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Enhancing Innovation Capabilities: The Role of Market Orientation and Collaboration in Guangdong's IoT Sector

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Abstract

This study investigates the impact of market orientation and collaboration with supply chain members on product innovation performance in Guangdong IoT companies. Empirical analysis reveals that both dominant and reactive market orientations positively influence collaboration with supply chain members and product innovation performance. The study identifies three dimensions of innovation competency—strategic collaboration, research and development collaboration, and marketing collaboration—and highlights their mediating role in the relationship between market orientation and product innovation performance. Moreover, environmental turbulence moderates the impact of market orientation on product innovation performance, emphasizing the importance of aligning market strategies with external conditions. These findings contribute to theoretical understanding and offer practical insights for Guangdong IoT companies to enhance their innovation capabilities and drive product innovation in dynamic market environments.

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1. Introduction

1.1 Background of Study

The inception of "Smart Earth" by IBM in January 2009, later endorsed by then-US President Obama, marked the rise of the Internet of Things (IoT) as a strategic imperative globally. Simultaneously, China embarked on its IoT journey, evident from Premier Wen Jiabao's call for the "Perception China" center in 2009. China's IoT development, rooted in both policy and technological advantages, gained momentum with significant achievements in core technologies, exemplified by the development of the "Tangxin No.1" chip in 2009. While China's IoT policies and technological prowess provide a solid foundation, challenges persist, requiring a shift towards efficient and innovative economic models (Yang & Zhang, 1999; Xi'an Development Foundation, 2009). Guangdong, a frontrunner in China's IoT landscape, boasts a robust market, particularly in smart home, smart city, intelligent manufacturing, and intelligent transportation sectors. Its initiatives, such as smart city construction and IoT integration in transportation and agriculture, underscore the province's commitment to IoT-driven advancement (Sun & Zuo, 2024; Sun et al., 2024). Notably, Guangdong's IoT penetration spans various sectors, promoting economic and societal progress.

1.2 Problem Statement

The escalating complexity of technological innovation, exacerbated by global upheavals like the recent pandemic, underscores the imperative for collaborative innovation in product development (Zhao et al., 2014; Xie et al., 2016). Particularly in the dynamic IoT sector, where rapid technology obsolescence is the norm, enterprises must forge partnerships to stay relevant (Anwar, 2018). The three-year action plan for IoT infrastructure underscores the importance of collaborative innovation to enhance technological prowess and meet market demands (National Development and Reform Commission, 2021). However, existing research on Guangdong's IoT companies often lacks granularity, overlooking specific collaborative dimensions and market-oriented strategies (Zhao et al., 2019; Zhang et al., 2019). Hence, this study aims to delineate and measure innovation competence among Guangdong's IoT enterprises, offering insights into collaborative innovation dynamics and the influence of market orientation on product innovation performance.

1.3 Research Questions

The IoT industry's complex structure necessitates collaboration across the supply chain for product innovation. However, in Guangdong, such collaborations often remain transactional, lacking strategic partnerships and efficient data utilization. Scholars emphasize that market-oriented multi-agent collaboration is pivotal for innovation (Feng & Zhang, 2021). Thus, this study aims to address the following questions:

RQ1: Does market orientation positively influence product innovation performance in Guangdong's IoT companies?

RQ2: Does market orientation positively affect collaborative innovation capability in Guangdong's IoT companies?

RQ3: Does collaborative innovation capability positively impact product innovation performance in Guangdong's IoT companies?

RQ4: Does collaborative innovation capability mediate the relationship between market orientation and product innovation performance in Guangdong's IoT companies?

RQ5: Does environmental volatility moderate the impact of market orientation on product innovation performance?

1.4 Research Objectives

This research combines literature review, company visits, and interviews to analyze the impact of market orientation and collaborative innovation on product innovation performance in Guangdong's IoT companies. The objectives are:

RO1: Validate the influence of market orientation on product innovation performance.

RO2: Confirm the impact of market orientation on collaborative innovation capability.

RO3: Assess the effect of collaborative innovation capability on product innovation performance.

RO4: Investigate the mediating role of collaborative innovation capability between market orientation and product innovation performance.

RO5: Analyze the moderating effect of environmental volatility on the relationship between market orientation and product innovation performance.

1.5 Research Significance

Research on promoting enterprise performance through market orientation has been extensive, yet synergy innovation competence remains relatively underexplored, especially within Guangdong's IoT companies. Existing studies have mostly examined collaborative innovation at a broader industry level, lacking a deep analysis of how Guangdong IoT companies engage in collaborative innovation and enhance product innovation performance. Consequently, there's a scarcity of empirical studies addressing the sub-factors of innovation competence and their measurement (Sun & Zuo, 2024).

The literature search reveals a significant gap in research on synergy innovation competence, particularly in the context of Guangdong's IoT companies. Empirical exploration is essential to understand how market orientation influences product innovation performance via collaborative innovation and innovation competence. This research aims to bridge this gap by proposing a conceptual definition of "Guangdong IoT company innovation competence," developing a measurement scale, and empirically investigating its mediating role in the relationship between market orientation and product innovation performance.

In the fiercely competitive landscape, Guangdong's IoT companies face challenges from global disruptors and technological constraints. Collaborative innovation with supply chain members is crucial for enhancing product innovation performance and gaining core technological advantages. This study seeks to elucidate how Guangdong's IoT companies can leverage market orientation and collaborative innovation to navigate dynamic market environments, offering management insights for collaborative innovation strategies. By developing a measurement model for synergy innovation competence, this research aims to provide a theoretical foundation for enhancing product innovation capabilities and bolstering the IoT industry's growth.

