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Article

The application of artificial intelligence in large-scale high-end equipment manufacturing projects: the moderating effect on the relationship between corporate culture, advertising investment, and strategic management of Shandong SMEs

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ABSTRACT

In view of the rapid development and penetration of artificial intelligence (AI) into the field of manufacturing, the strategic management of small and medium-sized enterprises (SMEs) in large-scale high-end equipment projects is undergoing a new transformation, yet previous studies have not taken artificial intelligence adoption as a boundary condition to examine the influence of corporate culture and advertising investment on strategic management effectiveness. Based on the Resource-Based View (RBV) and Contingency Theory, this study proposes a moderation model and tests it empirically. Questionnaires were distributed to 323 SME managers in Shandong Province, and hierarchical regression analysis and 5,000-resample bootstrapping were used to test the proposed model. The results show that all four hypotheses proposed in this study were verified. Corporate culture and advertising investment positively influence the effectiveness of strategic management. Artificial intelligence adoption plays a significant role in moderating these two relationships, and corporate culture is more important than advertising investment in this regard, since the interaction effect of corporate culture and artificial intelligence adoption on strategic management effectiveness is greater than that of advertising investment and artificial intelligence adoption. Under high levels of artificial intelligence adoption, the slope coefficient of corporate culture on strategic management effectiveness is 2.8 times that of low levels of artificial intelligence adoption. The study provides a new framework for strategic artificial intelligence management that integrates the RBV and Contingency Theory.

1. Introduction

One of the core regions for high-end equipment manufacturing in China, Shandong Province has a large number of small and medium-sized enterprises (SMEs) that are deeply involved in the industrial chains of large-scale projects, including computer numerical control (CNC) machine tools, industrial robots, rail transit equipment, and intelligent agricultural machinery, playing an irreplaceable role in the regional manufacturing upgrading process. With the rapid penetration of Artificial Intelligence (AI) technologies into industry, intelligent quality inspection, supply chain demand forecasting, and data-driven management decision-making are profoundly changing the strategic management approaches of enterprises involved in large-scale projects [1]. The introduction of AI technology has not only changed manufacturing processes but also profoundly influenced the relationship between internal resource management and external market

strategies, introducing new challenges for enterprise strategic management in the digital world. Therefore, from both theoretical and practical perspectives, exploring how the level of AI adoption affects the internal mechanisms of SME strategic management has profound implications for the sustainable development of Shandong Province's high-end equipment manufacturing industry. Based on existing literature, the positive effect of corporate culture on the effectiveness of strategic management in enterprises is supported by significant empirical evidence, highlighting that values and internal coordination mechanisms enable the effective implementation of strategic planning. Similarly, investment in advertising as a resource-allocation instrument in the market environment was found to improve the quality of SMEs' strategic decision-making by building brand equity and acquiring market intelligence. However, most of these studies were conducted in traditional, non-digital organizational settings, in which corporate culture and advertising investment were treated as independent variables with unconditional effects on strategic management in enterprises, without considering boundary effects arising from changes in the technological environment [2]. With the widespread use of AI in the manufacturing industry, it is possible that the ways in which organizational resources translate into strategic management might change significantly depending on the technological context, a possibility yet to be studied in the existing literature.

More concretely, for Chinese manufacturing SMEs within large-scale high-end equipment programs, there is a lack of empirical evidence on the impact of AI adoption levels on the efficiency of transforming corporate culture and advertising investment into strategic management effectiveness. This limits the explanatory power of the Resource-Based View (RBV) and Contingency Theory in the context of digitized manufacturing processes, both in general and in theoretical terms. Even though recent studies have explored the role of entrepreneurial innovation and strategic resources in achieving competitive advantage in SMEs [3], none included the level of AI adoption as a technological contextual variable within the resource-performance relationship. To bridge this gap, this study proposes a theoretical model that uses the level of AI adoption as a moderating variable and examines its moderating effects on the relationships between corporate culture and strategic management effectiveness, and between advertising investment and strategic management effectiveness. The study is based on a questionnaire survey of managers from 323 SMEs in Shandong Province and uses hierarchical regression analysis and moderation effect testing to conduct the empirical analysis. The contributions of this study lie in two aspects. This study is among the earliest to examine the moderating effects of AI adoption levels on the relationships among corporate culture, advertising investment, and strategic management effectiveness from the perspective of Chinese high-end equipment manufacturing SMEs. Additionally, this study combines the RBV and Contingency Theory to develop a new analytical framework and provides a theoretical basis for explaining changes in the strategic importance of resources in the digital age.

