth, and foster inclusive development.

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1. INTRODUCTION

In recent years, the global economy has undergone a significant shift towards a digital paradigm, underscoring the transformative role of digital technologies in shaping innovation ecosystems [1-3]. The rise of the digital economy has fundamentally redefined how innovation is conceived, developed, and commercialized, embedding digitalization as a cornerstone of both innovation processes and related economic activities [4]. This shift highlights the growing interdependence between technological advancement and economic outcomes, emphasizing the need to understand the dynamics of innovation ecosystems in fostering regional economic success.

In this context, regional profit growth has emerged as a vital measure of the health and effectiveness of innovation ecosystems [5, 6]. By fostering collaboration among diverse actors—such as firms, governments, and research institutions—innovation ecosystems create an environment conducive to technological progress, market expansion, and economic resilience. Sustained profit growth within regions reflects the successful alignment and interplay of ecosystem components, illustrating how innovation and resource optimization drive competitiveness and economic health [7]. Understanding the factors that contribute to regional profitability is therefore essential for policymakers and stakeholders aiming to promote sustainable development.

This study addresses the limited understanding of how diverse combinations of regional factors drive profitability in emerging economies, with a focus on China. While prior research has examined individual drivers such as technological investment or innovation, few studies take a holistic perspective to explore the interplay among multiple factors [8, 9]. Additionally, traditional linear models fail to capture the complex, non-linear relationships within regional

ecosystems or the principle of equifinality, which explains how diverse configurations of factors can achieve similar outcomes [10, 11]. To bridge this gap, this study seeks to answer the following research question: How do diverse combinations of regional factors drive profitability, and what configurations of these factors, following the principle of equifinality, lead to similar economic outcomes across Chinese provinces?

This study contributes to both theory and methodology by advancing Configuration Theory's application in regional profitability research by emphasizing systemic coherence and equifinality. It challenges linear models by showing how diverse configurations of factors can achieve similar outcomes and explores the interplay between digital transformation, innovation, and foundational resources. Methodologically, it applies fuzzy-set Qualitative Comparative Analysis (fsQCA) to reveal non-linear relationships, identifying five configurations that highlight the complexity of regional dynamics.

The remainder of this paper is structured as follows: Section 2 presents the literature review, outlining the theoretical underpinnings of Configuration Theory, its application in regional studies, and the role of key regional factors in driving profitability. Sections 3 and 4 outline the methodology and the results; section 5 is followed by discussing the results; and the final section discusses contributions, limitations and recommendations for future research.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

This study seeks to explore the diverse configurations of regional factors that contribute to profit growth and to identify whether multiple, equally effective pathways exist to achieve this outcome. By focusing on regional profitability, the research addresses a critical question for policymakers and stakeholders seeking to foster economic development. To analyze the complex interplay of factors influencing regional performance, the study adopts Configuration Theory as its guiding framework. Configuration Theory emphasizes the alignment and interaction of multiple interdependent variables within a system, offering a

robust lens for understanding how different combinations of factors lead to similar outcomes—a concept known as equifinality [10, 12]. This approach is particularly relevant for examining the heterogeneous strategies regions employ to achieve economic success.

Configuration Theory

Configuration Theory provides a holistic approach to understanding complex systems by emphasizing the interaction and alignment of multiple factors in determining outcomes. Originating in organizational studies, the theory posits that systems comprise interdependent elements that must achieve coherence for optimal performance [10]. Unlike traditional linear causality models, Configuration Theory adopts a systemic perspective, recognizing that systems often exhibit nonlinear dynamics where small changes in one component can produce significant ripple effects across the system.

A key contribution of Configuration Theory is the concept of equifinality, which suggests that multiple pathways can lead to similar outcomes. This principle is particularly relevant in contexts involving complexity and path dependence, where diverse configurations of factors, rather than single causal mechanisms, shape system performance [11]. For instance, Ragin [13] explore how configurations of causal conditions influence outcomes across varied contexts such as economic development and social movements. His work demonstrated that combinations of factors—like institutional strength and technological investment—can lead to similar outcomes, laying the groundwork for QCA as a methodological tool in social sciences. Similarly, Fiss [10] applied the framework to organizational studies, showing how diverse configurations of organizational structure, market positioning, and resource allocation could drive success. These studies highlight the importance of systemic coherence, where optimal performance depends on the alignment of strategies with environmental contexts.

Applications in Regional Studies

The principles of Configuration Theory and its methodology, such as QCA, have been widely applied to regional studies, particularly in understanding regional profitability and competitiveness. For instance, Tödtling and Trippl [8] used comparative case studies to examine regional innovation systems (RIS) in Europe. Analyzing factors such as knowledge networks, institutional frameworks, and policy support, they identified three distinct types of RIS—centralized, decentralized, and fragmented. Each system required unique configurations for success. For example, fragmented systems thrived with targeted policies fostering collaboration, while centralized systems excelled with strong institutional support. These findings illustrate the adaptability of Configuration Theory to diverse regional contexts and emphasize the importance of aligning innovation policies with specific regional dynamics. Asheim and Gertler [9] explored how configurations of innovation activities impact regional competitiveness. Their study examined variables such as human capital, institutional frameworks, market structures, and technological capabilities. They found that high-performing regions achieved systemic coherence by aligning innovation policies with their local strengths. For instance, regions specializing in advanced manufacturing benefited from R&D-focused policies, while service-oriented regions thrived through mechanisms facilitating knowledge transfer. These findings underscore the critical role of alignment in fostering regional success. Similarly, Gopalakrishnan and Damanpour [14] conducted a quantitative study analyzing market dynamism, technological change, organizational structure, and innovation practices. The study found that successful innovation relies on aligning internal structures with environmental conditions. Dynamic markets favored decentralized, adaptive strategies, while stable environments benefited from centralized, efficiency-focused configurations.

