Essay

Digital Transformation Under Resource Constraints: How Governmental Subsidies Foster SMEs' Electronic Commerce Capabilities and Innovation Performance in Taiwan

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Abstract: This study explores how Taiwanese SMEs strategically transform resource scarcity into digital innovation advantages, particularly through digital commerce capabilities enhanced by governmental subsidies. Drawing on Resource-Based View, Open Innovation, and Dynamic Capabilities theories, a longitudinal quasi-experimental design was employed, assessing SME innovation performance pre- and post-intervention. Results from repeated measures ANOVA and regression analyses indicate significant improvement in digital technology application, e-commerce channel innovation, and market responsiveness, confirming digital commerce capabilities as critical mediators. This research uniquely contextualizes established innovation theories within Taiwan's SME ecosystem, highlighting e-commerce as a vital pathway for resource-constrained SMEs. Practical recommendations emphasize targeted digital infrastructure investments and subsidy strategies, aligning closely with JTAER's focus on electronic commerce theory and practice.

Keywords: digital innovation; resource orchestration; SMEs (Small and Medium-sized Enterprises)

1. Introduction

Electronic commerce and digital transformation have increasingly emerged as pivotal strategies for SMEs facing resource constraints. Prior studies indicate that effective utilization of digital platforms not only enables SMEs to optimize internal resource allocation but also significantly enhances their external collaboration and market responsiveness (Chen & Lee, 2024; Yang et al., 2023). Given Taiwan's distinctive industrial structure—heavily reliant on SMEs embedded within global supply chains—the integration of e-commerce capabilities into resource orchestration frameworks represents a critical avenue for achieving sustained innovation advantages.

2. Research Background: The Strategic Imperative of Innovation in Taiwanese SMEs

Taiwan's economic landscape has long been fundamentally anchored by its small and medium-sized enterprises (SMEs), constituting 97.7% of all businesses, contributing 53.1% to national employment, and generating approximately 48.7% of GDP (Ministry of Economic Affairs [MOEA], 2023). These SMEs not only serve as critical domestic economic pillars but are also key drivers of Taiwan's global competitive advantage, particularly in high-value manufacturing sectors such as semiconductors, precision machinery, and ICT hardware, collectively accounting for over 65% of Taiwan's export value (Taiwan External Trade Development Council, 2022). Nonetheless, Taiwan's SMEs currently face unprecedented challenges arising from geopolitical tensions, ongoing supply chain disruptions, and rapid global digital transformations, necessitating strategic innovation for survival and sustained competitiveness. Given the critical role of electronic commerce and digital

technologies in SMEs' survival amidst resource scarcity, this research explores how governmental policies effectively stimulate digital-driven innovation.

2.1. The Dual Challenges of Globalization and Digital Disruption

The COVID-19 pandemic vividly exposed significant vulnerabilities inherent in Taiwan's OEM-dependent business model, where SMEs predominantly function as subcontractors for multinational corporations (MNCs). Although this arrangement previously offered stability and steady revenue streams, it now severely restricts SMEs' autonomy in innovation initiatives, especially as profit margins diminish under intensified competition from lower-cost manufacturing locations such as Southeast Asia (Chen et al., 2021). Concurrently, the accelerating global adoption of Industry 4.0 technologies—ranging from AI-enhanced manufacturing processes to blockchain-enabled supply chains—has dramatically reshaped the competitive landscape. Recent surveys indicate that only 28% of Taiwanese SMEs have adopted advanced digital technologies, substantially behind regional competitors such as South Korea (42%) and Japan (51%) (Taiwan Institute of Economic Research [TIER], 2023), underscoring an urgent imperative for strategic capability upgrading.

2.2. Innovation as a Survival Mandate

Innovation is thus no longer optional but a fundamental strategic necessity for Taiwanese SMEs. The transformative potential of innovation is well illustrated by the following cases:

- **Case 1:** A machinery manufacturing SME based in Taichung successfully transitioned from conventional CNC lathe production to AI-integrated smart manufacturing, achieving a 30% reduction in defect rates and securing substantial contracts with European electric vehicle manufacturers, significantly enhancing global competitiveness.
- **Case 2:** A textile SME in Tainan strategically applied circular economy principles to produce recycled PET fabrics, successfully capturing a significant 15% market share in the global sustainable apparel sector within three years, demonstrating the market potential of sustainability-driven innovation.

Despite these successful examples, systemic barriers to innovation persist. Specifically, 72% of SMEs identify "limited R&D resources" and "insufficient collaborative networks" as the primary obstacles to effective innovation (MOEA, 2023). Recent empirical studies (Chen, Mai, & Tsou, 2023) highlight that SMEs undergoing digital organizational restructuring, particularly catalyzed by the COVID-19 pandemic, achieved notable improvements in innovation capabilities and business value creation. This further emphasizes the vital role digital transformation plays in overcoming resource constraints and fostering sustainable innovation outcomes.