2. Literature review and hypotheses

2.1 Corporate culture and strategic management

The RBV approach regards corporate culture as an intangible resource with the characteristics of value, rarity, inimitability, and non-substitutability. Unlike other tangible resources, which may be accessible to the company's competitors through the market, corporate culture is closely linked with the company's history, social interactions, and identity, making it naturally difficult to imitate. Research has demonstrated the positive effect of corporate culture on the efficiency of strategic management, promoting shared values, innovation-oriented behaviors, and internal coordination mechanisms for strategic management and operational implementation [4]. The cultural cohesion of SMEs engaged in large-scale, high-end equipment manufacturing projects is particularly significant, given the nature of these projects, where cross-departmental cooperation and rapid strategic response are crucial. Based on the above analysis, the hypothesis is proposed.

H1. Corporate culture positively influences the effectiveness of strategic management.

2.2 Advertising investment and strategic management

Advertising investment serves as a market-oriented resource for SMEs to establish their brand positioning, generate customer awareness, and gather competitive intelligence. In the context of the RBV, systematic investment in advertising helps accumulate market knowledge and reputational capital, thereby enhancing the quality of decision-making during strategy formation [5]. In the high-end equipment manufacturing industry, where business-to-business relationships are critical to market access, advertising investment helps SMEs establish a technological brand identity and industry influence among business partners on equipment projects. The following hypothesis is proposed:

H2. Advertising investment positively influences the effectiveness of strategic management.

2.3 AI adoption in high-end equipment manufacturing

The scope of AI adoption in the manufacturing of large equipment includes intelligent quality inspections, supply chain forecasting, strategic decision support, and marketing analytics. This implies that AI adoption has transcended the scope of improving manufacturing efficiencies to the strategic management domain. Contingency Theory can be used to explain this phenomenon. On the technical level, these applications involve a range of computing approaches deployed across the manufacturing value chain. The applications of convolutional neural networks and machine vision algorithms in detecting defects during the manufacturing process are common, enabling real-time control for strategic quality assurance decisions. The applications of long short-term memory networks and time series forecasting algorithms in predicting supply chain demand provide inputs for strategic procurement decisions. The applications of natural language processing algorithms for customer feedback reports and other reports provide the inputs for strategic positioning decisions, which constitute the technological basis for the AI adoption level construct operationalized in the current study. Contingency Theory provides a suitable lens for understanding this phenomenon, asserting that the effectiveness of resource deployments is contingent rather than universal [6]. In this respect, the level of AI adoption is not viewed as a standalone driver of organizational performance but as a contextual variable that shapes

the conditions for resource utilization in achieving strategic management. The main argument is that the same levels of corporate culture and advertising investment can lead to different strategic management outcomes depending on the AI adoption levels.

2.4 The moderating role of AI adoption

Empirical research in manufacturing industries provides clear evidence that the adoption of AI is associated with fundamental changes in the efficiency of the use of existing organizational resources for SMEs [7]. Based on this research and the contingency theory developed above, the moderating effects can be theoretically justified. With reference to data analytics and intelligent decision support systems enabled through AI technologies, there is clear evidence that such systems can convert value consensus in enterprise culture, including innovation orientation, quality awareness, and cooperative culture, into quantified strategic actions. Enterprises with high levels of AI adoption can better leverage cultural advantages to translate them into quantifiable strategic actions. Concerning advertising investments, there is clear evidence that precision marketing analytics enabled through AI can convert advertising from a cost-oriented function to a source of strategic intelligence. Under high levels of AI adoption, advertising data can be converted into quantified strategic intelligence to improve the efficiency of converting advertising investments into strategic management effectiveness. Previous research provides clear evidence of AI's viability as a moderating variable in organizational management research [8]. Based on the analysis above, the following research hypotheses can be formulated.

H3. AI adoption positively moderates the relationship between corporate culture and strategic management effectiveness, such that the positive effect is stronger under higher levels of AI adoption.

H4. AI adoption positively moderates the relationship between advertising investment and strategic management effectiveness, such that the positive effect is stronger under higher levels of AI adoption.

The conceptual framework that ties the four hypotheses is presented in Figure 1. In this figure, corporate culture and advertising investment are considered independent variables that directly affect the effectiveness of strategic management, as stated in H1 and H2, respectively. In contrast, the AI adoption level is considered a moderating variable that conditions the direct effects of the other variables, as stated in H3 and H4.

