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Bridging the Gap: Barriers to Malaysian Public University Research Commercialisation

RESEARCH ARTICLE
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ABSTRACT

Introduction: Malaysian public universities achieve only 5-10% downstream commercialisation rates. This compares poorly to 30-60% rates in other Asian economies and developed nations. Current assessment frameworks inappropriately evaluate universities on post-transfer outcomes. These outcomes are beyond their institutional control rather than controllable pre-transfer activities. **Methods:** This study employed triangulated multi-qualitative analysis. It integrated commercialisation policies from all five Malaysian research universities. The study included comprehensive literature review of six innovation gap clusters and structured interviews with ten Technology Transfer Office (TTO) personnel. The Pre-Transfer Market Readiness Gaps Conceptual Framework applies six complementary theoretical perspectives. This distinguishes controllable pre-transfer activities from uncontrollable post-transfer outcomes. **Results:** The study validated and extended existing literature by identifying ten critical innovation gaps across three challenge domains that align with six established literature clusters (Strategic/Policy, Skills/Competency, Financial, Organisational/Cultural, Stakeholder Coordination, and Market Orientation). Go-to-market barriers include industry's lack of R&D adoption readiness (scoring 14.8). Policy framework deficiencies include inadequate commercial viability frameworks (scoring 12.4). Measurement standardisation issues also emerged. Multi-theoretical convergence validates that high-priority gaps operate simultaneously. They span institutional, organisational, resource-based, and relational dimensions identified in prior research. **Discussion:** The sphere of control analysis reveals important insights. Universities are evaluated against marketing and financial success metrics. These occur beyond their influence. Meanwhile, technical success activities within their control remain inadequately optimised. The performance measurement paradox demonstrates why standardised frameworks produce inconsistent results. There is 5-50% variation when institutions optimise reported performance rather than substantive effectiveness. **Conclusion:** The study confirms that innovation gaps require integrated multi-theoretical approaches rather than isolated frameworks and contributes both literature validation and a novel paradigm shift toward process-based assessment. This operates within universities' controllable operational sphere. This enables systematic evaluation of pre-

transfer market readiness capabilities whilst maintaining accountability within appropriate institutional boundaries. **Future Research**: Future studies should develop industry readiness assessment tools, pre-transfer commercial viability frameworks and unified measurement standards that distinguish university-controllable from external factors whilst exploring how the six validated gap clusters evolve through integrated intervention strategies.

Keywords: Commercialisation, Innovation Management, Market Readiness, Commercial Viability, Technology Transfer, University Policy, Performance Measurement, Malaysia

1. INTRODUCTION

Technology transfer serves as a crucial connection between university research and commercialisation. It converts university intellectual property (IP) into market-ready products. Malaysian public universities exhibit significantly lower commercialisation rates compared to international benchmarks. Malaysian public universities achieve only 5-10% commercialisation success rates. This is substantially lower than 30-60% rates in other Asian economies and developed nations (Edwards, 2021, Malay Mail). Despite Malaysia's scientific research output increasing 4.5-fold between 2008 and 2018, IP commercialisation rates fell by 8.3% from 2005 to 2015 (Edwards, 2021, Malay Mail).

The research gap emerges from a critical misalignment. Universities are evaluated based on market performance after technology transfer. This is beyond their control rather than their effectiveness during the controllable pre-transfer phases. Despite multiple frameworks and significant research output, little is known about specific factors. These are the organisational, institutional, or resource-related factors that most influence commercialisation outcomes. The focus should be on factors within universities' sphere of control. The objective is to identify and analyse pre-transfer market readiness gaps. This focuses on Malaysian public research universities' technology transfer frameworks. The study transcends outcome-based metrics to examine controllable factors which affect commercialisation potential.

2. LITERATURE REVIEW

2.1 Theoretical Frameworks in University Technology Commercialisation Research

University technology commercialisation research has predominantly employed several theoretical frameworks as presented by **Figure 1**. This is documented by Dzakiy et al. (2023) in their comprehensive analysis.