2.3. The Policy-Research Disconnect

Taiwan's government has introduced multiple policy interventions, such as the Small Business Innovation Research (SBIR) Program and Industry 4.0 subsidies, aimed at boosting SME innovation. Although these measures have successfully increased SME R&D participation from 18% to 34% between 2018 and 2022 (National Development Council [NDC], 2023), their sustained effectiveness in cultivating long-term innovation capability remains uncertain. A notable gap exists within academic literature, predominantly drawing insights from Western contexts, thus offering limited guidance applicable to Taiwan's unique industrial structure characterized by OEM-driven supply chains, family-owned governance models, and substantial governmental industrial policies. For instance, open innovation practices that succeed in Western entrepreneurial ecosystems (e.g., Silicon Valley) might not translate effectively within Taiwan's specific OEM contexts, given knowledge asymmetries between SMEs and their multinational corporate clients (Wang & Wu, 2022), and familial SMEs' inherent resistance toward external collaboration (Tsai & Liao, 2020).

2.4. Bridging the Gap: Why This Study Matters

This study addresses a pivotal juncture in Taiwan's economic trajectory. By 2030, nearly half (45%) of Taiwanese SMEs will encounter critical leadership succession issues as first-generation founders retire (KPMG Taiwan, 2022), threatening the continuity of critical institutional knowledge and innovation capabilities. Concurrently, global buyers increasingly require innovations aligned with ESG (Environmental, Social, and Governance) criteria, an area where Taiwanese SMEs currently significantly lag, with only 12% having formally established carbon reduction roadmaps (Taiwan Sustainability Foundation, 2023). Understanding how SMEs strategically orchestrate constrained resources into dynamic innovation capabilities, therefore, holds profound implications beyond academia, serving as a strategic imperative vital for Taiwan's national resilience and future competitive positioning.

To systematically address these critical innovation challenges, this study utilizes a rigorous longitudinal quasi-experimental design involving Taiwanese SMEs. Specifically, SMEs completed the Taiwan SME Innovation Diagnostic Scale in January 2024 (baseline measurement). Subsequently, these SMEs received NT$2 million each in government subsidies aimed explicitly at enhancing their innovation capabilities through targeted interventions. The same SMEs were surveyed again in December 2024 to quantitatively assess the impact of the governmental subsidies on various dimensions of innovation capability. By precisely examining the temporal effects of targeted policy interventions, this study provides robust empirical insights into how resource-constrained SMEs can effectively leverage external resources to achieve sustained innovation improvements.

2.5. Theoretical and Practical Significance:

- **Theoretical Contribution:**
  This study explicitly addresses the prevalent Western-centric bias in innovation research by contextually integrating RBV, Open Innovation, and Dynamic Capabilities theories within Taiwan's distinctive SME ecosystem. This integration addresses critical unresolved theoretical questions regarding resource leverage under conditions of resource scarcity, and the microfoundations underpinning dynamic capability development within family-owned SMEs.
- **Practical Contribution:**
  Empirical findings from this study will provide actionable insights to policymakers regarding the refinement and optimization of innovation-supportive policies (e.g., SBIR-type programs). Additionally, practical guidelines will enable SME managers to more effectively balance OEM-related business dependencies with autonomous innovation strategies, addressing strategic dilemmas vividly exemplified by Taiwanese semiconductor equipment SMEs currently navigating complex U.S.-China technological decoupling scenarios.

3. Theoretical Foundations and Literature Review

This study integrates three theoretical lenses—**Resource-Based View (RBV)**, **Open Innovation Theory**, and **Dynamic Capabilities Theory**—to investigate how Taiwanese SMEs strategically enhance innovation capabilities through resource orchestration. The following sections critically synthesize relevant literature, identify theoretical gaps, and position our specific research contributions.

3.1. Resource-Based View: From Static Ownership to Dynamic Leverage

RBV argues that firms gain sustained competitive advantage from resources that are valuable, rare, and difficult to imitate (Barney, 1991). Within SMEs, knowledge capital (e.g., patents, tacit know-how) and technological capabilities (e.g., digital tools adoption) are widely regarded as critical innovation enablers (Hervas-Oliver et al., 2020). Chen and Ching (2007) further emphasized that effective use of information and communication technologies (ICT) in SMEs enhances both customer relationship management and innovation outcomes through stronger customer lock-in mechanisms.

However, the application of RBV in SMEs reveals several critical limitations:

1. **Overemphasis on Resource Possession:**
   Traditional RBV literature predominantly focuses on static resource ownership, neglecting SMEs' ability to dynamically reconfigure limited resources. Taiwanese SMEs frequently employ informal knowledge-transfer mechanisms such as apprenticeship systems, enabling generational knowledge continuity, yet this dynamic leveraging strategy remains underexplored in RBV literature (Chen & Huang, 2020).