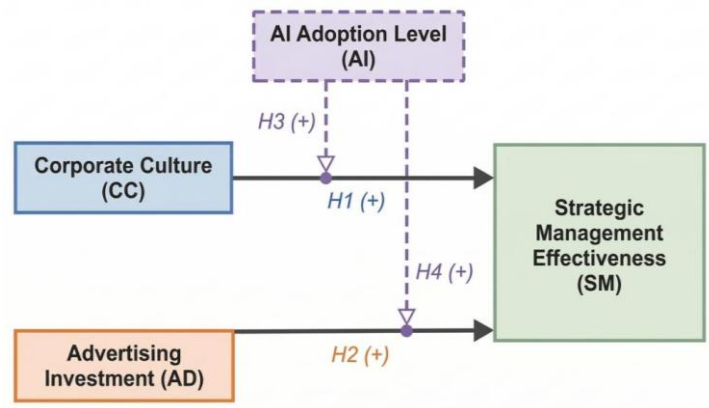

Figure 1. Conceptual framework

3. Materials and methods

3.1 Sample and data collection

The research targeted senior management and marketing executives of SMEs in Shandong Province, China, using a structured questionnaire for data collection. The sample included the manufacturing, services, retail, and technology sectors, with the manufacturing sector dominating the province's industrial output, as it is a core region for high-end equipment manufacturing in China. Of the 360 distributed questionnaires, 327 were received, and 323 were valid after excluding those with incomplete information or careless responses, yielding a high response rate of 89.5%. Among the four industry sectors, the manufacturing sector had the highest proportion of respondents (38.7%), followed by the services sector (24.5%), the technology sector (21.4%), and the retail sector (15.4%). The respondents were mostly males (58.2%) between the ages of 35 and 54 (68.7%), with 87.0% of the respondents possessing a qualification of at least a bachelor's degree, and 77.4% possessing more than ten years of work experience, indicating that the respondents were sufficiently qualified to make assessments on the research variables.

3.2 Measures

These four variables were measured using five-point Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree). The corporate culture scale consisted of 10 items related to shared values, encouragement of innovation, communication norms, and a culture of quality. The advertising investment scale consisted of 9 items related to advertising strategy planning, channel integration, brand communication, and advertising effectiveness evaluation. The strategic management effectiveness scale consisted of 10 items related to strategic planning, resource allocation, performance monitoring, and environmental adaptation. The scale for measuring the level of AI adoption consisted of 6 questions that focused on the adoption of particular computational systems within the organization, including intelligent manufacturing

systems that relied on machine learning, decision support systems that relied on artificial intelligence and predictive analytics, data-based marketing tools that relied on customer segmentation, the availability of human resources with specific competencies in artificial intelligence and data science, the organization's investment in the development of human computational skills, and the degree to which the organization incorporates the findings of artificial intelligence into the strategic planning process. The reliability test results showed that Cronbach's alpha coefficients for the corporate culture scale, advertising investment scale, strategic management effectiveness scale, and AI adoption level scale were 0.923, 0.911, 0.918, and 0.876, respectively, all greater than 0.70, thus proving satisfactory reliability for all the instruments used for data collection. Table 1 summarizes the measurement instruments.

Table 1. Summary of measurement instruments

Variable	Items	Sample item	Cronbach's α	Source
Corporate Culture (CC)	10	Our enterprise possesses shared values widely endorsed by employees	0.923	Adapted from validated instruments
Advertising Investment (AD)	9	Our enterprise systematically plans cross-channel advertising strategies	0.911	Adapted from validated instruments
Strategic Management Effectiveness (SM)	10	Our enterprise effectively translates strategic plans into operational actions	0.918	Adapted from validated instruments
AI Adoption Level (AI)	6	Our enterprise has deployed AI-assisted decision-making tools in production and management	0.876	Developed for this study

3.3 Analytical approach

To test the hypotheses, hierarchical multiple regression analysis was used, as recommended by Ref [9]. Model 1 included control variables: firm size, industry type, and years of business operation. Model 2 included corporate culture and advertising investment to test the main effects of the hypotheses (H1 and H2). Model 3 included the level of AI adoption to test the independent explanatory effects of the hypotheses. Model 4 included the product of corporate culture and the level of AI adoption, as well as the product of advertising investment and the level of AI adoption, to test the moderation effects of the hypotheses, i.e., H3 and H4. Before creating the interaction effects, all independent and moderating variables were mean-centered to avoid multicollinearity, and the bootstrapping method with 5,000 resamples was then used to obtain confidence intervals for the interaction effects, as recommended by Ref [10]. The moderation effects were examined by assessing the simple slopes of the independent variable at high (mean + 1 SD) and low (mean - 1 SD) levels of the moderating variable, i.e., AI adoption.