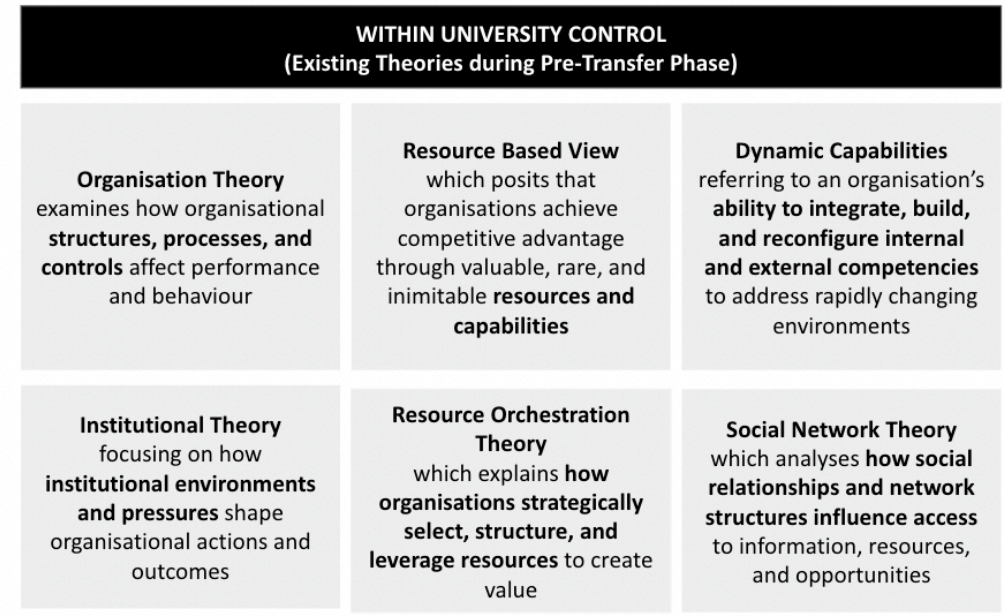

Figure 1. *Existing Theories Applicable to University Commercialisation*
Note: Existing theories documented by Dzakiy et al., 2023

Resource-Based View emerges as the most extensively applied framework. It identifies critical drivers of technology commercialisation performance. This emphasises how universities achieve competitive advantage through valuable, rare resources and capabilities. These include IP protection and business development capabilities (Shahidan et al., 2019).

Institutional Theory focuses on how university-level environmental factors shape organisational actions. **Organisation Theory** examines how managerial control impacts performance across different technology transfer stages. It also examines how organisational context influences academics' entrepreneurial decisions.

Emerging theoretical perspectives include **Resource Orchestration Theory**. This explains how universities strategically select and manage human, social, financial, and technological resources. **Dynamic Capabilities Theory** addresses how universities create and capture value. This occurs through technological exploitation and asset reconfiguration. **Social Network Theory** examines how relational and structural embeddedness in academic networks influences the outcome. It emphasises the critical role of active academic involvement and network relationships in technology transfer success (Dzakiy et al., 2023).

2.2 Success Factors in University Technology Transfer

Romanowski (2019) proposes a comprehensive multidimensional framework. This framework understands commercialisation success across three independent yet interrelated dimensions. Technical success (effective transfer). Marketing success market viability with revenues exceeding costs) and Financial success (cost recovery from development to market introduction).

International success requires coordinated supply-side (universities) and demand-side (industry) capabilities. European institutions such as KU Leuven demonstrate integrated collaboration models (124+ spin-offs over 50 years) (Ewalt, 2019). Asian approaches emphasise government-supported frameworks (Japan's Society 5.0) (Ueyama, 2018). US practices feature market-driven approaches supported by the Bayh-Dole Act.

Current evaluation frameworks show significant limitations. Malaysia's MyRA® in the *Glosari* MyRA® I & II (*Pindaan* 2023) (Jabatan Pendidikan Tinggi, 2023) guidelines evaluate universities on post-transfer outcomes beyond institutional control. This has created accountability misalignment.