2. Literature Review

2.1 Market Orientation

Market orientation, defined as creating exceptional customer value through analyzing customer and competitor insights, has garnered significant attention in academia and industry over the past three decades (Narver & Slater, 1990; Kandemir et al., 2006). Scholars recognize its pivotal role in providing organizations with vital information for effective decision-making in turbulent environments (Luo et al., 2005; Monferrer et al., 2015; Qiu, 2008). Two main perspectives—behavioral and cultural—shape the discourse on market orientation (Kohli & Jaworski, 1990; Narver & Slater, 1990). The behavioral view emphasizes market information acquisition, dissemination, and response, while the cultural perspective underscores its integration into organizational culture (Narver & Slater, 1990). Moreover, market orientation can be categorized into reactive and dominant orientations, reflecting a focus on current versus

future customer needs (Narver & Slater, 2004). Recent studies have delved into the nuances of market orientation, examining its impact on various aspects of organizational performance. For instance, forward-thinking market orientation influences new product development through continuous improvement, while responsive orientation impacts it through rapid trial and error (Li & Su, 2019). Additionally, market orientation's effectiveness in cross-border entrepreneurship is enhanced by local network embedding (He & Yuan, 2019). Scholars consistently find a positive correlation between market orientation and firm performance, particularly regarding product innovation (Ellis, 2006; Deshpande et al., 1993). Studies in various contexts reveal that market orientation positively influences organizational learning, innovation, and overall performance (Hu et al., 2020; Peng et al., 2019). Resource-based theory offers a lens to understand this relationship, emphasizing the strategic capabilities derived from market orientation that enhance firm performance (Barney, 1991; Murray et al., 2011).
However, some studies challenge this relationship, suggesting moderating factors like creativity, knowledge type, and competitive strength (Augusto & Coelho, 2009; Kim et al., 2013). Despite these nuances, market orientation serves as a strategic resource, fostering innovation and competitive advantage for organizations, particularly in rapidly evolving industries like IoT (Hu, 2010). Integrating market orientation with synergy innovation competence enables companies to navigate turbulent environments and achieve superior product innovation performance.

2.2 Synergy Innovation Competence

Enterprises engage in collaborative innovation by integrating ideas from collaborative environments into product development (Bucic & Ngo, 2012). To adapt to fluctuating customer demands, they enhance collaborative product development and innovation (Zhang & Yang, 2016). Scholars define synergy innovation competence as improved innovation capability resulting from cooperative relationships between research and development units (Persaud, 2005). Research has focused on constructing and strengthening synergy innovation competence. Initially, scholars advocated adopting product lifecycle management to integrate product and supply chain process innovation (Swink, 2006). Later studies emphasized innovation network characteristics (Wang & Wei, 2016), structural embeddedness (Lin et al., 2016), and internal innovation networks (Wang & Wei, 2018). Additionally, scholars investigated the role of enterprises in enhancing synergy innovation competence, revealing its positive impact on innovation openness (Luo et al., 2018). Various dimensions and measurements of synergy innovation competence exist. Persaud (2005) identified four dimensions, while Wen (2014) proposed cooperative initiative, relationship governance, internal coordination, and social capital. These frameworks influenced research on State Key Laboratories (Wang & Wei, 2018), small and medium-sized enterprises (Feng & Chen, 2015), and high-tech firms (Lin et al., 2016). Synergy innovation competence, the ability to integrate diverse market knowledge into innovation, is crucial for product innovation performance (Wang et al., 2017; Zou et al., 2017). Scholars conceptualize it as a dynamic capability, continuously transforming knowledge into new products and processes (Lawson & Samson, 2001; Agarwal & Selen, 2009). Dynamic capability theory guides research on the synergy between innovation competence and performance (Fuchs et al., 2000). Scholars argue that synergy innovation competence responds to changing environments, integrating external knowledge into innovative activities (Agarwal & Selen, 2009; Fawcett et al., 2012).

2.3 Environmental Turbulence

Environmental turbulence refers to the unpredictability and instability of changes in an organization's external environment, encompassing dynamic shifts and future fluctuations (Duncan, 1972; Miller & Friesen, 1983). Scholars conceptualize it as a combination of

environmental complexity and volatility, affecting organizational activities (Tan & Litschert, 1994; Jansen et al., 2006). This turbulence includes technological and market aspects, impacting product development (Calantone et al., 2003). Market volatility involves unpredictable changes in product demand and customer preferences, while technological volatility relates to rapid technological advancements and uncertain future developments (Lichtenthaler & Lichtenthaler, 2009; Jiang Xucan et al., 2011). Environmental turbulence comprises three dimensions: technological, market, and competitive intensity (Jaworski & Kohli, 1993; Danneels & Sethi, 2011; Feng Changli et al., 2015). It influences firms' competitive strategies, innovation capabilities, and collaborative efforts to navigate dynamic environments (Moorman & Miner, 1997; Meng et al., 2020). In studying corporate innovation performance, environmental turbulence emerges as a significant moderating variable (Dong & Zhuang, 2019; Yang & Chen, 2015). Scholars find that market volatility amplifies the impact of market orientation on innovation performance, while technological advancements influence firms' responses to competition (Hao, 2018; Atuahene Gima, 2010). Enterprises' innovation activities are embedded within their environmental context, necessitating attention to external factors (Jansen et al., 2006; Fredrickson & Laquinto, 1989). Various studies highlight environmental turbulence's positive moderating role in driving factors of innovation performance, albeit with nuanced effects across different contexts (Schilke, 2014; Wilden & Gudergan, 2015). However, contrasting views suggest that heightened turbulence may lead to conservative business practices, hindering innovation (Hannan & Freeman, 1984). Given the significance of environmental characteristics, understanding their moderating effects on innovation performance is crucial. Future research should delve into the specific mechanisms through which environmental turbulence influences the relationship between market orientation, innovation competence, and product innovation performance.

2.4 Product Innovation Performance

Product innovation performance, integral to enterprise innovation, lacks a unified definition, delineated variously by scholars. Scholars like Hagedoorn and Cloodt (2003) define it broadly as the comprehensive output from innovation endeavors or narrowly as the market response to new products. It mirrors a company's ability to innovate and its contribution to society (Gima et al., 2005). It encompasses not only short-term product development prowess but also long-term societal impact (Drucker, 1993). Research emphasizes measuring it through product innovation process and output performance (Gao et al., 2004). Factors affecting product innovation performance are diverse. Strategic orientation, a reflection of a company's value in the market, directs resource investment priorities (Dawes, 2000). Technology and market orientations within strategic orientation are crucial (Zhang Xiao and Hu Lina, 2012). Market orientation involves understanding and fulfilling customer needs (Narver&Slater, 1990), while technology orientation emphasizes technological advancement (Gatignon&Xuereb, 1997). Empirical studies suggest positive correlations between strategic orientation and product innovation performance (Xue Lei et al., 2011). However, ongoing research seeks to identify key factors influencing product innovation, considering the dynamic business environment and the imperative of enhancing internal innovation efficiency (Deng Xincai et al., 2017).