These studies collectively demonstrate the utility of Configuration Theory in analyzing complex systems and the principle of equifinality in diverse contexts.

Methodological approaches such as QCA, comparative case studies, and quantitative surveys highlight the theory's adaptability. The factors analyzed—ranging from institutional frameworks and technological infrastructure to market dynamics and innovation practices—underscore the importance of systemic coherence. These studies reveal that multiple configurations can lead to similar outcomes, reinforcing the need to tailor strategies to contextual requirements.

For regional profitability studies, these insights emphasize that success is not reliant on a single pathway but on aligning key factors with the region's specific strengths and challenges. Configuration Theory provides a robust framework for exploring how diverse regional systems can achieve economic success, offering practical and actionable strategies for policymakers and stakeholders.

Regional Factors Driving Profitability

The following literature review categorizes these regional factors into four key themes: *Digital Readiness and Technological Integration, Market and Economic Enablers, Innovation Capacity and Activity, and Foundational Artifacts and Resources*, highlighting their roles in driving profitability [15, 16]. The selected themes are justified based on their foundational relevance to regional profitability and their alignment with Configuration Theory [17]. These themes were derived from a synthesis of theoretical and empirical literature, which consistently identifies these factors as critical drivers of regional success. Configuration Theory [11], which emphasizes systemic coherence and the interaction of interdependent elements, provides the theoretical lens through which these themes were identified. Each theme represents a core dimension of regional systems that must align for optimal performance. The rationale for selecting these factors, and not others, lies in their consistent empirical support and practical relevance. While other factors, such as cultural dynamics or governance [18], are important, they often operate indirectly through these

primary drivers or are embedded within them. For instance, governance is included within Market and Economic Enablers, and social dynamics influence innovation networks or foundational resources [19]. These four themes were chosen to ensure a structured yet comprehensive analysis of regional profitability, focusing on factors that are actionable, measurable, and directly aligned with the study's objectives.

Digital Readiness and Technological Integration

In an increasingly digitized economy, regional competitiveness and profitability are fundamentally linked to a region's digital readiness and capacity for technological integration. The ability of regions to harness digital transformation influences their economic performance by enhancing productivity, streamlining business operations, and fostering innovation. A well-developed digital ecosystem allows firms to optimize workflows, improve operational efficiency, and respond dynamically to evolving market demands [20]. Moreover, digital integration facilitates collaboration between firms, institutions, and consumers, strengthening the overall business environment.

The variables that define this readiness include enterprise informatization and digital infrastructure. Enterprise informatization captures the extent to which businesses adopt and integrate digital technologies into their operations. Research highlights that firms with higher digital adoption levels experience superior productivity, operational agility, and market responsiveness [20]. Another variable is digital infrastructure, which forms the backbone of technological integration by enabling seamless communication and connectivity. Broadband networks, optical cable lines, and mobile infrastructure play a crucial role in supporting digital activities and interactions. Empirical studies show that regions with robust digital infrastructure experience increased economic activity due to improved market access, enhanced collaboration opportunities, and accelerated innovation processes [1, 21, 22].

Together, these variables ensure that regions can effectively integrate into the global digital economy, driving sustained profitability.

Market and Economic Enablers

A region's ability to support efficient market transactions, competition, and collaboration is crucial for long-term economic growth and profitability. The presence of well-developed market structures, supportive economic policies, and investment in technology enables businesses to scale, innovate, and create economic value. Strong market enablers create an environment where firms can effectively participate in commerce, attract investments, and leverage digital transformation to improve competitiveness [23].

The variables within this theme include e-commerce and technological investment. E-commerce is one of the most significant drivers of market readiness in the digital economy. By reducing transaction costs, expanding market access, and fostering a conducive environment for digital innovation, e-commerce enhances economic activity and regional competitiveness [23]. Additionally, technological investment—representing the financial commitment of firms and regions to acquire and develop new technologies—has been widely recognized as a catalyst for sustainable growth. Higher investment levels in technological advancements correlate with improved innovation capacity, increased productivity, and enhanced market competitiveness [24]. Ensuring that financial resources are allocated toward strategic technological advancements enables regions to remain resilient and adaptive in a rapidly evolving economic landscape.

Innovation Capacity and Activity

Innovation is a fundamental driver of regional competitiveness and economic performance [20]. Regions that cultivate a strong innovation ecosystem attract external investments, stimulate knowledge spillovers, and enhance their ability to respond to dynamic market conditions. A robust innovation ecosystem typically involves collaboration between

businesses, research institutions, and governments, collectively fostering an environment conducive to technological breakthroughs and business growth [9].

The variables representing innovation capacity and activity include research and development (R&D) initiatives and innovation output. R&D activities drive new product development, enhance production processes, and lead to the emergence of new business models, all of which contribute to regional profitability [25]. Additionally, innovation output—comprising product, process, organizational, and marketing innovations—further reinforces a region's competitive edge by ensuring that firms can continuously adapt to consumer needs and technological advancements [25]. By fostering strong innovation ecosystems, regions can stimulate job creation, diversify economic opportunities, and drive long-term economic sustainability.

Foundational Artifacts and Resources

Economic success is built on a region's access to both physical and intangible resources that support business activities and technological adoption. The availability of these resources determines the extent to which businesses can engage in digital transformation and develop competitive advantages [1].

The variables that support economic success include hardware and software. Hardware infrastructure, including electronic products and devices, serves as the foundation for digital business operations. Regions with strong manufacturing capabilities in electronics often experience higher levels of productivity and innovation due to the accessibility of essential technological resources [1]. At the same time, software plays an equally critical role by enabling automation, data analysis, and digital service delivery. Research highlights that investment in software solutions enhances decision-making processes, improves customer engagement, and drives business model transformation [24]. Together, these variables ensure

that regions can effectively integrate technology into their economic activities, strengthening their long-term profitability.