2.3 Innovation Gaps Based on Literature Review

Despite RM1.152 billion in government research investment, Malaysia achieved only 20 successful commercialisations generating RM7.6 million revenue (Mudaa et al., 2021). This study identifies six interconnected innovation gap clusters hindering research commercialisation in Malaysian public universities from the literature review: Strategic & Policy Gaps (**Table 1**), Skills & Competency Gaps (**Table 2**), Financial Constraints (**Table 3**), Organisational & Cultural Barriers

Table 1: *Innovation Gaps Cluster 1 – Strategic & Policy Gaps.*

Innovation Gaps	Description	Source	Relevant Theory
Protective IP Strategy Limitations	The protective IP strategy in Malaysian public universities limits commercialisation success and increases gaps, with traditional focus on preserving IP rights rather than enabling collaboration	Sarujee et al. (2022) Palfrey (2011)	Resource-Based View (IP protection capabilities)
Inadequate IP Awareness	Weak IP awareness amongst researchers and institutions, hindering effective commercialisation strategies	Mudaa et al. (2021)	Resource-Based View (IP capabilities and knowledge resources)
Lack of Policy Uniformity	No uniformity on commercialisation policy across institutions, creating inconsistent approaches	Mudaa et al. (2021)	Institutional Theory (institutional frameworks)

Source: Authors, 2025

Table 2: *Innovation Gaps Cluster 2 – Skills & Competency Gaps.*

Innovation Gaps	Description	Source	Relevant Theory
Lack of Entrepreneurship Skills	Researchers lack entrepreneurial skills necessary for successful commercialisation of research outputs	Mudaa et al. (2021)	Resource Orchestration Theory (human resource management)
Absence of Entrepreneurial Behaviour	Absence of entrepreneurial behaviours amongst researchers, limiting commercialisation potential	Khademi et al. (2015)	Organisation Theory (academics' entrepreneurial decisions)
Business Skills Deficiency	Lack of business skills and expertise in commercialisation amongst academic staff	Khademi et al. (2015)	Resource Orchestration Theory (strategic human capabilities)

Source: Authors, 2025

(**Table 4**), Stakeholder Coordination & Collaboration Gaps (**Table 5**), and Market Orientation & Commercial Focus Gaps **(Table 6)**. Each cluster is systematically mapped to established theories—Resource-Based View, Resource Orchestration Theory, Institutional Theory, Organisation Theory, and Social Network Theory —to validate the gaps against existing theoretical frameworks.

These six clusters can be reorganised into two broader domains: Firstly, **Go-to-Market and Operational Readiness Challenges** encompassing Skills and Competency Gaps and Market Orientation & Commercial Focus Gaps. And secondly, **Support System and Organisational Framework Challenges** including Financial Constraints, Organisational & Cultural

Table 3: *Innovation Gaps Cluster 3 – Financial Constraints.*

Innovation Gaps	Description	Source	Relevant Theory
Insufficient Financial Resources	Lack of capital funds and limited access to industrial funding, with availability of finance being the most critical factor affecting commercialisation from start to finish	Khademi et al. (2015)	Resource Orchestration Theory (strategic financial resource management)
Inadequate Infrastructure	Poor infrastructure supporting commercialisation activities, including inadequate technology transfer office capabilities	Khademi et al. (2015)	Resource-Based View (technological and infrastructure capabilities)
Over-dependence on Government Grants	Over-dependence on government grants leading to complacency and inefficiency in income generation	Lim et al. (2016)	Institutional Theory (environmental dependency and institutional frameworks)

Source: Authors, 2025

Table 4: *Innovation Gaps Cluster 4 – Organisational & Cultural Barriers.*

Innovation Gaps	Description	Source	Relevant Theory
Organisational Culture Barriers	Organisational culture not fully supporting entrepreneurship, with focus on research rather than commercialisation	Yusof et al. (2012)	Organisation Theory (organisational context influence on entrepreneurial culture)
Weak Control Systems	Lack of effective control measures and prudence in control systems, with uncertainty about rewards for risk-taking	Yusof et al. (2012)	Organisation Theory (managerial control systems and performance)
Leadership Deficiencies	Absence of strong entrepreneurial leadership amongst academic leaders	Yusof et al. (2012)	Organisation Theory (managerial control and leadership impact)
Complexity and Risk Aversion	Complexity and risk involved in commercialisation processes, with costs and risks associated with commercialisation activities	Khademi et al. (2015)	Organisation Theory (risk management and organisational decision-making)

Source: Authors, 2025

Table 5: *Innovation Gaps Cluster 5 – Stakeholder Coordination & Collaboration Gaps.*

Innovation Gaps	Description	Source	Relevant Theory
Weak Cooperation Between Stakeholders	No cooperation between universities, industry, and government, creating significant gaps in the commercialisation ecosystem	Mudaa et al. (2021)	Social Network Theory (network relationships and structural embeddedness)
Stakeholder Coordination Issues	Gaps between stakeholders including researchers, TTOs, university managers, industry, and government	Othman et al. (2014)	Social Network Theory (multi-stakeholder network coordination)

Source: Authors, 2025

Table 6: *Innovation Gaps Cluster 6 – Market Orientation & Commercial Focus Gaps.*

Innovation Gaps	Description	Source	Relevant Theory
Limited Market Research Capabilities	Insufficient market research and lack of awareness of market requirements by researchers	Khademi et al. (2015)	Dynamic Capabilities Theory (value creation and capture through market intelligence)

Source: Authors, 2025

Barriers, and Stakeholder Coordination & Collaboration Gaps.