2.5 Limitations and Research Opportunities of Existing Literature

The literature on market orientation has developed systematically over the past three decades, with scholars extensively exploring its impact on corporate performance. While most studies support a positive relationship between market orientation and performance, inconsistencies exist, and the direct effect is sometimes elusive, moderated, or mediated by various factors (Gatignon & Xuereb, 1997). However, scant research exists on this relationship in the context of Guangdong IoT companies. Therefore, this study aims to delve into how market orientation

strategies in these companies affect their product innovation performance, potentially mediated by synergy innovation competence (Sun & Zuo, 2024). Regarding synergy innovation competence, scholars have varied perspectives, suggesting a need for context-specific examination. Focusing on Guangdong IoT companies, this study aims to assess their synergy innovation competence within supply chain collaborations (Deng et al., 2017). While prior research provides a foundation for understanding innovation competence, refinement and expansion specific to the IoT industry are necessary (Gatignon & Xuereb, 1997). This study defines IoT companies as those involved in developing, producing, and operating IoT products, emphasizing collaboration with supply chain members for innovation. It identifies three dimensions of innovation competence: strategic collaboration, research and development collaboration, and marketing collaboration (Sun et al., 2024). Incorporating environmental volatility into the research framework, including both market and technological volatility, distinguishes this study, given the technology-intensive nature of the IoT industry (Zhang & Hu, 2012).

2.6 Theoretical Basis

The theoretical basis of this study draws from resource-based theory, dynamic capability theory, and strategic matching theory. Resource-based theory, originating from Penrose's work in the 1950s and Wernerfelt's seminal publication in 1984, emphasizes the significance of internal resources and capabilities for achieving competitive advantage (Wernerfelt, 1984; Penrose, 1959). According to Barney and Clark (2007), valuable, rare, inimitable, and nonsubstitutable resources contribute to sustained competitive advantage. This theory underscores the importance of tangible and intangible resources in enhancing firm performance (Barney & Clark, 2007). Notably, internal factors, rather than industry-level factors, determine a company's profits (Wernerfelt, 1984). Dynamic capability theory complements resource-based theory by addressing the adaptability of firms in dynamic environments (Teece et al., 1997). Teece et al. (1997) propose that dynamic capabilities enable firms to continuously create, expand, and reallocate resources to seize opportunities and maintain competitiveness. Dynamic capabilities, integrated with strategic vision, aid firms in product development and market responsiveness (Rumelt, 2011). In dynamic environments, firms must reorganize and innovate to sustain competitive advantage (Teece & Pisano, 1994).
Strategic matching theory, a cornerstone of strategic management, emphasizes the alignment between corporate strategy and the external environment (Ginsberg & Venkatraman, 1985). Scholars assert that strategic alignment positively influences firm performance, particularly in turbulent environments (Zajac et al., 2010; Lucas et al., 2001). Strategic matching involves synchronizing internal resources, external conditions, market demands, and management strategies to achieve organizational goals (Xu et al., 2020). This theory highlights the importance of resource integration, environmental adaptation, and strategic coherence for organizational success. In summary, the theoretical framework of this study integrates resource-based theory, dynamic capability theory, and strategic matching theory to examine the relationship between market orientation, innovation competence, and firm performance in the context of Guangdong IoT companies. Through this interdisciplinary approach, the study aims to contribute to the understanding of strategic management in dynamic environments.

2.7 Theoretical Model

The theoretical model of this study, depicted in Figure 2-1, integrates resource-based theory, dynamic capability theory, and strategic matching theory to explore the causal relationship between market orientation, innovation competence, and product innovation performance (Sun & Zuo, 2024).

