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METHODS FOR EVALUATING DIGITAL PLATFORM INNOVATION MECHANISMS

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A comparative analysis of digital platform innovation research methods is conducted in the research topic. Some research methods, such as single-case studies and regression analysis, have the disadvantages of few research cases, single research factors, and poor timeliness. Digital platform innovation research is multifactorial and can be realized through multiple paths. PLS-SEM and fsQCA were finally selected.

Keywords: PLS-SEM; fsQCA; ecosystem; innovation; digital platform.

МЕТОДЫ ОЦЕНКИ МЕХАНИЗМОВ ИННОВАЦИЙ ЦИФРОВОЙ ПЛАТФОРМЫ

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В работе проводится сравнительный анализ методов исследования инноваций в области цифровых платформ. Некоторые методы исследования, такие как исследования отдельных случаев и регрессионный анализ, имеют недостатки в виде небольшого количества исследовательских закономерностей, отдельных факторов исследования и несвоевременности. Исследование инноваций в области цифровых платформ является многофакторным и может быть реализовано несколькими путями. В конечном итоге были выбраны методы PLS-SEM и fsQCA.

Ключевые слова: PLS-SEM; fsQCA; экосистема; инновации; цифровая платформа.

Previous scholars on the research methods of innovation mechanisms will help to establish the research methods of digital platform innovation mechanisms and make the research results achieve effectiveness and reliability. Irfan, M., Razzaq, A., Sharif, A., & Yang, X. applied the difference-in-differences (DID), mediation effects, and panel vector autoregression (Panel VAR) model to empirically test the impact mechanism and policy effectiveness of capacity green finance on green innovation. The results show that green finance innovation reform areas have more obvious regional effects on green innovation and growth. In addition, industrial structure, economic growth, and R&D investment are the core transmission channels for green finance to affect innovation [1]. Wang Haijun, Chen Xiao, Mou Dai, Jin Shutong constructed an evolutionary game theory based on the Hotelling model to explore the implementation mechanism of complementary innovation of digital platforms. They introduced the interactive behaviors of the platform core modules, innovation profits, and complementary modules into the dynamic game and obtained the optimal difference between the complementary modules and the core modules of the digital platform [2]. Ren Zhimin studied the platform innovation ecology based on the niche theory. The study proposed to use the order of dissipative structure to characterize the effectiveness of the innovation ecology and constructed a model of the operation mechanism of the platform innovation ecology. Finally, the clear-set qualitative comparative analysis method (csQCA) was used to verify the examples of 10 network platforms [3]. Shao Peng and Hu Ping adopted the multiple case study method and the semi-structured interview method. The study selected seven cases as research samples and conducted interviews. The research results

proposed different development stages of e-commerce platforms: technology-driven, market-driven, value chain-driven, and economies of scope-driven mechanisms [4]. Li Wei, Dong Jiangyuan, Yang Xuecheng adopted the single case study method and selected Chongqing Miaoyin Technology Co., Ltd. as the research object. The qualitative data came from primary and secondary data. The primary data was obtained through structured, in-depth interviews. The secondary data came from the collected materials. The research results show that technical resources and cognitive systems are the main factors for the innovation of efficiency-centered platform business models. The driving forces for the NPI are market resources and regulatory systems. The driving mechanisms for the upgrade of the EPI to the NPI are operational resources and regulatory systems [5]. Peng Benhong and Zhong Zhaoqiang focused on the role of governance mechanisms and network embeddedness in platform-open innovation and constructed a theoretical model. The research hypotheses were empirically tested based on questionnaire surveys and regression analysis methods. The results showed that there is an inverted U-shaped relationship between governance mechanisms and platform-open innovation. In addition, different network embeddedness modes have different interactive effects on platform open innovation [6]. Gu Enshu derived the mechanism of business model innovation and value co-creation of video platforms through literature analysis and typical case studies. On this basis, he developed an evaluation scale, collected data in the form of questionnaires, and conducted quantitative research [7]. A. P. Codini, T. Abbate, A. M. Petruzzelli used a case study approach to investigate a company's business model innovation through expansion. The case analysis approach identified key expansion processes that activated value creation, value delivery, and value capture mechanisms [8]. Zhang Jichang and Long Jing used data from listed high-tech enterprises from 2007 to 2019 as samples to empirically test the positive impact of digital transformation on corporate innovation performance. Dynamic capabilities have a significant mediating effect between digital transformation and corporate innovation performance through the three aspects of innovation, absorption, and adaptability [9]. M. J. Beynon and P. Jones used fsQCA to demonstrate the path of key internal strategies of UK SMEs to support enterprise innovation. This study helps to provide an overview of the goals and priorities of SMEs in different sectors, which helps to effectively evaluate enterprise development plans and provide information for decision-making [10].