By adopting Configuration Theory as a guiding framework, the current study aims to answer the research question "*How do diverse combinations of regional factors contribute to profitability, and what multiple, equally effective configurations align with the principle of equifinality to achieve similar economic outcomes?*". By focusing on the interplay of regional factors and the existence of multiple pathways to success, this study contributes to a more nuanced understanding of regional profitability. It advances the theoretical application of Configuration Theory in regional studies and provides a practical framework for designing tailored economic strategies that reflect the unique characteristics of individual regions.

3. METHODOLOGY

Data

Our data was sourced from the China Stock Market & Accounting Research Database (CSMAR)[1], comprising aggregated data from 31 province-level administrative divisions[2], spanning the period from 2015 to 2022. The starting point of 2015 was selected for this study because it marks a significant milestone in China's digital transformation journey. In that year, the Chinese government released the Document [2015] No.40, signalling the formal beginning of a national effort to advance digitalization across various sectors. This policy initiative set the stage for substantial digitalization-related changes in subsequent years. Additionally, in 2015, China introduced the "Notice of Action Plan for Promoting the Development of Big Data," which accelerated the adoption and implementation of the national big data strategy

[1] **CSMAR** is one of the most comprehensive and widely used research databases for economic, financial, and corporate data in China. It is maintained by the Shenzhen GTA Information Technology Company and is designed to provide accurate and extensive data for academic research, policy analysis, and decision-making. CSMAR is considered the Chinese equivalent of internationally recognised databases such as **Compustat** and **CRSP**. It is widely used by researchers, universities, and institutions for its reliability and detail.

2 Anhui, Fujian, Gansu, Guangdong, Guizhou, Hainan, Hebei, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Jilin, Liaoning, Qinghai, Shaanxi, Shandong, Shanxi, Sichuan, Yunnan, Zhejiang, Guangxi (Zhuang Autonomous Region), Inner Mongolia (Autonomous Region), Ningxia (Hui Autonomous Region), Tibet (Autonomous Region), Xinjiang (Uyghur Autonomous Region), Beijing, Chongqing, Shanghai, Tianjin.

[21]. These developments underscore 2015 as a pivotal year in China's commitment to leveraging digital technologies, therefore this year serves as a logical and strategic starting point for the data used in this study.

Measures

The current study leverages measurable variables (refer to Appendix A for complete details) to empirically test diverse configurations of factors driving regional profitability, offering actionable insights for researchers and policymakers.

Enterprise Informatization: Captures the extent to which enterprises adopt and integrate digital technologies into operations, reflecting technological readiness and digital transformation capacity.

Digital Infrastructure: Measures the availability of essential infrastructure (e.g., broadband, optical cable lines) that supports digital connectivity and interaction.

E-commerce: Reflects the digital transformation of market transactions, supporting economic activity, and facilitating digital readiness in market environments.

Technological Investment: Highlights financial commitments to acquiring and developing technologies, enabling firms to adapt and respond to market demands.

Innovation: Measures the extent of product, process, organizational, and marketing innovations, reflecting the ecosystem's adaptability and innovative potential.

Hardware: Represents the physical infrastructure necessary for digital transformation, such as electronic products and devices.

Software: Reflects the intangible capabilities enabling automation, data analysis, and digital services that drive innovation and economic growth.

Analysis method

Given the heterogeneity and complexity of the China context, fsQCA was used to explore the relationship between various configuration of factors and profit growth across 31

Chinese provinces. The process involved calibrating variables into fuzzy sets, constructing a truth table to represent the causal configurations, and identifying multiple pathways that lead to the same outcome. This method proves effective in capturing the complexity and non-linearity of innovation processes, highlighting that various combinations of actors, activities, and artifacts can equally contribute to profit growth.

As a method derived from complexity theory and configurational theory [22], fsQCA is an asymmetric analysis method that adopts Boolean logic to eliminates redundant conditions, leaving only the essential combinations that are sufficient to explain the outcome [13, 23] and can provide more nuanced results in explaining the causal relationships in complex scenarios than regression-based methods [24, 25]. Moreover, fsQCA is most effective when applied to a moderate number of cases, typically ranging between 20 and 50, as this allows for the exploration of multiple causal pathways while maintaining a balance between complexity and manageability [26]. The selection of 31 cases in this study falls comfortably within this ideal range, enabling a detailed examination of causal configurations without overwhelming the analysis, ensuring that the results remain robust and insightful.

As Gigerenzer (1992) emphasised on the importance of complexity, conventional linear models oversimplify the relationship that only high outcomes of X are associated with high outcomes of Y. Indeed, the causal relationships under complex context cannot be captured fully by analysis routed in simple or linear logic [27]. According to the diversity-oriented view, causal conditions may combine in different ways and sometimes may appear in a conflicting manner but still lead to the same or similar results [13].

Due to the significant regional and provincial disparities across China, directly using provincial data in its absolute values can lead to distortions in the analysis. This is particularly relevant when studying profit growth over time, as such variations can obscure the true drivers of growth. To address this issue and focus on how changes in key factors have contributed to

sustained profit growth, we employ a relative approach. Specifically, we aim to capture the dynamic percentage of changes rather than the amount of change in absolute values.

Various methods have been used to assign weights to variables, as these weights can directly impact empirical results [28, 29]. For instance, some scholars have used the propensity score matching approach [30]. Ayadi, et al. [31] rerun a baseline model using propensity score matched (PSM) and entropy balanced samples that confirm our earlier findings. Some other scholars measure the market's reaction to analyst revisions by calculating the mean market-adjusted cumulative abnormal returns (CARs) of the up/downgraded stocks over a 2-day event window [32].