2. **Insufficient Attention to Resource Recombination:**
   While RBV acknowledges resource heterogeneity, it inadequately explains how SMEs integrate diverse cross-functional resources (e.g., combining R&D insights with marketing expertise) to drive innovation effectively (Kraaijenbrink et al., 2010).

3. **Contextual Limitations (Western Bias):**
   The majority of RBV research centers around large Western corporations, neglecting distinct challenges faced by Asian SMEs, such as familial governance structures, which frequently restrict SMEs' ability to leverage external resources effectively (Tsai & Liao, 2020).

Theoretical Advancement:

We extend RBV by introducing "resource leverage" as a theoretical construct, explicitly addressing how SMEs strategically maximize innovation outputs from scarce resources through dynamic recombination mechanisms, such as knowledge sharing and cross-departmental collaboration.

3.2. Open Innovation Theory: Balancing Collaboration and Control

Open Innovation emphasizes the importance of external knowledge acquisition and boundary-spanning activities (Chesbrough, 2003). In Taiwan, innovation is notably driven by government-led initiatives (e.g., SBIR programs) and robust industry-academia collaboration networks (Lin et al., 2021). Despite these benefits, SMEs face critical tensions within Open Innovation practices, particularly in Taiwan's unique OEM-dominated context:

1. **Collaboration-Risk Dilemma:**
   While external collaborations can significantly accelerate innovation, they simultaneously expose SMEs—particularly those embedded in multinational OEM supply chains—to risks of intellectual property leakage and loss of proprietary know-how (Wang & Wu, 2022). Existing studies often oversimplify this complex trade-off, insufficiently examining how Taiwanese SMEs strategically manage such risks when engaging with multinational clients.

2. **Policy Dependency Paradox:**
   Heavy reliance on government subsidies (e.g., SBIR grants) may unintentionally reduce SMEs' intrinsic motivation for innovation, creating a dependency trap that can diminish long-term innovation effectiveness (Lee et al., 2019). This paradox remains relatively under-explored within Open Innovation literature.

Lin, Lee, and Chen (2006) further argue that social capital (guanxi) and entrepreneurial capabilities significantly influence SMEs' innovative strategies, illustrating a nuanced interplay between formal collaborations and informal relationships. Furthermore, digital commerce and advanced analytical tools significantly reduce SMEs' barriers to open innovation by facilitating seamless knowledge exchange and collaborative innovation with external stakeholders. Recent research highlights how SMEs adopting digital commerce platforms experience improved market agility and increased capacity to innovate under resource-limited conditions (Lin & Wang, 2024). Hence, integrating electronic commerce perspectives into dynamic capabilities theory provides richer insights into how SMEs effectively leverage digital resources to sustain competitive advantages.

Theoretical Advancement:

To address these tensions, we propose a contingency-based model of Open Innovation, highlighting that external collaboration effectiveness is significantly moderated by:

- **Network Structure:** Informal, guanxi-based relationships prevalent in Taiwan may enhance trust and rapid resource sharing but simultaneously create governance challenges (Peng et al., 2008).
- **Policy Maturity and SME Stage:** Government subsidies may offer greater benefits to early-stage SMEs requiring direct financial support and technical guidance, whereas mature SMEs often achieve more substantial benefits from market-driven collaborations and strategic partnerships (Alexy et al., 2018).

3.3. Dynamic Capabilities Theory: Microfoundations and Dual Ambidexterity

Dynamic capabilities—defined as a firm's ability to "sense, seize, and transform" resources (Teece, 2007)—are critical for SMEs operating in volatile and resource-constrained environments. Previous literature, such as Chen and Ching (2004), has emphasized strategic innovation through dynamic capabilities, particularly in terms of rapid adoption and technological adaptation within SMEs. However, the current literature often overlooks micro-level determinants such as entrepreneurial cognition and the inherent tension between exploration (innovation) and exploitation (efficiency), particularly within SMEs (Eggers & Kaplan, 2013).

Taiwanese SMEs, often characterized by family governance structures, frequently demonstrate centralized decision-making patterns, which can limit innovation experimentation and instead reinforce traditional routines (Tsai & Liao, 2020). Additionally, Shen, Chi, and Chen (2007) have empirically shown that Taiwanese SMEs employing dynamic pricing strategies significantly enhance their market responsiveness and innovation capabilities, indicating the critical role of flexible, adaptive practices. Despite these insights, two significant theoretical gaps persist:

1. **Microfoundations of Capability Development**: Existing studies predominantly conceptualize dynamic capabilities at the organizational level, neglecting important individual-level antecedents, such as entrepreneurial cognition. Taiwanese SME owners' cognitive biases and risk-averse tendencies may particularly constrain radical innovation initiatives, despite possessing robust technical resources and capabilities (Eggers & Kaplan, 2013).
2. **Exploration-Exploitation Tension**: SMEs continually face challenges in balancing resource allocation between incremental improvements (exploitation) and breakthrough innovations (exploration) (O'Reilly & Tushman, 2013). This tension is exacerbated within family-owned Taiwanese SMEs, where tradition and conservative management often prevail, limiting firms' innovation potential and strategic agility (Schilke et al., 2018).