Combining the advantages (see the table) and disadvantages of different research methods, this study uses a combination of PLS-SEM (Partial least squares structural equation modeling) and fsQCA to explore the mechanism of digital platform innovation. And literature analysis, multiple case analysis, and mathematical statistics will also be selected.

1. Literature analysis method. This research collects and sorts out the literature related to the theory and economic essence of digital platform innovation. In addition, it investigates the latest research on innovation factors and methods, which lay the theoretical foundation for the overall research.

2. Multi-case analysis method. Based on the official classification of Chinese digital platforms, this paper selects innovative digital platform companies in different industries and fields as cases. Then, the fsQCA research method is used to analyze the configuration effect between factors so as to derive a general and universal innovation mechanism. In the multi-case analysis method, cases come from China Management Case Sharing Center (CMCC) and China Business Case Library (CBCP). Because the two case libraries are mostly reports collected and compiled by scholars or companies after field research, they have a higher degree of reliability and persuasiveness.

3. Mathematical statistics method. After scoring the case, researchers need to use mathematical statistics methods to test the reliability and validity.

4. PLS-SEM method. Using PLS-SEM to analyze digital platform innovation has the following advantages: PLS-SEM is suitable for exploratory prediction studies. It has advantages in analyzing the net effect of multiple antecedent variables on one or more outcome variables. [11; 12]. PLS-SEM can be used to estimate small sample data [13]. While CB-SEM needs data to follow a normal distribution, PLS-SEM is less strict about the type of data distribution and doesn't need the data to follow a normal distribution [14].

Advantages and disadvantages of the innovation mechanism methods

Methods	Advantage	Disadvantages
DID, mediation effects, and Panel VAR model	Those methods estimate the causal effect of factors on innovation.	Only a single factor or the relationship between multiple factors and the dependent variable can be measured.
Hotelling model	This method can derive the optimal difference between the complementary modules and the core modules of the platform innovation.	It is not possible to measure configuration effects between factors.
Questionnaire	This method can explore the combined effects of multiple factors on innovation.	The small number of questionnaires limited the number of factors.
csQCA	csQCA can measure the presence or absence of variables	csQCA cannot measure the presence or absence of variables, thus reducing the complexity of the phenomenon.
Semi-structured interviews	Semi-structured interviews allow for in-depth investigations based on the interviewee's background and circumstances, allowing for better interpretation and analysis of data.	Due to the limited sample size, only a few cases could be explored in depth.
Longitudinal case study method	The complete development process and key turning points are clear in this method. Case studies are more targeted.	This method has poor timeliness, and the innovation mechanism studied has weak universality.
Regression analysis	This method estimates the causal effect of factors on innovation.	This method cannot measure the configuration effects between factors
Typical cases	Typical case studies provide a deeper understanding of a company.	Typical case studies provide a deeper understanding of a company.
Single case study method	Single-case studies are more targeted.	Single-case studies are more targeted.
Quantitative research	Quantitative research data is more objective.	Quantitative research data is more objective.
fsQCA	This method demonstrated the configuration effect between various factors and successfully developed multiple innovation paths.	This method has only been used in small and medium-sized enterprises and has not yet been expanded to the platform field.
Literature analysis	This approach analyzes digital platform innovation from a macro perspective.	The research is too macro and lacks support.