For the allocation of weights to our sampled data, the process of collecting data (i.e., sampling) can either follow a probability or nonprobability approach [33]. Feng and Gong [34] used an integrated linguistic entropy weight method to allocate the weight. Chang [35] employed the hesitant fuzzy linguistic term sets and minimal variance of the ordered weighted geometric averaging (OWGA) weights to affect flexible allocation of system reliability. Accordingly, the feasible-improved weight allocation (FIWA) method is now proposed by considering a design optimization problem objectively [36]. As the original data points reflect the point-in-time values, we re-programmed the datasets and produced values that reflect the interval changes by comparing the corresponding data points between two years: 2015 and 2022. This can mitigate the potential impact of company size differences and other regional variations that could otherwise skew the results. The specific weights are assigned as follows：

$$\text{Avefactor value} = \frac{\sum_1^n C_1 + \cdots \ldots + C_n}{n} \text{ where } C = \frac{x_{2022} - x_{2015}}{x_{2015}} \quad (1)$$

This method accounts for proportional changes over time, enabling a focus on the underlying shifts driving profit growth while minimizing disparities between provinces. The processed data are then recalibrated into values between 0 and 1. For fuzzy-set responses, three

thresholds are needed where 0 means the value is fully outside of the set, 1 means the value is fully in the set, and 0.5 means the value is neither in nor out of the set [22]. Three percentiles at 0.05, 0.5, and 0.95 are applied as recommended by Cao, et al. [37]. After calibration, we performed analysis on necessary and sufficient conditions respectively which were used to calculate the effect of the variables on the profit increase. The first test examined necessary conditions—those that must be present across all cases for the outcome to occur. The second test evaluated sufficient conditions—those that, when present, consistently lead to the outcome, even if not universally required. These tests ensure a comprehensive understanding of diverse configurations of factors driving regional profitability.

Rigor of the Methodology

The configurational approach, as emphasized by Fiss [10] and Ragin [13], provides a robust framework for analyzing pathways to regional profit growth. By incorporating the principle of equifinality, this approach acknowledges that multiple, distinct configurations of factors can lead to similar outcomes, making it particularly suitable for complex systems such as regional economies. Prior studies, such as Crespo et al. [38] has demonstrated the utility of configurational analyses in exploring regional innovation systems and economic development, highlighting the interplay of diverse regional factors that contribute to competitiveness and resilience. Furthermore, Díez-Vial and Montoro-Sánchez [39] effectively illustrate how fsQCA can be applied to study digital transformation and entrepreneurial ecosystems, demonstrating its relevance for understanding the dynamic processes that drive regional success. These works collectively reinforce the methodological foundation and relevance of fsQCA for the current study. Further, calibration thresholds were set based on established methodologies recommended in studies such as Cao et al. [37], Greckhamer et al. [40], Misangyi et al. [41] and Ragin [13], ensuring alignment with academic best practices. Calibration was performed using three percentiles (0.05, 0.5, and 0.95) as recommended by leading methodological

research [13, 37, 40, 41]. This approach minimizes bias and ensures that the data reflect true set membership, thus enabling robust and meaningful fsQCA analysis. Additionally, the weight allocation approach builds on methods employed in production and operations research, such as entropy-based weight allocation [34] and hesitant fuzzy linguistic term sets [35], ensuring that the analysis captures proportional changes across provinces while mitigating the effects of data heterogeneity. By recalculating data to reflect interval changes, this study mitigates potential biases due to disparities in firm size or regional variations, following practices highlighted in Ayadi et al. [31] and other empirical research in leading journals.

4. RESULTS

Descriptive information

The descriptive statistics (Appendix B) highlight the variability across the key variables analyzed in the study. Enterprise informatization had a mean of 0.16 with a relatively small standard deviation (0.14), reflecting comparable relative percentage changes in adoption levels across provinces over the years. Innovation showed significant variability, with a mean of 1.39 and a high standard deviation of 4.37, reflecting uneven innovation activities. Similarly, e-commerce exhibited low average engagement (mean = 0.09) and a standard deviation of 0.26, suggesting regional disparities in digital market transactions.

Technological investment (mean = 1.33, SD = 2.17) and digital infrastructure (mean = 1.05, SD = 0.33) showed moderate variability, while software (mean = 2.59, SD = 2.42) and hardware (mean = 25.6, SD = 60.39) demonstrated significant differences across provinces, reflecting disparities in technological resources. Lastly, profit growth displayed considerable variability (mean = 5.69, SD = 22.98), highlighting diverse economic outcomes among regions. These statistics underscore the heterogeneous nature of the regional factors driving profitability.

Necessary conditions

A condition is considered necessary if it must be either present or absent to achieve a specific outcome and if its consistency score exceeds 0.9, as recommended by Ragin [13]. Table 1 details the results of the analysis of necessary conditions for profit increase. Consistency and coverage values of the seven conditions and the negation of those conditions (as denoted with ~) for the outcome (i.e. profit increase) and its negation were calculated. No necessary conditions were identified as all consistency values were below 0.90.

Insert Table 1 about here

Sufficient conditions

In fsQCA analysis, sufficient conditions are those that, when present, can generally lead to a particular outcome. For optimal profit increase, it is proposed that all conditions should be met. Conversely, if none of the conditions are fulfilled, it is expected to result in minimal profit growth. The frequency cut-off and the consistency cut-off values were set to 1 and 0.8 respectively as recommended by Ragin [13] and Fiss [10]. Proportional Reduction in Inconsistency (PRI) value was set to 0.7 as recommended by Greckhamer, et al. [40].

Table 2 presents the intermediate solutions for both high and low levels of increased profit, where five configurational solutions collectively account for 67% of the cases (solution consistency=0.89; solution coverage=0.67) and thus representing a good fit. From the fuzzy set analysis, five solutions for high increase in profit have returned high consistency levels, between 0.83 and 0.96.