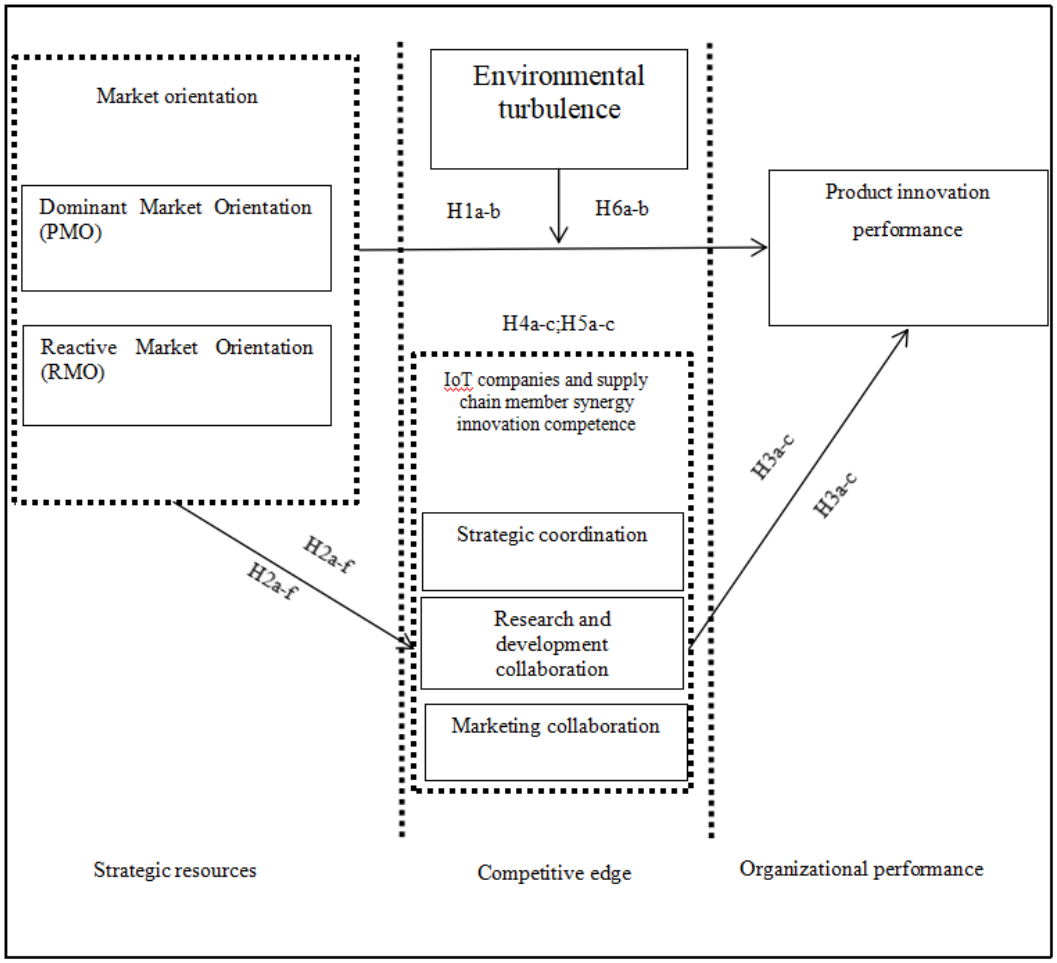

Figure 2-1 Theoretical Model

Resource-based theory, pioneered by Penrose in the 1950s and Wernerfelt in 1984, emphasizes the role of internal resources and capabilities in achieving competitive advantage (Wernerfelt, 1984; Penrose, 1959). Dynamic capability theory extends this perspective by focusing on firms' ability to adapt and innovate in dynamic environments (Teece et al., 1997). Strategic matching theory complements these frameworks by emphasizing the alignment between corporate strategy and the external environment (Ginsberg & Venkatraman, 1985). The research hypotheses delineate the expected relationships between market orientation, synergy with supply chain members, and product innovation performance. For instance, H1a posits that dominant market orientation positively influences product innovation performance, while H3a suggests that strategic synergy with supply chain members enhances product innovation performance. Moreover, the mediating roles of synergy (H4a-c) and environmental turbulence (H6a-b) in the relationship between market orientation and product innovation performance are explored (Sun & Zuo, 2024).

(1) H1a: Dominant market orientation positively impacts product innovation performance.
(2) H1b: Reactive market orientation positively affects product innovation performance.
(3) H2a: Dominant market orientation positively influences the strategic synergy between IoT companies and supply chain members.
(4) H2b: Reactive market orientation positively affects the strategic synergy between IoT companies and supply chain members.
(5) H2c: Dominant market orientation positively impacts the research and development collaboration between IoT companies and supply chain members.
(6) H2d: Reactive market orientation positively affects the research and development collaboration between IoT companies and supply chain members.

(7) H2e: Dominant market orientation positively impacts the marketing synergy between IoT companies and supply chain members.
(8) H2f: Reactive market orientation positively affects the marketing synergy between IoT companies and supply chain members.
(9) H3a: Strategic synergy between IoT companies and supply chain members positively impacts product innovation performance.
(10) H3b: Research and development collaboration between IoT companies and supply chain members positively impacts product innovation performance.
(11) H3c: Marketing synergy between IoT companies and supply chain members positively affects product innovation performance.
(12) H4a: Strategic synergy plays a mediating role in the impact of dominant market orientation on product innovation performance.
(13) H4b: Research and development collaboration plays a mediating role in the impact of dominant market orientation on product innovation performance.
(14) H4c: Marketing synergy plays a mediating role in the impact of dominant market orientation on product innovation performance.
(15) H5a: Strategic synergy plays a mediating role in the impact of reactive market orientation on product innovation performance.
(16) H5b: Research and development collaboration plays a mediating role in the impact of reactive market orientation on product innovation performance.
(17) H5c: Marketing synergy plays a mediating role in the impact of reactive market orientation on product innovation performance.
(18) H6a: The impact of market orientation dominated by positive regulation of environmental turbulence on product innovation performance.
(19) H6b: The impact of negative regulatory market orientation on product innovation performance in response to environmental turbulence.

In summary, the theoretical framework and research hypotheses provide a structured approach to investigate the complex interplay between market orientation, innovation competence, and product innovation performance in Guangdong IoT companies. Through empirical analysis, this study aims to contribute to the understanding of strategic management in dynamic environments.

3. Methodology

3.1 Research Method

The methodology employed in this study encompasses various research methods to ensure a comprehensive exploration of the research questions. Firstly, the literature research method was utilized, involving an extensive review of existing literature on topics such as collaborative innovation capability among IoT companies (Sun et al., 2024). This approach helped identify research gaps and formulate theoretical frameworks based on previous findings (Sun & Zuo, 2024). Secondly, in-depth interviews were conducted with management personnel from typical Guangdong IoT companies to gain insights into the practical challenges and operational dynamics within the industry (Sun & Zuo, 2023). These semi-structured interviews provided valuable qualitative data to complement the literature review findings. Thirdly, a questionnaire survey method was employed, wherein a custom innovation competency scale for Guangdong IoT companies was developed to align with the research objectives (Sun & Zuo, 2023). While mature scales from existing literature were utilized for other variables, the questionnaire was distributed online and administered to selected respondents via WeChat. Regarding data analysis, SPSS 21.0 and AMOS 22.0 were utilized for processing and analysis. Initially, descriptive statistical analysis was conducted to summarize the collected data, including variables such as enterprise role, establishment years, property rights, and size. Subsequently,

a multivariate test of variance was performed to examine the impact of control variables on the major variables. Multicollinearity tests were conducted to assess correlated relationships between variables. Validity testing comprised content, convergent, and discriminant validity tests. Content validity was ensured through collaboration with a marketing professor and reference to authoritative scales (Sun & Zuo, 2023). Convergent validity was assessed using the Kaiser-Meyer-Olkin (KMO) and Bartlett's test, followed by exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Finally, hierarchical regression analysis was employed to evaluate the validity of direct, mediating, and moderating effects within the model.

3.2 Development of Scales

In the examination of market orientation, this study embraced a scale derived from Narver and Slater (2004), comprising 15 items. These items encapsulate facets such as enterprises' endeavors in anticipating future market trends, innovating products notwithstanding potential obsolescence risks, and fostering collaboration with leading users (Narver & Slater, 2004). Additionally, the development process of the scale for IoT companionship innovation competence meticulously adhered to Churchill's (1979) guidelines. First, a foundation was laid through advanced research, including in-depth interviews with key management personnel from typical Guangdong IoT companies, revealing insights into collaborative innovation within the IoT industry (Shahzad et al., 2016). The interviews underscored strategic, research and development, and marketing collaborations as pivotal dimensions of IoT company innovation competence (Chen Liping, 2014; Ren nan et al., 2018). Following interviews, the scale's definition and dimension division were meticulously crafted. Strategic collaboration was defined as a cohesive partnership with shared visions and risks among enterprises and supply chain members, echoing extant literature (Jin et al., 2014). Research and development collaboration was delineated as joint endeavors in technology innovation and knowledge exchange, aligning with findings by Li and Lu (2017). Finally, marketing collaboration, emphasizing targeted market communication and end-user engagement, was informed by existing scholarship (Chen Jing, 2013). Subsequently, measurement items were refined through pre-surveys and expert consultations, resulting in a pool of 29 items for IoT innovation competence (Wen ke et al., 2014). This process encompassed aspects such as strategic coordination, research and development synergy, and marketing collaboration (Cao & Zhang, 2011). Further, scales for environmental turbulence and product innovation performance were developed. Drawing from Kohli and Jaworski (1993) and Yang and Chen (2015), the environmental turbulence scale comprised eight items measuring factors such as technological volatility and evolving customer preferences (Kohli & Jaworski, 1993; Yang & Chen, 2015). Similarly, the product innovation performance scale, rooted in Xie Xuemei et al. (2015), assessed enterprises' success rates, speed, and technological prowess in new product development (Xie et al., 2015). These scales provided robust metrics for gauging environmental influences and organizational performance (Jie et al., 2015). Lastly, control variables encompassing enterprises' industry roles, establishment periods, property rights, and scales were identified, laying a comprehensive groundwork for subsequent analyses (Yang & Li, 2017).