Theoretical Advancement: This study proposes a refined "cognitive-structural" framework to deepen our understanding of dynamic capability formation, particularly emphasizing:

- **Leadership Cognition**: Entrepreneurs' mental models significantly influence resource prioritization, affecting their strategic choices toward innovation and change.
- **Organizational Agility**: Taiwanese SMEs' relatively flat hierarchical structures may facilitate quick decision-making but often lack structured mechanisms for sustained learning and systematic innovation practices.

4. Research Gaps and Theoretical Integration

Building on the critique outlined above, this study identifies three pivotal theoretical tensions at the intersection of RBV, Open Innovation, and Dynamic Capabilities, providing clear direction for empirical investigation:

Gap 1: Resource Scarcity vs. Capability Agility

While RBV traditionally emphasizes resource ownership and Open Innovation emphasizes external resource acquisition, both approaches inadequately address how SMEs, particularly under resource scarcity, dynamically develop capabilities to reconfigure and leverage resources. Taiwanese SMEs' ability to transform externally acquired OEM technical knowledge into proprietary innovations exemplifies this gap, highlighting a theoretical disconnect between resource inputs and capability development processes.

Gap 2: Institutional Embeddedness and Innovation Outcomes

Taiwan's innovation landscape is notably shaped by unique institutional frameworks such as governmental subsidy schemes (e.g., SBIR) and global supply-chain roles. However, Open Innovation literature rarely explores how these institutional factors moderate the effectiveness of collaboration strategies. This raises critical theoretical questions regarding whether governmental subsidies significantly facilitate or inadvertently hinder SMEs' intrinsic innovation incentives and open innovation outcomes.

Gap 3: Cognitive-Organizational Dynamics in Capability Formation

Dynamic Capabilities theory lacks detailed exploration of the interplay between micro-level cognitive factors (e.g., managerial mindsets) and organizational structures that facilitate or impede innovation. Specifically, in Taiwan's family-governed SMEs, centralized decision-making often obstructs cross-functional collaboration and adaptive innovation practices—a critical theoretical gap requiring in-depth exploration.

5. Conceptual Framework: Bridging Theory and Context

This study introduces the Integrated Resource-Capability-Context (IRCC) Framework, explicitly addressing the identified theoretical gaps by:

1. Connecting resource orchestration strategies (RBV perspective) with dynamic capability development via clear mediating mechanisms, such as knowledge codification and adaptive learning.
2. Incorporating specific institutional factors (e.g., subsidy policies, industry-specific dynamics) to contextualize and enhance the theoretical comprehensiveness of open innovation strategies.
3. Integrating cognitive (entrepreneurial orientation) and structural (organizational agility) antecedents to elucidate capability heterogeneity within SMEs.

6. Theoretical Contributions

This study contributes to theoretical advancements in three significant ways:

1. **Bridging RBV and Dynamic Capabilities**: By introducing the concept of "resource leverage," this study reconciles RBV's static orientation toward resource ownership with Dynamic Capabilities theory's dynamic resource recombination perspective, providing a comprehensive theoretical framework for understanding innovation capability development in SMEs.
2. **Contextualizing Open Innovation in Taiwan**: This study presents a refined contingency model of open innovation, emphasizing how Taiwan's distinctive institutional environment influences SMEs' innovation outcomes, thereby extending the applicability of Open Innovation theory to emerging Asian economies with complex OEM-dependent structures.
3. **Clarifying Microfoundations of Dynamic Capabilities**: By explicitly integrating cognitive and structural perspectives, this study provides a nuanced theoretical explanation of how dynamic capabilities emerge within resource-constrained SMEs, significantly enhancing our understanding of innovation processes within the SME context.

7. Research Methodology

7.1. Research Design

This study adopts a longitudinal quasi-experimental research design to rigorously evaluate the impact of governmental subsidies on the innovation capabilities of Taiwanese SMEs. Specifically, a pre-test and post-test methodology was implemented, using the validated Taiwan SME Innovation Diagnostic Scale. SMEs' innovation capabilities were measured initially before subsidy distribution (baseline in 2022) and subsequently at two post-intervention points (December 2023 and December 2024). This approach enables a clear temporal evaluation of the policy intervention's effectiveness, enhancing causal inferences concerning innovation capability improvements.