Insert Table 2 about here

In Table 4, it can be observed that the five configurational solutions for the high increase in profit are: (1) low increase of innovation * high increase of e-commerce * high increase of technological investment * low increase of software, with raw coverage=0.304; consistency=0.829; (2) low increase of enterprise informatization * high increase of e-

commerce * high increase of technological investment * low increase of software, with raw consistency=0.258; consistency=0.955; (3) low increase of enterprise informatization * high increase of innovation * low increase of technological investment * high increase of digital infrastructure, with raw consistency=0.454; consistency=0.939; (4) low increase of enterprise informatization * low increase of technological investment * high increase of digital infrastructure * high increase of software, with raw consistency=0.418; consistency=0.954; (5) low increase of enterprise informatization * low increase of technological investment * high increase of digital infrastructure * high increase of hardware, with raw consistency=0.271; consistency=0.952.

Using data from all 31 provinces, this study identified five distinct configurations of regional factors that contribute to a high increase in profit as above (Table 4). These solutions were then matched with specific cases (provinces) to determine which provinces align with the identified configurations. As is common in fsQCA, not all cases necessarily match the derived solutions [42]. This method emphasizes identifying sufficient configurations of conditions that can lead to the outcome, rather than requiring every case to fit within a solution. In our study, eight provinces (Gansu, Guangdong, Hainan, Ningxia, Sichuan, Xinjiang, Xizang, and Yunnan) were found to align with the five identified solutions, meaning their regional conditions matched at least one of the configurations associated with high-profit growth (a summary of profit growth by province and alignment with identified solutions is shown in Appendix C). The remaining provinces, while part of the initial dataset, did not align closely with the identified solutions and thus were not included in the interpretation of configurational matches.

Solution 1: (Guangdong province)

- E-commerce (core presence): Indicates that regions with a strong presence of e-commerce activities significantly drive profit growth.

- Technological Investment (core presence): Suggests that technological investment is critical for enhancing profitability.
- Innovation and Software (absent): Indicates that the lack of these factors in some regions is not a barrier to profitability.

Solution 2: (Guangdong province)

- Digital Infrastructure (core presence): Highlights the foundational role of digital infrastructure in driving profit.
- E-commerce (peripheral presence): Suggests that while e-commerce supports profitability, its impact is secondary in this pathway.
- Enterprise Informatization and software (both absent): Indicates these factors are not necessary in this configuration.

Solution 3: (Xizang, Ningxia, Hainan, Xinjiang, and Sichuan provinces)

- Innovation (peripheral presence): Reflects the role of innovation in supporting profit growth, though it is not central.
- Digital infrastructure (core presence): These are essential drivers in this pathway.
- Enterprise Informatization and Technological Investment (both absent): Indicates these factors are not necessary in this configuration.

Solution 4: (Yunnan, Hainan, Xinjiang, Sichuan, and Ningxia provinces)

- Digital infrastructure (core presence): This is a critical for-profit growth in this pathway.
- Software (peripheral presence): Plays a supporting role in enabling profitability.
- Enterprise Informatization and Technological Investment (both absent): Indicates these factors are not necessary in this configuration.

Solution 5: (e.g. Gansu province)

- Digital infrastructure (core presence): This is key to profit growth in this pathway.

- Hardware (peripheral presence): Plays a secondary but supportive role in achieving profit growth.
- Enterprise Informatization and Technological Investment (both absent): Indicates these factors are not necessary in this configuration.

Robustness analysis

To ensure the credibility and reliability of our findings, this study conducted a comprehensive robustness analysis, reducing the likelihood of contingent results due to sample-specific factors. One commonly used approach in fsQCA-based studies is to adjust thresholds for raw consistency and Proportional Reduction in Inconsistency (PRI) values [40, 42]. In this study, raw consistency values are generally high, PRI value was therefore re-set at PRI=0.65 to test the robustness of the sample. Table 3 shows the results at PRI=0.65：

Insert Table 3 about here

The comparison between the results in Table 4 and Table 5 demonstrates strong robustness of the solutions. The first two solutions remain entirely stable and unchanged across both tables, indicating a consistent relationship between the causal conditions and the outcome. Solutions 3, 4, and 5 also largely maintain their structure, with the only notable difference being a substitution of absent conditions: *Enterprise Informatization* in Table 4 is replaced by *Hardware* in Table 5 in solutions 3 and 4. Despite this minor variation, all the other core and peripheral conditions remain consistent, suggesting that the overall findings are stable and reliable. These results confirm that the analysis is not highly sensitive to small changes, thus supporting the robustness of the identified configurations.

The robustness of the findings is further evident through several key aspects. First, the principle of equifinality ensures that multiple pathways to profit growth are identified, meaning the conclusions are not overly dependent on a single set of conditions. This flexibility allows

the findings to be more widely applicable across different regions and time periods, particularly in diverse economic environments like those of China's provinces. Second, the study's use of fsQCA ensures consistency in identified configurations, as the factor combinations remain stable across various regional settings. This method also captures interactions between different ecosystem factors, which strengthens the internal validity of the results. Lastly, the findings are cross-validated with data from 31 provinces over a seven-year period, minimizing the risk of random or coincidental outcomes. This broad temporal and geographic scope enhance both the reliability and generalizability of the conclusions.