4. Results

4.1 Descriptive statistics and correlations

Before hypothesis testing, the distributional characteristics of the variables and intervariable relationships were examined. As indicated in Table 2, all means were above the scale's midpoint of 3.00. Corporate culture had the highest mean among all variables (M = 3.71, SD = 0.74), followed by advertising investment (M = 3.63, SD = 0.79) and strategic management effectiveness (M = 3.57, SD = 0.76), while AI adoption level had the lowest mean among all variables (M = 3.48, SD = 0.82), indicating that AI adoption is still in its developing phase in SMEs of Shandong Province. All Pearson correlation coefficients were positive and significant at $p < 0.01$. The strongest correlation was between corporate culture and strategic management effectiveness ($r = 0.536$), while the weakest was between AI adoption level and advertising investment ($r = 0.394$). All Variance Inflation Factor values were between 1.654 and 2.341.

Table 2. Descriptive statistics and correlation matrix (N = 323)

Variable	M	SD	1	2	3	4
1. CC	3.71	0.74	—			
2. AD	3.63	0.79	0.487**	—		
3. AI	3.48	0.82	0.412**	0.394**	—	
4. SM	3.57	0.76	0.536**	0.478**	0.451**	—

Note: **p < 0.01. CC = Corporate Culture; AD = Advertising Investment; AI = AI Adoption Level; SM = Strategic Management Effectiveness.

4.2 Hierarchical regression analysis

Table 3 presents the four-step hierarchical regression results with strategic management effectiveness as the dependent variable.

Table 3. Hierarchical regression results (Dependent variable: strategic management effectiveness)

Variable	Model 1 (β)	Model 2 (β)	Model 3 (β)	Model 4 (β)
Firm size	0.089	0.067	0.054	0.048
Industry type	0.074	0.051	0.043	0.039
Years of operation	0.112*	0.083	0.071	0.064
CC		0.318***	0.287***	0.276***
AD		0.269***	0.241***	0.232***
AI			0.213***	0.198***
CC × AI				0.194***
AD × AI				0.153**
R^2	0.063	0.437	0.478	0.531
ΔR^2	0.063	0.374***	0.041***	0.053***
F change	7.21**	106.34***	25.12***	17.89***

Note: *p < 0.05, **p < 0.01, ***p < 0.001. Standardized coefficients reported. Variables mean-centered prior to interaction term construction.

Model 1 only included the control variables, which explained 6.3% of the variance ($R^2 = 0.063$, F change = 7.21, $p < 0.01$). Only the years of business operation were significant ($\beta = 0.112$, $p < 0.05$). Model 2 included corporate culture and advertising investment, which increased the explanatory power of the model by a substantial margin ($R^2 = 0.437$, $\Delta R^2 = 0.374$, F change = 106.34, $p < 0.001$). Corporate culture ($\beta = 0.318$, $p < 0.001$) and advertising investment ($\beta = 0.269$, $p < 0.001$) were found to have a positive impact, thereby supporting H1 and H2, respectively. Model 3 included the level of AI adoption, which had a positive impact ($\beta = 0.213$, $p < 0.001$). The change in R^2 was 4.1% ($\Delta R^2 = 0.041$, F change = 25.12, $p < 0.001$). Model 4 included the two interaction terms, which increased the explanatory power of the model to 53.1% ($R^2 = 0.531$, $\Delta R^2 = 0.053$, F change = 17.89, $p < 0.001$). Corporate culture–AI adoption ($\beta = 0.194$, $p < 0.001$) was supported, thereby supporting H3, while the advertising investment–AI adoption interaction ($\beta = 0.153$, $p < 0.01$) was also supported, thereby supporting H4 as well. The two interaction terms explained 5.3% of the variance, thereby confirming the moderation effects of AI adoption on the two paths. The validated path coefficients are presented in Figure 2.