3.3 Questionnaire Survey

The questionnaire survey for this study adhered to rigorous design and implementation procedures to ensure data accuracy and reliability. Drawing on established methodologies, the questionnaire was crafted with input from reputable research institutions and refined through feedback from management experts and industry practitioners. This iterative process helped enhance the questionnaire's content validity and suitability for the study's objectives (Law et al., 2019; Sun & Zuo, 2023). To minimize response bias and ensure data integrity, the

questionnaire was distributed using the Questionnaire Star platform, which restricts multiple submissions from the same IP or device, thus safeguarding the authenticity of responses (Sun et al., 2024). The survey was disseminated from September 1, 2023, to November 1, 2023, targeting IoT companies primarily in the Guangdong region. Leveraging the network of the Guangdong IoT Companies Association, questionnaires were distributed to member units, resulting in a robust sample size. Out of 400 questionnaires distributed, 336 valid responses were obtained, yielding an impressive effective response rate of 87.04% (Sun et al., 2024; Sun, 2022).

3.4 Scale Test

The study conducted a comprehensive examination of the Synergy Innovation Competence Scale, specifically focusing on factor analysis, validity testing, and reliability testing to ensure the robustness of the measurement instrument. Initially, exploratory factor analysis (EFA) was performed on 160 randomly selected questionnaires using SPSS 21.0 software. The results revealed a KMO value of 0.928 and a significant Bartlett's test ($p < 0.01$), indicating suitability for factor analysis. Through orthogonal rotation, a three-factor structure was identified, explaining 77.421% of the variance. Further refinement involved removing items with cross-loadings, resulting in a cumulative explained variance of 79.564%. Subsequently, validity testing, including content and structural validity, was conducted using AMOS 22.0 software on 176 questionnaires. Confirmatory factor analysis (CFA) indicated satisfactory overall fit coefficients ($x^2/df = 2.264$, CFI = 0.911, TLI = 0.901, RMSEA = 0.076, NFI = 0.908). Moreover, the scale demonstrated good convergent validity and combination reliability, with standardized factor loadings exceeding 0.6 and composite reliability values above 0.8. Discriminant validity was established through correlation analysis, showing significant interrelationships ($p < 0.001$) with correlation coefficients lower than the square root of the average variance extracted (AVE), indicating adequate discriminant validity. Reliability testing further affirmed the scale's consistency and stability. Cronbach's α coefficients exceeded 0.95 for the overall scale and individual factors, demonstrating high internal consistency. Additionally, reliability testing on related constructs, such as market orientation, environmental turbulence, and product innovation performance, yielded Cronbach's α values above 0.91, further supporting the scale's reliability. In conclusion, the Synergy Innovation Competence Scale demonstrated sound psychometric properties, including factorial validity, convergent validity, discriminant validity, and reliability, making it a robust tool for assessing innovation competence in the context of IoT companies.

4. Results and Discussion

4.1 Interviewee Summary

The official questionnaire survey targeted IoT companies in the Guangdong region, conducted from September 1, 2023, to November 1, 2023. Out of 400 distributed questionnaires, 386 were collected, with 336 deemed valid after screening, resulting in an effective response rate of 87.04%. Before analyzing empirical data, descriptive statistics were performed on various aspects of the surveyed companies, including their roles, years of establishment, property rights, and scale within the IoT industry. Regarding the roles within the IoT industry, the survey found that 19.048% were IoT accessory suppliers, 41.071% were IoT device providers, 30.357% were IoT application developers, and 9.524% were IoT system integrators. In terms of establishment period, 13.690% of companies had been established for 7-9 years, 22.619% for 10-20 years, and 16.667% for over 20 years. The majority of companies surveyed (62.500%) were private enterprises, while foreign-funded enterprises accounted for 10.119%. Further analysis of the nature of property rights revealed that 26.190% of companies had property rights of 20-99, followed by 19.643% with property rights of 1000-4999. The scale of

companies varied, with 9.524% having a scale of 20-99, 10.119% having a scale of 100-299, and 13.690% having a scale of 300-499. Companies with larger scales were also represented, with 19.643% having a scale of 1000-4999 and 16.667% having a scale of over 5000. These descriptive statistics provide a comprehensive overview of the characteristics of the surveyed IoT companies, setting the foundation for further analysis and discussions.

4.2 Multivariate Analysis of Variance and Multicollinearity Test

Before proceeding with formal data analysis, it is essential to assess whether control variables such as industry role, establishment years, property rights, and enterprise size significantly influence the main variables of the study. A multivariate analysis of variance (MANOVA) was conducted on the overall sample, revealing no significant relationship between the main variables: market orientation, Guangdong IoT company innovation competence, and product innovation performance, and the control variables. The p-values exceeded 0.05, indicating no need to distinguish samples for subsequent testing.

Table 4-1: Multivariate ANOVA Results

Control variable	Main variables	Mean square	F
	Market orientation	2.667	1.286
Industry Role	Guangdong IoT company innovation competence	2.702	3.253
	Product innovation performance	3.169	1.367
	Market orientation	1.017	2.410
Establishment period	Guangdong IoT company innovation competence	0.911	1. 141
	Product innovation performance	1.466	1.242
	Market orientation	1.507	3.571
Nature of Property Rights	Guangdong IoT company innovation competence	3.602	4.513
	Product innovation performance	11.311	9.582
	Market orientation	0.009	0.022
Enterprise scale	Guangdong IoT company innovation competence	0.888	1. 112
	Product innovation performance	3.81	3.228