5. DISCUSSION

The aim of this study is to identify various configurations of factors driving regional profitability and to assess whether multiple, equally effective pathways exist to achieve this outcome. The present study preliminarily identifies five distinct configurations that drive profit growth across Chinese provinces, demonstrating how the interplay of variables such as e-commerce adoption, technological investment, and digital infrastructure creates diverse pathways to success. This empirical evidence aligns with the principle of equifinality in Configuration Theory, which emphasizes that complex systems often achieve similar outcomes through multiple combinations of conditions [10, 13]. The findings reveal that regional variations, such as the economic disparities between the advanced eastern provinces and the less developed western regions, result in unique but equally effective configurations of factors driving profitability. These observations lead to:

Proposition 1: *No single best configuration of factors drives regional profitability; rather, multiple, equally effective configurations of causal factors exist.*

Empirical evidence from the study demonstrates that underdeveloped factors, such as limited enterprise informatization in less developed regions, act as bottlenecks, constraining

economic outcomes. This finding supports the argument that strengthening these weak links within the ecosystem is essential for enhancing overall performance. The practical implications align with the concept of bottleneck factors frequently discussed in regional development literature [8]. Targeted policy interventions aimed at improving these critical gaps can promote systemic alignment, enhance resilience, and ultimately drive regional profitability. These observations lead to:

Proposition 2: In Chinese provinces, sustained profit growth depends on improving the weakest elements in the configuration, as success is constrained by the least developed factors.

These findings must be understood within China's broader economic and digital transformation, where uneven provincial development plays a key role in shaping regional configurations. China began its large-scale industrialization process in the 1980s after the implementation of the Reform and Opening policy. Consequently, the development of industrial and information technology has only had about 40 years of history in China. Given China's vast population and diverse geography, significant disparities persist among different provinces in terms of technological and economic development levels [43, 44]. In general, eastern regions tend to surpass western regions in areas like infrastructure growth, technological progress, and transportation benefits [45]. he central region, marked by high population density and a more rigid economic structure, further explains the diversity observed in the identified solutions.

These regional nuances highlight the diverse pathways to profit growth, with five distinct configurations identified. Each configuration represents a unique combination of factors that drive profit growth across different regions, reflecting how various elements interact within specific local contexts to produce similar outcomes. Some variables play a central role while others contribute peripherally, demonstrating the dynamic interplay of factors shaping regional profitability. The identification of these configurations highlights how

regional economic ecosystems evolve differently yet achieve comparable outcomes, reinforcing the principle of equifinality in Configuration Theory. The following sections provide a detailed discussion of each identified configuration, highlighting the unique combination of variables that drive regional profitability in different contexts.

The case of Guangdong province aligns with both Solution 1 and Solution 2, demonstrating multiple pathways that contributed to its profit growth between 2015 and 2022. 2. This dual alignment highlights Guangdong's strategic flexibility in leveraging diverse configurations of factors, even as the specific contributions of these factors vary across solutions. In Solution 1, Guangdong's profit growth is primarily driven by the strong presence of *e-commerce* and *technological investment* as core factors. These elements reflect Guangdong's leadership in digital commerce and its robust commitment to technological advancement [40]. The province's integration of platforms like Alibaba and JD.com has positioned it as a hub for *e-commerce*, showcasing the critical role of market-facing activities in fostering economic growth [46]. *Technological investment,* particularly in cutting-edge industries such as electronics and advanced manufacturing, has further strengthened its economic base. In Solution 2, the focus shifts to digital infrastructure (*hardware and software*) as the core driver, with *e-commerce* playing a more peripheral role. Guangdong's advanced digital infrastructure, including broadband networks and connectivity solutions, serves as the backbone for seamless global trade and industrial operations. This solution emphasizes Guangdong's ability to optimize its well-established infrastructure, ensuring continued economic success even when other factors like *technological investment* and *enterprise informatization* are less prominent.

However, the relatively low increase in *software* adoption (Solution 1) reflects Guangdong's reliance on established, off-the-shelf solutions and cloud services rather than custom software development. The province's businesses likely prioritized scaling their e-

commerce operations using existing resources without heavy investment in new software. Similarly, the modest increase in *enterprise informatization*, referring to the digitalization of internal processes, indicates that many businesses had already undergone significant digital transformation prior to 2015. Guangdong's advanced technological maturity left limited room for substantial gains in this area during the study period.

Guangdong's *economic environment*, characterized by a well-established industrial base and access to global supply chains, further contextualizes these findings. Its economic openness and integration into global markets have attracted significant foreign investment, fostering knowledge spillovers and reinforcing its leadership in digital and technological innovation. These dynamics have allowed the province to focus on optimizing its existing strengths rather than pursuing extensive new developments in areas like software or enterprise informatization.

In solution 3, high increases in *innovation* and *digital infrastructure* drive profit growth, despite low increases in enterprise informatization and technological investment. These provinces, such as **Xizang**, **Ningxia**, **Hainan**, **Xinjiang**, and **Sichuan** provinces , typically have lower levels of development compared to China's coastal regions. The low increase in *enterprise informatization* likely reflects the slower pace of internal digitalization, as many businesses in these regions may not yet have fully integrated IT systems into their operations. However, the high increase in *innovation* suggests that these provinces are focusing on developing new ideas, products, or services. This could be supported by regional policies aimed at fostering innovation in less developed areas, such as through government initiatives or local entrepreneurship. For instance, **Xinjiang** and **Sichuan** have been pushing to diversify their economies by encouraging innovation in sectors like agriculture, energy, and technology (Deng et al., 2017). At the same time. the high increase in *digital infrastructure* is crucial for these regions, as improved connectivity, access to the internet, and better data management systems

can significantly enhance economic activity (Baark, 2022). For less developed regions like **Xizang** and **Ningxia**, improving digital infrastructure helps overcome geographic challenges and connects local businesses to broader markets, enabling them to innovate and grow. The low increase in *technological investment* may reflect the financial constraints often seen in these provinces, where large-scale investment in hardware and advanced technologies might not be feasible. However, the focus on *innovation* and *digital infrastructure* provides an alternative pathway to profit growth, demonstrating how improving certain artifacts (such as infrastructure) can compensate for weaker elements like technological investment.