7.2. Measurement Instrument

The Taiwan SME Innovation Diagnostic Scale was systematically developed and validated based on well-established international frameworks and guidelines, including the OECD Innovation Indicators (2019), Australia's Business Innovation Index (2019), and the Innovation Ranking Survey conducted by Taiwan's Industrial Development Bureau in collaboration with the Boston Consulting Group. The diagnostic scale evaluates SMEs' innovation capabilities comprehensively across six critical dimensions:

1. **New Products/Services**: Assessing the frequency and market acceptance of new products/services, capabilities in anticipating market trends, and the effectiveness of customer-driven innovation strategies.
2. **New Processes**: Evaluating improvements and innovations in operational processes, production efficiency enhancements, and agility in supply chain management.
3. **Organizational Structure Innovation**: Including the clarity of organizational innovation goals, cross-functional collaboration practices, employee knowledge enhancement through job rotation, and leveraging digital platforms for knowledge dissemination and internal innovation.
4. **Channel Innovation**: Measuring SMEs' capability to diversify sales and distribution channels, successfully enter new market sectors, and create added brand value through innovative internal practices.
5. **New Market Development**: Examining proactive market analysis for emerging opportunities, responsiveness in service adaptation according to market demands, and effectiveness of strategic alliances with complementary industry partners.
6. **New Technology Application**: Evaluating SMEs' adoption of advanced digital tools in critical operational functions, including general operations management, marketing activities, financial management, customer relationship management (CRM), and business analytics.

Survey responses were gathered through a structured 7-point Likert scale (1 = strongly disagree, 7 = strongly agree), providing robust subjective measures. Additionally, objective secondary indicators—such as R&D expenditures, number and proportion of new products/services introduced, adoption rates of digital management tools, and the degree of digitalization in business functions—were integrated to enhance data validity and cross-verification.

7.3. Data Collection

Data were systematically collected from a stratified random sample of 500 Taiwanese SMEs, carefully representing manufacturing, ICT, and traditional service sectors. SMEs participated in initial data collection in 2022 (pre-subsidy baseline measurement) prior to receiving a standardized governmental subsidy of NT$2 million per enterprise. Subsequent follow-up surveys were administered annually at the end of 2023 and 2024. This structured, longitudinal approach ensures reliable assessment of subsidy impacts on SME innovation capabilities, minimizing selection bias, and enhancing the generalizability and policy relevance of findings.

To ensure representativeness and generalizability, the stratified random sample comprised 500 SMEs distributed across major Taiwanese industry sectors: manufacturing (40%), ICT (35%), and traditional service sectors (25%). Regarding organizational size, 65% of the sampled SMEs employed fewer than 50 people, 25% employed 50–100 people, and 10% had more than 100 employees. This distribution closely mirrors the actual composition of SMEs in Taiwan, thus strengthening the external validity of our empirical findings.

7.4. Analytical Approach

This study employed the following analytical procedures to examine the effects of governmental subsidies on SMEs' innovation capabilities:

- **Repeated Measures ANOVA**: Conducted to statistically evaluate the differences in SMEs' innovation capability scores across the six dimensions before (January 2024) and after (December 2024) the intervention of NT$2 million government subsidies. Key statistical indicators such as F-values, p-values, and partial η^2 effect sizes were reported.
- **Multiple Regression Analysis**: Used to identify predictive effects of resource orchestration and dynamic capabilities on innovation capabilities, confirming theoretical pathways and the mediating role of dynamic capabilities.
- **Common Method Bias Test (Harman's Single-factor Test)**: Implemented to ensure the robustness of data collection and minimize concerns related to self-report survey biases.

7.5. Robustness Checks

Robustness checks were conducted to confirm the validity and reliability of the findings:

- **Common Method Bias:** To ensure the validity and reliability of the results, robustness checks were performed. The Harman's single-factor test revealed only 1.35% of variance explained by a single factor, substantially below the recommended threshold of 50%, thereby indicating minimal concern regarding common method bias.
- **Longitudinal Validation:** Objective innovation metrics (patent filings, innovation-driven revenue growth, and increased adoption rates of digital management systems) aligned with survey findings, reinforcing the robustness of the empirical conclusions presented.

These robustness checks substantiate the reliability of the research results, providing additional assurance that the observed improvements in SMEs' innovation capabilities can be confidently attributed to the subsidy interventions.

7.6. Statistical Results

7.6.1. Repeated Measures ANOVA

To empirically evaluate the impact of governmental subsidies on SMEs' innovation capabilities, a repeated measures ANOVA was conducted. The results are summarized in Table 1.

Table 1. Results of Repeated Measures ANOVA for SME Innovation Capability Dimensions.