Table 4-2: Multicollinearity Test in the Model

Variables	Non standardized coefficient		Standard coefficient	t	Sig.	Collinearity statistic	
	B	SE	β			SE	VIF
Industry Role	0.076	0.054	0.203	1.542	0.667	0.439	1.657
Establishment period	0.004	0.085	0.003	0.042	0.966	0.727	1.376
Nature of Property Rights	0.095	0.047	0.118	2.035	0.043	0.905	1.105
Enterprise scale	0.089	0.046	0.160	1.922	0.056	0.442	2.263
Dominant market orientation	0.359	0.084	0.260	4.248	0.000	0.818	1.223
Reactive market orientation	0.323	0.080	0.265	4.054	0.000	0.716	1.396
Strategic coordination	0.149	0.094	0.140	1.578	0.116	0.387	2.582
Research and development collaboration	0.072	0.090	0.070	0.806	0.422	0.400	2.498
Marketing collaboration	0.295	0.093	0.259	3.169	0.002	0.458	2.182

Furthermore, a multicollinearity test was performed to ascertain if there was high correlation among the main variables in the causal relationship model, potentially impacting data analysis results. Results from SPSS 21.0 software indicated that the Variance Inflation Factor (VIF) values ranged from 1.105 to 2.582, well below the threshold of 10, suggesting no issues of multicollinearity. Similarly, tolerance values ranging from 0.387 to 0.905, exceeding the threshold of 0.1, further confirmed the absence of multicollinearity among the main variables. These findings validate the robustness of the data analysis model, indicating that the main variables in the study operate independently of the control variables and are not unduly influenced by multicollinearity issues. Thus, subsequent data analysis can proceed with confidence in the reliability of the results.

4.3 The Impact of Market Orientation on Product Innovation Performance

The impact of market orientation on product innovation performance in Guangdong IoT companies was investigated through regression analysis. Control variables including industry roles, establishment years, property rights, and enterprise size were incorporated. Regression analysis revealed that both subdimensions of market orientation—dominant and reactive—positively influenced product innovation performance significantly. The inclusion of explanatory variables in Model 1 resulted in significant improvements in R^2 and F-values ($p < 0.001$), supporting hypotheses H1a and H1b.

Table 4-3 Regression Analysis of Market Orientation on Product Innovation Performance

Variable	Model 1	Model 2	Model 3
Constant term	3.890***	1.161***	1.355***
Control variable			
Industry Role	.022	.062	.109
Establishment period	.118	.117	.011
Nature of Property Rights	.182**	.163**	.137*
Enterprise scale	. 105+	.091+	. 114*
Explanatory variables			
Dominant market orientation		.550***	
Dominant market orientation			.760***
Dominant market orientation			
R^2	.089	.242	.280
Adjusted R^2	.069	.221	.261
F	4.487*	31.620***	34.186***

The study's empirical findings suggest that Guangdong IoT companies adopt dominant and reactive market orientations, both of which impact product innovation performance. Regression analysis indicated significant positive impacts ($\beta = 0.550$ and 0.760, respectively) of dominant and reactive market orientations on product innovation performance ($p < 0.001$). Reactive market orientation was found to have a more direct effect on product innovation performance, aligning with the operational status of Guangdong IoT companies. The research underscores the importance of market orientation in enhancing product innovation performance. Reactive market orientation, focusing on understanding and rapidly responding to explicit customer needs, facilitates targeted marketing, reduces risks associated with new product launches, and ultimately enhances new product innovation performance. In contrast, dominant market orientation allows companies to explore and predict future customer needs, paving the way for technological leadership and long-term improvement in product innovation performance. While prior research has yielded mixed findings on the relationship between market orientation and new product development performance, this study highlights the significance of reactive market orientation in driving innovation performance. It emphasizes the need for companies to cultivate awareness and responsiveness to existing and future customer needs, fostering stable growth in product innovation performance. Moreover, reactive market orientation enables companies to adapt to explicit customer needs through innovative improvements, reducing the risks associated with new product launches and increasing market adaptability. By focusing on understanding and responding to explicit customer needs, companies can effectively innovate, reduce risks, and enhance product innovation performance.

4.4 The Impact of Market Orientation on the Innovation Competence of Guangdong IoT Companies

Regression analysis was employed to examine the impact of market orientation on the innovation competence of Guangdong IoT companies. The results revealed significant positive

effects of both dominant and reactive market orientations on strategic collaboration, research and development (R&D) collaboration, and marketing collaboration.

Table 4-4 Regression Analysis of Market Orientation on Innovation Competence in Guangdong IoT Companies

Variable	Strategic C.			R&D C.			Marketing C.		
	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9
Constant	4.359***	2.078***	2.632***	4.410***	2.097***	2.681***	4.374***	2.639***	2.017***
C.V.									
Industry Role	.028	.016	.034	.065	.053	.079	.041	.026	.039
Establishment period	. 124	.123	.051	.037	.036	-.036	.119	.118	.019
Nature of Property Rights	.097+	.081	.059	.094	.078	.056	.117**	.106	.067
Enterprise scale	.039	.027	.045	.074	.062	.080	.039	.030	.047
E.V.									
Dominant market orientation		.760***			.766***			.705***	
Reactive market orientation			.715***			.695***			.741***
Model statistics									
R^2	.064	.184	.164	.067	.182	.160	.088	.168	.303
Adjusted R^2	.043	.162	. 141	.046	.159	.137	.068	.145	.284
F	3.121*	28.211***	21.132***	3.269*	38.073***	24.925***	4.418**	27.364***	35.810***

Regardless of the type of market orientation adopted, both dominant and reactive orientations had a significant positive impact on strategic, R&D, and marketing collaborations. This implies that irrespective of their focus—whether on technological advancement or customer satisfaction—Guangdong IoT companies benefit from strong collaborative relationships within their supply chains. Strategic collaboration, in particular, emerged as a critical factor for these companies, suggesting the importance of establishing long-term partnerships with suppliers and channel partners to achieve mutual benefits. For companies adopting dominant market orientation, integration of technical knowledge and market information is crucial for achieving industry-leading technological levels. On the other hand, those with reactive market orientation must prioritize marketing collaboration to collect market information and iterate products based on customer demands. This underscores the importance of adaptive innovation strategies aligned with market orientation. Market orientation plays a vital role in enhancing innovation capabilities by stimulating awareness, promoting cross-functional collaboration, and facilitating learning within the enterprise. It enables companies to accurately predict market trends, develop unique products, and maintain a competitive edge. Moreover, the correlation between market orientation and innovation competence may vary across industries and company sizes, with market orientation being particularly crucial in highly competitive sectors. Market orientation is closely linked to synergy innovation competence in enterprises, driving innovation awareness, collaboration, and adaptation to market changes. Strengthening market orientation alongside innovation strategies is essential for maintaining competitiveness and achieving success in dynamic market environments.