Solution 4 shows that high increases in *digital infrastructure* and *software* are key drivers of profit growth, while *enterprise informatization* and *technological investment* remain underdeveloped. Provinces such as **Yunnan**, **Hainan**, **Xinjiang**, **Sichuan,** and **Ningxia** provinces often face financial limitations and may not be able to invest heavily in advanced technologies or large-scale IT integration. The low increase in *enterprise informatization* is consistent with the economic reality in these regions, where many businesses may not yet have fully embraced digital transformation internally. Similarly, the low increase in *technological investment* suggests that these provinces are not heavily investing in cutting-edge technologies or upgrading their hardware infrastructure, possibly due to budget constraints or a focus on more immediate economic priorities. However, the high increase in *digital infrastructure* reflects significant improvements in these provinces' ability to connect digitally. Yunnan, for example, has invested in improving its internet infrastructure to support industries such as tourism and agriculture, which benefit from better connectivity [47]. Similarly, **Xinjiang** and **Sichuan** have worked to enhance their digital infrastructure to support economic development, helping local businesses gain access to digital markets and resources [48]. The high increase in *software* indicates that businesses in these regions are focusing on adopting or developing software solutions to improve their operations. For instance, provinces like **Hainan** and

Xinjiang may have adopted cloud computing services, enterprise resource planning (ERP) systems, or other digital tools that streamline business processes and help firms remain competitive. This highlights the role of artifacts like software in compensating for weaker internal IT systems and technological investments, allowing these regions to grow despite their economic challenges.

Solution 5 reflects that high increases in both *digital infrastructure* and *hardware* are key to profit growth in **Gansu** province, while *enterprise informatization* and *technological investment* remain comparatively less improved. Gansu is one of China's less economically developed provinces, and the low increase in *enterprise informatization* suggests that businesses in this region have not fully integrated IT into their operations. The low increase in *technological investment* similarly reflects the financial limitations of the province, where large-scale investments in advanced technologies are less feasible. However, Gansu has focused on improving its *digital infrastructure*, which is crucial for its long-term development [49, 50]. By enhancing internet access, digital connectivity, and data management systems, the province is building the foundations needed to support economic activity. Improved digital infrastructure enables local businesses to expand their reach and integrate into broader digital markets, overcoming geographic challenges that previously limited growth [48]. At the same time, the high increase in *hardware* suggests that Gansu has prioritized upgrading physical technologies, such as servers, computers, and data storage systems. This may reflect a strategic choice to improve basic infrastructure before focusing on more advanced digital transformations. In less developed regions like Gansu, improving artifacts such as hardware and digital infrastructure can create the foundation for future growth, even when activities like technological investment and actors like enterprise informatization are underdeveloped.

This study's findings strongly support the principles of Configuration Theory, particularly equifinality, which suggests that multiple, equally effective configurations can lead

to similar outcomes [10, 11]. By identifying five distinct configurations across China's provinces, the study illustrates the diverse ways regional factors interact to drive profitability. These configurations align with the theoretical framework, demonstrating that the interplay of digital infrastructure, technological investment, and innovation is essential for success. For example, the role of digital infrastructure (*hardware* and *software*) in several configurations aligns with the literature emphasizing its foundational importance in enabling technological and economic integration. Studies such as those by Tödtling and Trippl [8] have shown that regions with robust infrastructure are better positioned to foster collaboration and innovation, which is reflected in the solutions where digital infrastructure serves as a core driver.

Similarly, the principle of addressing bottlenecks, as seen in Proposition 2, aligns with the systemic coherence emphasized in regional studies. Literature on regional innovation systems highlights that the least developed components often constrain overall success, underscoring the need for targeted improvements to enhance systemic performance [51, 52]. For instance, less developed regions like Gansu and Xinjiang demonstrate that focusing on *software* and *hardware* can compensate for lower levels of *technological investment* or *enterprise informatization*.

Moreover, the findings on *e-commerce* and *innovation* align with Configuration Theory's emphasis on the interplay of interdependent factors. In advanced regions like Guangdong, the strategic emphasis on e-commerce and technological investment reflects the importance of aligning strengths with regional characteristics to maximize outcomes, resonating with the systemic alignment described in the literature.

6. Contributions, managerial relevance, limitations and future research

The contribution of this paper is twofold. Firstly, this paper makes a significant theoretical contribution by advancing the application of Configuration Theory to the study of regional profitability, offering a nuanced perspective on how diverse combinations of regional factors

interact to drive economic outcomes. The study addresses critical gaps in the literature by examining the systemic interplay between factors such as digital infrastructure, technological investment, and innovation activities, highlighting the importance of alignment among these elements in complex systems [10, 11]. Secondly, by incorporating the principle of equifinality, which posits that multiple configurations can lead to similar outcomes, the study challenges traditional linear models and underscores the value of exploring diverse pathways to regional profit growth. This approach aligns with prior research emphasizing the complexity of economic systems and the need for multi-factorial analyses [8, 13]. Furthermore, the inclusion of measurable and actionable variables broadens the practical applicability of Configuration Theory, enabling a more data-driven exploration of regional economic strategies.

The study presents findings that challenge conventional growth strategies. First, economically developed regions demonstrate diminishing returns from new investments in overdeveloped areas such as digital infrastructure. Instead, optimizing existing systems yields greater benefits. Second, less developed regions achieve significant growth by focusing on foundational infrastructure like connectivity and hardware, rather than prematurely investing in advanced technologies. Lastly, the the assumption that uniform innovation across all factors is necessary for growth. Instead, it demonstrates that targeted investments in weaker components, identified through data-driven analysis and tailored to regional contexts, have the greatest impact. This finding emphasizes the strategic importance of region-specific approaches, grounded in empirical insights, rather than relying on generalized or intuitive strategies.