Therefore, this study uses the partial PLS-SEM method to test the direct effect of a single factor in the model. This method can effectively calculate multiple indicators, such as path coefficients, significance levels, goodness of fit, and model prediction correlations between antecedent variables and outcome variables.

The PLS-SEM model contains two parts: the measurement model and the structural model. We use measurement models to assess the validity and reliability of our measurement tools. Structural models are used to study the causal relationships between variables. It can be used to explore direct, indirect, mediating, or moderating effects between variables. PLS-SEM uses path coefficients to represent the direct effects between variables and uses the bootstrap method to evaluate the significance of the effects. The measurement steps of PLS-SEM are as follows:

- Data preparation: Dealing with missing values and outliers is necessary to ensure the quality of the data.

- Model setting: Build a model based on theory or hypotheses.

- Model evaluation: Test the reliability and validity of the measurement model.

- Model estimation: Gradually improve the explanatory power of the model through the PLS algorithm and find the best model configuration.

The PLS-SEM estimation results show not only the path coefficients but also a number of other pieces of information, like the model's fitting index and predictive correlation. These metrics help us evaluate the fit and predictive power of the model.

5. FsQCA, the main research method for exploring the path of digital platform innovation, has the following advantages:

First, digital platform innovation is a complex process that is affected by multiple factors. It is the result of the interaction of technology, organization, and environment. A single factor cannot determine digital platform innovation. Whether it is the binary analysis based on variance theory or the moderating effect based on contingency theory, it is impossible to explore the impact of multi-factor interactions from a holistic perspective. Only qualitative analysis can conduct research from a holistic perspective. This method breaks through the boundaries of single factor analysis and is suitable for studying the impact of the configuration of three or more different conditional variables on digital platform innovation.

Second, from a practical point of view, there may be multiple implementation paths for the same outcome variable. That is, different conditional variables can achieve the same result through complex interactions. In general, statistical methods, when the conditioning variable is changed, the outcome variable is limited to either substitution or cumulative relationships. This will form mutually exclusive theories or non-equivalent explanations. However, fsQCA has path equivalence when different conditional variables explain the outcome variables. fsQCA can well study the paths that are driven by technology, organization, and environment. And by comparing different combination configurations, the research mechanism can be better discussed. This is more in line with the actual situation of digital platform innovation.

Third, the fsQCA research method has the dual attributes of case analysis and qualitative analysis. While focusing on causal relationships, the fsQCA evaluation method pays more attention to case-oriented analysis. The fsQCA research method is applicable to all case studies, and the robustness of the analysis results depends on whether the sample is representative. It can not only take into account the in-depth understanding of the case but also simplify the relationship between the conditional variables and the outcome variables with the help of quantitative analysis tools.

Fourth, fsQCA is more accurate than csQCA and mvQCA. There are continuous variables in this study. CsQCA and mvQCA have limitations in data processing. Before the fsQCA method is used for data analysis, the scores of each variable need to be converted into membership scores in the set. This provides a more accurate grasp of the comprehensive impact of the conditional variable on the outcome variable.

Digital platform innovation is a complex and dynamic evolution process. It is determined by the configuration of multiple factors, and multiple paths can achieve the same result. For causal asymmetry, fsQCA is more applicable. And fsQCA has the dual attributes of case analysis and qualitative analysis. Since the variables are continuous, fsQCA is more accurate than csQCA. Based on the above considerations, this study finally selected fsQCA for the configuration analysis of digital platform innovation paths. Based on the above considerations, this study finally selected PLS-SEM and fsQCA for digital platform innovation analysis.

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