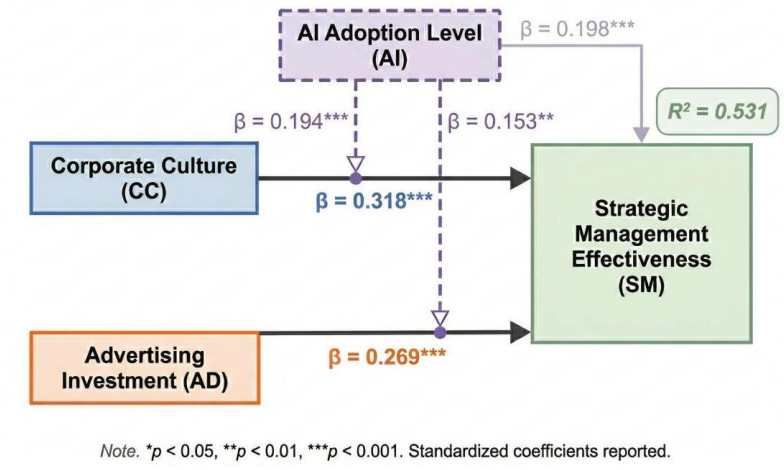

Figure 2. Validated structural model path diagram

4.3 Moderation analysis

Simple slopes analysis was used to examine high (mean plus one standard deviation) and low (mean minus one standard deviation) levels of AI adoption to determine the shape of the moderating effect. With regard to the corporate culture-strategic management relationship, the conditional slope at high levels of AI adoption was 0.467 ($p < 0.001$), which was steep, and at low levels of AI adoption, the slope dropped to 0.169 ($p < 0.05$), though still significant. In addition, the strategic conversion efficiency of corporate culture at high levels of AI adoption was nearly 2.8 times that at low levels, suggesting that AI adoption substantively enhances the conversion of corporate culture into strategic

management. This moderating effect is shown in Figure 3. The same pattern was found for the advertising investment-strategic management relationship, where the slope under high AI conditions was 0.398 ($p < 0.001$), reducing to 0.141 ($p < 0.05$) under low AI conditions, showing an amplification pattern for the corporate culture pathway. The moderating effect of advertising investment on the strategic management relationship is presented in Figure 4.

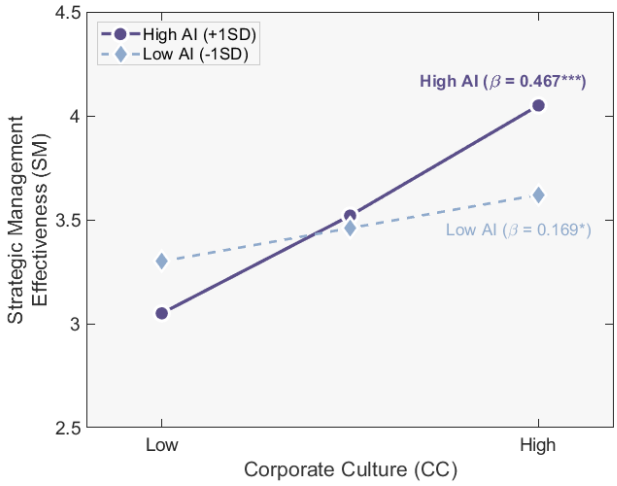

Figure 3. The moderating effect of AI adoption on the corporate culture–strategic management relationship

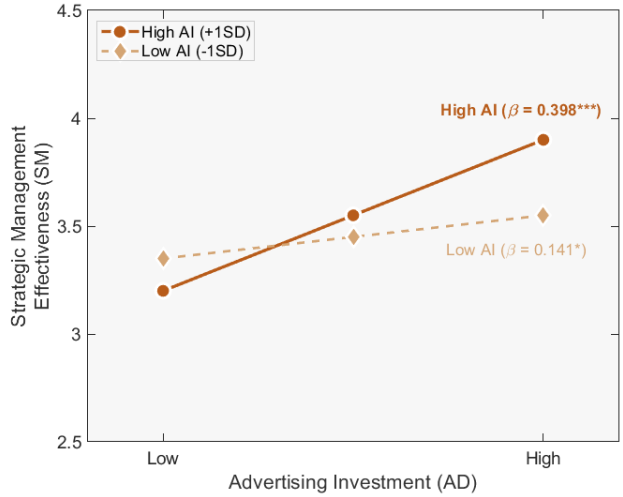

Figure 4. The moderating effect of AI adoption on the advertising investment–strategic management relationship

The interaction effect of corporate culture and AI adoption was slightly higher than that of advertising investment and AI adoption. This implies that AI has a greater strategic amplification effect on corporate culture, as a firm's internal tacit resource, than on advertising investment, as a firm's external market activity. This finding is also supported by the simple slopes results. The conditional slope for corporate culture under high AI conditions was higher than that for advertising investment. However, the gap was significantly reduced under low-AI conditions.