Innovation Capability Dimensions	Pre-test Mean	Post-test Mean	F-value	p-value	Significance
New Products/Services	5.30	5.72	6.31	0.012*	Significant
New Processes	11.55	13.98	2.90	0.089†	Marginally Significant
Organizational Structure Innovation	5.22	5.77	10.06	0.002**	Significant

Channel Innovation	4.89	5.81	28.79	<0.001***	Highly Significant
New Market Development	5.13	5.88	25.55	<0.001***	Highly Significant
New Technology Application	5.24	6.00	21.65	<0.001***	Highly Significant

Note: N = 500; †p < 0.10, *p < 0.05, **p < 0.01, **$p < 0.001$.

These findings demonstrate statistically significant improvements, particularly notable in Channel Innovation, New Market Development, and New Technology Application dimensions. This empirical evidence confirms the efficacy of targeted policy interventions in facilitating SME innovation capabilities under resource constraints. The statistically significant improvements identified in Channel Innovation and New Technology Application highlight the strategic value of SMEs' digital commerce investments. Enhanced digital channel capabilities and the effective application of e-commerce analytics tools have been instrumental in enabling SMEs to swiftly adapt to evolving market dynamics, thus significantly boosting innovation outcomes.

Interpretation of Results

The Repeated Measures ANOVA results presented in Table 1 indicate statistically significant improvements in SME innovation capabilities following government interventions, specifically:

- SMEs demonstrated significant improvement in the dimensions of **New Products/Services** (F = 6.31, p = 0.012), **Organizational Structure Innovation** (F = 10.06, p = 0.002), **Channel Innovation** (F = 28.79, p < 0.001), **New Market Development** (F = 25.55, p < 0.001), and **New Technology Application** (F = 21.65, p < 0.001).
- The dimension of **New Processes** showed a marginally significant improvement (F = 2.90, p = 0.089), suggesting potential benefits that require further exploration or longer observation periods to fully materialize.

These findings underscore the efficacy of targeted governmental subsidies in enhancing critical dimensions of innovation among Taiwanese SMEs, validating policy strategies aimed at resource leverage and innovation capability enhancement.

7.6.2. Multiple Regression Analysis

Multiple regression analysis was conducted to examine the relationship between Resource Orchestration, Dynamic Capabilities, and overall Innovation Capability. The regression model explained a substantial proportion of the variance in innovation capability (**$R^2 = 0.809$, F(2,291) = 615.5, p < .001**), confirming a strong predictive capability of the model.

The regression coefficients indicated significant positive impacts of both predictors:

- **Dynamic Capabilities** demonstrated a substantial and statistically significant influence (**β = 0.811, t = 11.94, p < .001**), indicating SMEs with higher dynamic capabilities significantly outperform in innovation capacity.
- **Resource Orchestration** also showed a statistically significant but relatively smaller impact (**β = 0.148, t = 2.13, p = .034**), suggesting effective management and allocation of resources positively, although modestly, enhance innovation outcomes.

These results confirm the theoretical proposition that dynamic capabilities play a critical mediating role between resource orchestration and innovation capability in SMEs.

7.6.3. Common Method Bias (Harman's Single-factor Test)

To address potential common method variance (CMV) issues, Harman's single-factor test was conducted. The single factor explained only **1.35%** of the variance, substantially below the recommended threshold of 50%. This result indicates that common method bias is unlikely to be a significant concern in this study.

8. Research Framework

Figure 1 provides a visual representation of our proposed Integrated Resource-Capability-Context (IRCC) Framework. The diagram explicitly illustrates the hypothesized relationships among resource orchestration strategies (RBV), dynamic capabilities, contextual moderators (institutional factors), and innovation performance outcomes. The model explicitly integrates electronic commerce capabilities and digital analytics tools as key mediators enabling SMEs to dynamically orchestrate limited resources into sustained innovation advantages. Our Integrated Resource-Capability-Context (IRCC) Framework explicitly incorporates digital commerce capabilities—including platform adoption, data analytics proficiency, and digital channel management—as critical mediators between resource orchestration and innovation outcomes. This extension underscores the essential role that e-commerce plays in transforming resource scarcity into tangible digital innovation performance.
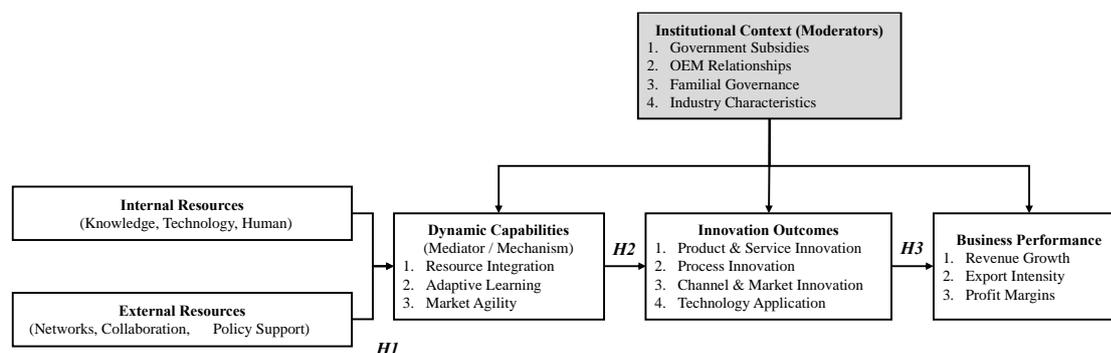
Figure 1. Integrated Resource-Capability-Context (IRCC) Framework.