4.5 The Impact of IoT Company Innovation Competence on Product Innovation Performance

The study focused on exploring the dimensions and scale development of innovation competency within Guangdong IoT companies. It rigorously followed established procedures for developing and testing a new scale, revealing three dimensions: strategic collaboration, research and development (R&D) collaboration, and marketing collaboration, comprising a total of 28 items. Strategic collaboration involved establishing cooperative relationships, joint risk-sharing, and mutual communication. R&D collaboration included technical joint research, product information sharing, and meeting technical standards. Marketing collaboration encompassed communication on market demand, end-user demand prediction, and joint promotion. Regression analysis was conducted to investigate the impact of these dimensions

on product innovation performance, with industry role, establishment period, property rights nature, and enterprise size as control variables. The results demonstrated significant improvements in R^2 and F-values across all models, indicating a positive influence of the three innovation competency dimensions on product innovation performance. Hypotheses H3a, H3b, and H3c were supported.

Table 4-5 Regression Analysis of Strategic, R&D, and Marketing Collaboration on Product Innovation Performance

Variable	Model 1	Model 2	Model 3	Model 4
Constant	3.890***	2.266***	1.331***	1.054***
C.V.				
Industry Role	.022	.079	.138*	.087
Establishment period	.118	.105	.049	.038
Nature of Property Rights	.182**	.147*	.113*	.109*
Enterprise scale	. 105+	.078	.082	.081
E.V.				
Strategic coordination		.452***		
Research and development collaboration			.368***	
Marketing collaboration				.585***
Model statistics				
R^2	.089	.210	.329	.350
Adjusted R^2	.069	.189	.311	.325
F	4.487*	22.733***	27.887***	23.862***

Empirical analysis revealed significant positive effects (β values of 0.452, 0.368, and 0.585, all at P<0.001) of all three dimensions of IoT company innovation competency on product innovation performance. This underscores the importance of deep collaboration with supply chain members at strategic, R&D, and marketing levels to meet end-user needs effectively, leading to enhanced market returns and shortened innovation cycles. External collaborative innovation, exemplified by Silicon Valley, fosters innovation through partnerships between enterprises, universities, and research institutions, offering insights for establishing multi-subject collaborative innovation models. Similarly, internal collaborative innovation within enterprises promotes cross-departmental resource sharing and information exchange, vital for achieving innovation goals and reducing costs. Collaboration not only enhances innovation capabilities but also reduces innovation costs through technology and market resource interactions, improved cross-departmental work, and knowledge transfer. Consequently, modern enterprises should prioritize improving business processes, reducing communication barriers, and strengthening cooperation to enhance innovation performance.

4.6 The Mediating Effect of IoT Companionship Innovation Competence

In examining the mediating effect of Guangdong IoT company innovation competence, the study employed regression analysis and Bootstrap sampling method. Results from Model 2, Model 3, and Model 4 indicated that the introduction of three sub-dimensions of innovation competence as mediating variables reduced the impact of dominant market orientation on product innovation performance (β values decreased from 0.550 to 0.290, 0.355, and 0.205 respectively, all at p<0.001). Similarly, for reactive market orientation, the β values decreased from 0.760 to 0.523, 0.588, and 0.438 respectively (all at p<0.001). These findings supported hypotheses H4a, H4b, H4c, H5a, H5b, and H5c.

Table 4-6 Regression Analysis Results of Guangdong IoT Company Innovation Competence Mediation

Variable	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8
Constant	1.161***	.450***	.628***	-.131***	1.355***	.485***	.694***	.480***
C.V.								
Industry Role	.062	.086	.027	.076	.109	.104	.038	.072
Establishment period	.117	.075	.108	.059	.011	-.006	.020	.003
Nature of Property Rights	.163**	.136**	. 144**	. 112*	.137*	. 108+	. 113+	.098+
Enterprise scale	.091+	.082	.075	.076	. 114*	.099+	.094+	.093+
E.V.								
Dominant market orientation	.550***	.290***	.355***	.205***				
Reactive market orientation					.760***	.523***	.588***	.438***
Mediating variables								
Strategic coordination		.342***				.331***		
R & D collaboration			.254***				.247***	
Marketing collaboration				.490***				.434***
Model statistics								
R^2	.242	.327	.293	.396	.280	.362	.329	.381
Adjusted R^2	.221	.305	.269	.375	.261	.340	.307	.361
F	31.620***	44.653***	42.477***	39.738***	34.186***	47.087***	44.807***	48.605***

Further analysis using Bootstrap sampling method confirmed the mediation effects, with confidence intervals excluding zero. Strategic coordination, R&D collaboration, and marketing collaboration were identified as significant mediators in both dominant and reactive market orientations. The proportions of the mediating effects ranged from 31.2% to 62.7%.

Table 4-7 Bootstrap Results for Strategic, R&D, and Marketing Collaboration as Mediators

Path	Mediating variables	Efect	BootSE	BootILCI	BootULC
Leading market orientation →	Strategic coordination	0.260	0.028	0. 144	0.378
Product innovation performance	R & D collaboration	0.195	0.026	0. 121	0.275
	Marketing collaboration	0.345	0.031	0.196	0.491
Reactive market orientation →	Strategic coordination	0.237	0.025	0. 121	0.366
Product innovation performance	R & D collaboration	0.171	0.028	0.101	0.250
	Marketing collaboration	0.322	0.023	0.151	0.478

The study elucidated the significance of collaborative innovation within the IoT industry, involving entities such as enterprises, governments, universities, and research institutions. Collaborative innovation facilitates resource sharing and integration, leading to the construction of new models and mechanisms. Specifically, the formation of synergy innovation competence between IoT companies and supply chain members enhances product innovation performance by integrating external resources, co-creating brands, and improving market satisfaction and patent conversion rate. Scholars have identified barriers to collaborative innovation in the IoT, including system integration, standardization, cost, and technological challenges (Zhao et al., 2019; Zhang et al., 2019). Strategies for overcoming these barriers include strengthening cooperation among stakeholders, improving policies, creating trust mechanisms, and enhancing security guarantees. Additionally, scholars advocate for a multidisciplinary collaborative innovation platform, people-oriented mechanisms, and flexible agreements to promote collaborative innovation in the IoT industry. Innovative models like the "Innovation System Element Linkage Method (LAFIS)" emphasize the role of government in fostering collaboration among various stakeholders. This approach highlights the need to enhance collaborative innovation within and between subsystems of the IoT industry, as well as among different entities, environments, and functions. Collaborative innovation is pivotal for the development of the IoT industry, driving technological advancements, resource integration, and performance improvement. Effective collaboration requires addressing

barriers, implementing supportive policies, and fostering trust among stakeholders, ultimately contributing to the sustainable growth of the IoT ecosystem.