5. Discussion

The results for the main effects indicate that corporate culture ($\beta = 0.318$) and advertising investment ($\beta = 0.269$) positively influence the effectiveness of strategic management, with corporate culture having a greater influence than advertising investment. This is in line with the RBV, which posits that intangible resources that meet the VRIN criteria are more strategically important. Corporate culture is a more inimitable attribute than advertising investment, which is more replicable in a market context. The moderation results show that the essential finding of this study is that, while AI adoption level as an independent variable explains only 4.1% more variance, it explains 5.3% more variance via interaction terms. This suggests that the true value of AI in management lies not in its use as an independent driver of better performance but in its role as a technological contextual condition that alters the strategic importance of existing resources, thus validating

the fundamental proposition of Contingency Theory. From a computational standpoint, this moderating factor can be explained by the data processing and pattern recognition capabilities of AI systems, which allow organizations to derive strategic information from resources that would otherwise have remained underutilized without such computational infrastructure. The interaction effect between corporate culture and AI adoption (β = 0.194) was slightly greater than that between advertising investment and AI adoption (β = 0.153). Corporate culture is a deep-level tacit resource, and components such as tacit knowledge and value consensus cannot be easily transformed into implementable strategic actions. However, AI tools can help bridge this gap to implement corporate culture resources in the form of explicit strategic actions such as decision-making, thereby generating more incremental value than the optimization effect on advertising investment, which is already an explicit market activity with limited room for improvement. This is in line with the RBV theory on resource complementarity, which suggests that the more heterogeneous two resources are, the more synergistic value they can generate [11].

The above theoretical results have direct implications for Shandong SMEs' involvement in implementing large-scale high-end equipment manufacturing projects. With stronger culture-AI interaction, SMEs' focus should shift to co-developing cultural and AI capabilities, rather than simply escalating advertising expenditures. This can be done by advancing AI training in parallel with cultural development, helping employees enhance their understanding of organizational values through AI skills. Furthermore, enterprises can use AI tools to convert cultural values into quantified strategic key performance indicators, thereby establishing a direct link between cultural resources and strategic performance. The decision on the escalation of advertising expenditures should also be integrated into the aforementioned framework for the synergistic development of culture and AI, thereby preventing resource waste [12]. Although the above results provide strong empirical evidence for the proposed moderation model, several limitations should be noted in the context of the current study, which are discussed in the concluding section of the paper.

6. Conclusion

This study established and tested a moderation model examining the impact of the level of AI adoption on the relationships between corporate culture and strategic management effectiveness, and between advertising investment and strategic management effectiveness, using data collected from managers of SMEs in Shandong Province. All the hypotheses were empirically supported. The level of AI adoption had a significant moderating effect on the relationships between corporate culture and strategic management effectiveness, and between advertising investment and strategic management effectiveness. The amplification effect of corporate culture on strategic management effectiveness was stronger than that of advertising investment. This study's theoretical contribution was the integration of the Resource-Based View and the Contingency Theory to demonstrate that AI did not serve as an independent driver of performance but rather as a contextual condition that altered the strategic value of existing resources. From a practical perspective, this study suggests that a "culture first, AI enablement, advertising synergy" approach should be adopted by high-end equipment manufacturing SMEs. There are several limitations to note. Firstly, the cross-sectional nature of this study limits our ability to make causal inferences and to rule out reverse causality. Second, our sample is limited to Shandong Province, and cross-regional generalizability has yet to be verified. Third, single-source perceptual data may suffer from common method bias. Fourth, this study treats AI adoption as a unidimensional concept without distinguishing between manufacturing-oriented and marketing-oriented AI. Future research could adopt longitudinal designs to verify causal directions and cross-provincial designs to clarify the geographic boundary conditions. The inclusion of objective financial variables can also help eliminate common method bias. Dividing the AI variable into manufacturing and marketing dimensions to examine differential moderation effects can further extend the model. Including the competitive advantage variable as the mediating variable in the moderated mediation model can also reveal the underlying transmission mechanisms.

Ethical issue

The authors are aware of and comply with best practices in publication ethics, specifically regarding authorship (avoidance of guest authorship), dual submission, figure manipulation, competing interests, and compliance with research ethics policies. The authors adhere to publication requirements that the submitted work is original and has not been published elsewhere in any language.

Data availability statement

The manuscript contains all the data. However, more data will be available upon request from the corresponding author.

Conflict of interest

The authors declare no potential conflict of interest.

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