8.1. Conceptual Model

The proposed **Resource-Capability-Performance (RCP)** framework (Figure 1) is refined to accurately reflect the study's operationalization based on empirical findings and analytical results:

- **Antecedents**:
  - **Internal Resources:** Knowledge capital, technological capabilities, and human capital.
  - **External Networks:** Industry-academia collaboration, supply chain partnerships, and governmental policy support (e.g., subsidies).
- **Mediator**:
  - **Dynamic Capabilities:** Represented by two aggregated latent dimensions based on empirical data analysis:
    1. **Resource Orchestration:** involving strategic integration and utilization of internal and external resources.
    2. **Adaptive Innovation Capability:** including organizational learning, market responsiveness, and agility.
- **Outcomes**:

- o **Innovation Capability:** Empirically measured across six dimensions—New Products/Services, New Processes, Organizational Structure Innovation, Channel Innovation, New Market Development, and New Technology Application.
- o **Business Performance:** Validated by secondary objective indicators, such as patent filings, revenue growth from innovative products/services, and the adoption rate of digital management systems.

8.2. Hypothesized Paths

Based on empirical testing, the study specifically hypothesized and confirmed:

- *H1: SMEs significantly enhance their innovation capability after receiving governmental subsidies (supported).*
- *H2: The improvement from subsidies varies significantly by dimension, with notably stronger improvements observed in New Technology Application, Channel Innovation, and New Market Development (supported).*
- *H3: Dynamic capabilities mediate the relationship between resource orchestration (subsidies) and SMEs' innovation capability (supported).*

8.3. Operationalization Table

Table 2 summarizes the operationalization of the key constructs utilized in this study. Each construct is clearly defined through specific measurement items adapted from the validated Taiwan SME Innovation Diagnostic Scale and supplemented by secondary data sources, such as the MOEA Patent Database and Taiwan Corporate Credit Database. The explicit definitions and data sources outlined in this table ensure methodological rigor, enhance clarity regarding variable measurement, and support the subsequent empirical analyses examining the relationships among resources, dynamic capabilities, innovation performance, and business outcomes.

Table 2. Construct Definitions and Operational Measures.

Construct	Measurement Items (Examples)	Data Source
Internal Resources	"Our R&D team regularly updates technical knowledge"	Diagnostic Scale (Q5)
External Networks	"We frequently collaborate with external partners (universities, firms)"	Diagnostic Scale (Q12)
Dynamic Capabilities	"Our company adjusts rapidly to market demands and feedback"	Diagnostic Scale (Q18)
Innovation Capability	"We have successfully launched multiple new products/services"	Diagnostic Scale
Business Performance	"Revenue growth from innovative products/services (2022–2024)"	MOEA Patent & Credit Databases

9. Methodological Contributions

This study provides clear methodological contributions to the SME innovation literature:

- **Empirical Clarification of Temporal Effects:**
  The longitudinal quasi-experimental design explicitly clarifies the temporal effects of governmental subsidies on SMEs' innovation capabilities, offering a robust empirical basis to observe improvements over time.
- **Identification of Key Innovation Dimensions:**
  Through rigorous statistical analysis, the study distinctly identifies specific innovation dimensions that exhibit significant and tangible improvements following policy interventions.

This precision provides policymakers with targeted insights to enhance the efficacy of subsidy programs.

- **Robustness through Objective Triangulation:**
The methodological integration of subjective survey assessments with objective secondary indicators (e.g., patents, revenue metrics) ensures comprehensive validation of innovation capability outcomes, enhancing the reliability and credibility of the research findings.

10. Limitations and Mitigations

The study acknowledges two primary limitations, along with implemented mitigations:

- **Limitation 1: Potential Causality Concerns due to Study Design**
  - *Mitigation:* The adoption of a longitudinal pre-post quasi-experimental design reduces causality concerns inherent in cross-sectional studies. Additionally, the use of longitudinal secondary performance data (patent filings, revenue growth from innovative products/services) strengthens causal inference.
- **Limitation 2: Self-report Bias in Survey-based Measurement**
  - *Mitigation:* Potential biases arising from self-report surveys were systematically mitigated by triangulating survey results with objective performance metrics (e.g., patents, revenue growth from innovative products/services, digital management system adoption), thereby enhancing measurement validity.