4.7 The Moderating Effect of Environmental Turbulence

The study investigated the moderating effect of environmental turbulence on the relationship between market orientation and product innovation performance in Guangdong IoT companies. Regression analysis results revealed significant interactions between market orientation, environmental turbulence, and product innovation performance. For dominant market orientation, introducing environmental turbulence as a moderating variable (Model 3) yielded a coefficient of -0.176 ($p<0.001$), while including the interaction term (Model 4) resulted in a coefficient of 0.121 ($p<0.001$). Similarly, for reactive market orientation, the coefficients were -0.109 ($p<0.001$) and -0.153 ($p<0.001$) respectively. These findings supported hypotheses H6a and H6b.

Table 4-8 Moderating Effect of Environmental Turbulence on Dominant Market Orientation and Product Innovation Performance

Variable	Model 1	Model 2	Model 3	Model 4
Industry Role	.022	.062	0.107	0.048
Establishment period	.118	.117	.026	.059
Nature of Property Rights	.182**	.163**	.118*	. 112*
Enterprise scale	. 105+	.091+	.101*	.076
Dominant market orientation		.550***	.552***	.553***
Environmental turbulence			-.176***	-.189***
Dominant market orientation x Environmental turbulence				. 121***
R^2	.089	.242	.269	.379
Adjusted R^2	.069	.221	.250	.358
F	4.487*	31.620***	12.367***	19.628***

Table 4-9 Moderating Effect of Environmental Turbulence on the Relationship Between Reactive Market Orientation and Product Innovation Performance

Variable	Model 1	Model 2	Model 3	Model 4
Industry Role	.022	.109	0.011	0.116
Establishment period	.118	.011	.092	.005
Nature of Property Rights	.182**	.137*	.108	. 112*
Enterprise scale	. 105+	. 114*	.117	. 144**
Reactive market orientation		.760***	.773***	.724***
Environmental turbulence			-.109***	. 112***
Reactive market orientation x Environmental turbulence				-0.153***
R^2	.089	.280	.219	.271
Adjusted R^2	.069	.261	.197	.251
F	4.487*	34.186***	14.697***	18.595***

In graphical representation, the slope of the regression lines indicated that the impact of market orientation on product innovation performance varied with environmental turbulence levels. Specifically, in highly turbulent environments, dominant market orientation had a stronger positive impact on product innovation performance, while reactive market orientation's impact weakened. Environmental turbulence, defined as the speed and unpredictability of external changes, encompasses market demand shifts, customer preferences, technological updates, and shortened product lifecycles. Despite posing challenges, turbulent environments also present opportunities for innovation and competitive advantage. Dynamic capabilities, rooted in resource acquisition, integration, and utilization, play a crucial role in navigating such environments. Studies have shown that dynamic capabilities are more effective in highly volatile environments, enabling firms to identify opportunities, create, and upgrade resources, thus enhancing organizational performance.

Environmental turbulence moderates the relationship between market orientation and product innovation performance in Guangdong IoT companies. Understanding and adapting to dynamic environments through dynamic capabilities are essential for achieving innovation and maintaining competitiveness. Dynamic capabilities are particularly valuable in highly turbulent environments, where they enable firms to capitalize on opportunities and drive innovation effectively. These findings contribute to the understanding of how firms can leverage market orientation and dynamic capabilities to thrive in dynamic business landscapes.

4.8 Summary of Hypothesis Testing Results

The empirical analysis supported all 19 hypotheses. For instance, dominant and reactive market orientations positively impacted product innovation performance (H1a, H1b). Additionally, these orientations positively influenced strategic synergy (H2a, H2b), R&D collaboration (H2c, H2d), and marketing synergy (H2e, H2f) between IoT companies and supply chain members. Moreover, the strategic synergy, R&D collaboration, and marketing synergy positively affected product innovation performance (H3a, H3b, H3c). Furthermore, mediating roles were observed for strategic synergy (H4a, H5a), R&D collaboration (H4b, H5b), and marketing synergy (H4c, H5c) in the impact of market orientations on product innovation performance. Lastly, environmental turbulence moderated the relationship between market orientation and product innovation performance (H6a, H6b).

5. Conclusions

The Internet of Things (IoT) industry in China, as a strategic emerging sector, plays a pivotal role in global technological and economic advancement. However, despite its significance, the Chinese IoT industry faces challenges such as inadequate core technology patents and immature business models. This study focuses on the innovation capabilities of Guangdong IoT companies and their collaboration with supply chain members to enhance product innovation performance. Empirical research identified three dimensions of innovation competency: strategic collaboration, research and development (R&D) collaboration, and marketing collaboration, each positively impacting product innovation performance. Both dominant and reactive market orientations positively influenced collaboration with supply chain members and product innovation performance. Additionally, collaboration with supply chain members mediated the relationship between market orientation and product innovation performance. Environmental turbulence moderated the impact of market orientation on product innovation performance, highlighting the importance of adapting market strategies to external conditions. This study contributes theoretically by delving into the interplay between market orientation, collaboration with supply chain members, and product innovation performance in Guangdong IoT companies. It refines the concept of synergy innovation competence within the context of IoT product innovation and provides a reliable measurement scale for its assessment. By exploring the mediating role of collaboration with supply chain members, it sheds light on the mechanisms through which market orientation influences product innovation performance. Moreover, the inclusion of environmental turbulence expands existing knowledge on the contextual factors affecting the relationship between market orientation and product innovation performance. Practically, this study underscores the importance for Guangdong IoT companies to leverage market orientation strategies and cultivate collaborative innovation capabilities with supply chain members to enhance product innovation performance. It advocates for a deeper understanding of market demand, integration of innovative resources from supply chain members, and dynamic alignment of market strategies with external environmental conditions. By adopting progressive or disruptive innovation approaches based on market and technological turbulence levels, IoT companies can better navigate the competitive landscape and drive product innovation. Despite its contributions, this study has

limitations that warrant future research. It primarily focuses on market and technological turbulence, neglecting other potential moderating effects of environmental turbulence. Moreover, the study's geographic scope is limited to the Pearl River Delta region, necessitating validation in other areas of China. Furthermore, the reliance on cross-sectional data limits the depth of causal relationships between variables, suggesting the need for longitudinal or panel data analysis in future studies to capture temporal dynamics more comprehensively.

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