In advance regions where higher levels of economic development, technological maturity, and infrastructure sophistication engineering managers' focus should be on optimizing existing systems, such as improving the efficiency of digital infrastructure and scaling e-commerce operations. Efforts to enhance profitability should include data-driven

decision-making and leveraging established systems to achieve greater scalability. In less developed regions, managers should prioritize foundational investments like improving digital connectivity and hardware to integrate businesses into broader markets. Incremental, industry-specific innovation, such as in agriculture or manufacturing, can further support sustainable growth.

For policymakers, this study highlights the need for targeted interventions to address regional disparities. Strengthening underdeveloped areas like connectivity and enterprise informatization can significantly enhance economic performance in less developed regions, while advanced regions benefit more from fostering collaborative innovation and scaling digital capabilities. Policymakers are encouraged to focus resources on the weakest components of regional ecosystems, ensuring maximum returns and fostering inclusive development.

While this study provides valuable insights into regional profitability through the lens of Configuration Theory, it is not without limitations. Nonetheless, the current study partially addresses this limitation by focusing on proportional changes (rather than absolute values) to mitigate the impact of size differences and regional variations. Aggregating firm-level data at the provincial level may obscure intra-regional disparities or variations within provinces. Smaller, localized factors contributing to profitability might not be fully captured. Additionally, the focus on listed companies excludes a large portion of non-listed firms, particularly smaller enterprises, limiting the study's representativeness and ability to capture the full scope of digital transformation across various business types.

Future studies could extend the analysis to include data from multiple countries, enabling comparisons of how different cultural, institutional, and policy contexts shape the configurations that drive profitability. This would enhance the generalizability of the findings and offer insights into global trends. Further, exploring other relevant factors, such as

workforce skills, environmental sustainability, or social capital, could provide a more comprehensive understanding of regional profitability drivers. This would help capture the multidimensional nature of regional economic development. Additionally, integrating insights from disciplines such as urban planning, sociology, and environmental science could enhance the understanding of regional profitability by considering a broader set of factors that impact regional ecosystems. Further, future research could expand on this study by incorporating broader place-based characteristics—such as socio-political factors, regional governance, and cultural dynamics—to explore how these elements interact with digital transformation in shaping the functioning and outcomes of innovation ecosystems.

In sum, this study provides valuable insights into the diverse configurations of regional factors that drive profitability, emphasizing the principle of equifinality through the lens of Configuration Theory. By analyzing measurable variables such as digital infrastructure, e-commerce, innovation activities, and technological investment, the research highlights multiple pathways through which regions can achieve economic success. Employing fsQCA, the study uncovers the critical interplay of digital capabilities and foundational resources in fostering regional profit growth, offering actionable strategies for policymakers and stakeholders.

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Table 1: Analysis of necessary conditions

	High increase in profit growth		Low increase in profit growth	
	Consistency	Coverage	Consistency	Coverage
Enterprise informatization	0.529376	0.538070	0.697884	0.777350
~Enterprise informatization	0.780948	0.702274	0.585292	0.576787
Innovation	0.628152	0.695903	0.521315	0.632911
~ Innovation	0.668650	0.695903	0.749522	0.688368
E-commerce	0.652559	0.631924	0.650935	0.690782
~ E-commerce	0.680684	0.640214	0.653156	0.673216
Technological investment	0.528091	0.557889	0.678018	0.784944
~ Technological investment	0.796430	0.692982	0.618113	0.589388
Hardware	0.513961	0.631605	0.596212	0.802925
~ Hardware	0.839632	0.654872	0.726448	0.620913
Software	0.670746	0.640850	0.667530	0.698921
~ Software	0.684876	0.652748	0.656981	0.686191
Digital infrastructure	0.726861	0.695768	0.575668	0.603870
~ Digital infrastructure	0.586167	0.557628	0.709976	0.740160

Note: The absence of conditions is represented by "~ [condition]")

Table 2: Analysis of Sufficient Conditions (PRI=0.7)

	Solution: Increase in profit				
	1	2	3	4	5
Enterprise informatization		◯	◯	◯	◯
Innovation	◯		●		
E-commerce	⬤	⬤			
Technological investment	⬤	●	◯	◯	◯
Digital infrastructure			⬤	⬤	⬤
Software	◯	◯		●	
Hardware					●
Consistency	0.829	0.955	0.939	0.954	0.952
Raw coverage	0.304	0.258	0.454	0.418	0.271
Unique coverage	0.055	0	0.081	0.029	0.027
Solution coverage			0.67		
Solution consistency			0.89		

Note: ⬤ or ● indicate condition presence, ◯ or ○ indicate condition absence, "blank space" refers to "don't care" conditions, large ⬤ or ◯ refers to core condition, small ● or ○ refers to the peripheral condition; consistency cut-off = 0.9, PRI cut-off = 0.7

Table 3: Analysis of Sufficient Conditions (PRI=0.65)

	Solution: Increase in profit					
	1	2	3	4	5	6
Enterprise informatization		◯			◯	◯
Innovation	◯		●			
E-commerce	⬤	⬤				
Technological investment	⬤	●	◯	◯	◯	◯
Digital infrastructure			⬤	⬤	●	
Software	◯	◯		●		●
Hardware			◯	◯	●	●
Consistency	0.829	0.955	0.905	0.91	0.952	0.934
Raw coverage	0.304	0.258	0.456	0.405	0.271	0.269
Unique coverage	0.042	0	0.093	0.036	0.034	0.048
Solution coverage			0.76			
Solution consistency			0.89			

Note: ⬤ or ● indicate condition presence, ◯ or ○ indicate condition absence, "blank space" refers to "don't care" conditions, large ⬤ or ◯ refers to core condition, small ● or ○ refers to the peripheral condition; consistency cut-off = 0.9, PRI cut-off = 0.6