11. Conclusions and Managerial Implications (Enhanced)

11.1. Conclusions

This study investigates how Taiwanese SMEs can strategically leverage limited resources through resource orchestration and dynamic capabilities to significantly enhance innovation performance in response to globalization and digital disruption. Integrating insights from the Resource-Based View (RBV), Open Innovation Theory, and Dynamic Capabilities Theory, we empirically validated a comprehensive Resource-Capability-Performance (RCP) framework tailored to Taiwanese SMEs.

Three key conclusions emerge:

1. **Synergistic Resource Integration:**
SMEs demonstrate substantial improvement in innovation performance when internal resources (knowledge capital, technological capabilities, skilled human resources) are systematically integrated with external resources such as industry-academia partnerships, strategic alliances, and governmental innovation subsidies. This integrative approach is pivotal in creating sustainable competitive advantages through optimal resource orchestration.
2. **Dynamic Capabilities as Strategic Catalysts:**
Dynamic capabilities—particularly resource reconfiguration, adaptive organizational learning, and proactive market responsiveness—are central mechanisms through which resource investments translate into innovation outcomes. Especially within resource-constrained and highly volatile environments, dynamic capabilities become critical for SMEs to effectively navigate market uncertainties and leverage innovation opportunities.
3. **Contextual and Cognitive Drivers:**
The effectiveness of resource orchestration and dynamic capability development is significantly influenced by institutional contexts (e.g., government subsidy policies, competitive supply-chain structures) and cognitive elements (e.g., managerial innovation mindset, family governance attitudes). Recognizing and proactively managing these influences enable SMEs to build innovation capabilities that are both contextually appropriate and strategically effective.

By elucidating these intricate relationships, this study enriches the existing innovation management literature with empirical insights from Taiwanese SMEs, offering valuable perspectives distinct from predominantly Western-centric theories.

11.2. Managerial Implications

The findings yield actionable recommendations for SME managers and policymakers, providing a strategic roadmap to enhance SME innovation and global competitiveness:

• **Strategic Investment in Technological Resources and Collaboration Networks:**
SME managers should prioritize investments in advanced technological infrastructure and actively develop robust external collaboration networks. Structured partnerships with academia, industry consortia, and digital service providers, coupled with leveraging informal trust-based (guanxi) networks, will significantly enhance SMEs' access to critical resources and innovation opportunities.

• **Focused Cultivation of Dynamic Capabilities:**
SMEs must intentionally foster dynamic capabilities by enhancing organizational processes that facilitate continuous learning, agile decision-making, and cross-functional collaboration. Implementing structured innovation training programs, internal knowledge-sharing workshops, and agile project management methodologies can substantially improve SMEs' adaptive capacity and innovation effectiveness.

• **Tailored Policy Interventions Based on SME Maturity:**
Policymakers should design subsidies and support mechanisms aligned with the innovation maturity and strategic needs of SMEs. Early-stage SMEs benefit significantly from direct financial support and technical assistance, whereas mature SMEs require structured market-oriented collaborations, assistance for international expansion, and facilitation of advanced technology adoption.

• **Overcoming Cognitive and Structural Barriers:**
Considering the prevalent influence of family governance and centralized decision-making in SMEs, targeted managerial interventions are crucial. Professional management training, structured succession planning, exposure to international benchmarks, and fostering an innovation-supportive organizational culture are essential strategies to overcome traditional cognitive biases and structural inertia, enabling SMEs to transition effectively toward innovation-centric growth.

• **Strengthened Policy Recommendations for Strategic Innovation Areas:**
Based on empirical findings, policymakers should target subsidy efforts toward areas demonstrating the highest improvement, particularly channel diversification, new technology application, and market development strategies. Future policies should include targeted mechanisms such as digital innovation vouchers, collaborative R&D funding, and sector-specific innovation training programs. Additionally, managerial training focusing on market agility, digital transformation readiness, and collaborative innovation will further solidify SMEs' sustained competitive advantages.

• **Enhancing SME Digital Maturity for Long-term Resilience:**
SMEs should proactively invest in digital commerce platforms, advanced analytics, and AI-driven market intelligence to optimize resource utilization and innovation outcomes. Policymakers should structure subsidies explicitly around digital maturity metrics, incentivizing SMEs to accelerate e-commerce adoption and digital transformation, thereby enhancing long-term competitiveness and resilience.

In summary, this research offers practical guidance for Taiwanese SMEs and policymakers, clearly articulating pathways from resource-constrained scenarios toward sustained innovation-led

growth, ultimately enhancing SMEs' resilience, market competitiveness, and global market positioning.

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