3. METHODS

3.1 Research Design and Data Sources

As per **Table 7, Table 8** and **Table 9**, this research employs comparative policy analysis design using triangulated multi-qualitative approach with three data sources ensuring reliability through convergent validation.

Trustworthiness and Validity Measures: To ensure rigour and trustworthiness, the study employed member checking whereby Tier 2 interviewees were able to edit and review their submission via SurveyMonkey for verification and accuracy; maintaining a detailed audit trail via detailed documentation of analytical decisions, coding processes, and theme maturation; conducting peer debriefings with Supervisors to challenge assumptions; and using triangulation across data sources and methods to verify outcomes.

3.2 Data Collections

Policy Analysis: Thematic analysis following Krippendorff's (2004) method examined institutional processes. This covered all five research universities

Table 7: *Data Sources, Types and Collection Methods.*

Data Source	Type	Specific Data Collected	Collection Method	Sample Size	Purpose
Primary Literature	Secondary	Official policy documents, commercialisation guidelines, technology transfer frameworks	Document analysis	Five Documents (100% of Research Universities' Policies)	Identify institutional processes and operational constraints
Secondary Literature	Secondary	Academic articles on commercialisation strategies, existing theories and innovation gaps	Systematic literature review	Multiple databases	Support policy analysis with theoretical foundation and literature review
Stakeholder Interviews	Primary	TTO experiences, innovation gaps validation, commercialisation challenges	Tier 1 TTO – Unstructured interviews Tier 2 TTO Structured interviews	Five TTOs (100% of Research Universities)	Validate findings and identify additional gaps

Source: Authors, 2025

Table 8: *Data Source Cross-Validation Matrix.*

Validation Process	Primary Literature	Secondary Literature	Stakeholder Interviews	Reliability & Credibility Purpose
Policy Framework Validation	Identifies formal institutional constraints.	Provides theoretical context for policy effectiveness	Confirms practical implementation challenges	Cross-verification of policy-practice gaps
Innovation Gap	Documents official support mechanisms	Offers academic explanations for commercialisation barriers	Validates gaps through practitioner experience	Triangulated identification of persistent issues
Commercialisation Process Verification	Outlines prescribed procedures	Presents best practice frameworks	Reveals actual operational realities	Multi-source validation of process effectiveness
Institutional Context Validation	Establishes regulatory environment	Provides comparative international perspectives	Confirms local application challenges	Comprehensive understanding through source convergence

Source: Authors, 2025

Table 9: *Data Triangulation Matrix.*

Validation Method	Primary Literature	Secondary Literature	Stakeholder Interviews	Purpose
Source Triangulation	Policy document themes	Academic theory validation	Practitioner experiences	Convergent validation of gaps
Method Triangulation	Document analysis	Literature review	Semi-structured interviews	Multiple data collection methods
Investigator Triangulation	Independent coding	Mapping to the stakeholder validated innovation gaps identified from the thematic analysis of institutional policies	Participant prior completion of the SurveyMonkey form	Reduce researcher bias
Theory Triangulation	Policy framework analysis	Multiple theoretical lenses and six literature review clusters	Practical validation	Comprehensive understanding

Source: Authors, 2025

Table 10: *Tier 2 Interview Participant Details.*

University	Number of participants	Positions	Interview Mode
UTM	3	Director and Officers	SurveyMonkey & Face-to-Face
USM	1	Director	SurveyMonkey & Face-to-Face
UM	1	Director	SurveyMonkey & Face-to-Face
UKM	4	Deputy Director and Officers	SurveyMonkey & Google Meet
UPM	1	Deputy Director	SurveyMonkey & Google Meet
Total	10	3 Directors, 2 Deputy Directors and 5 Officers	Mixed Mode

Source: Authors, 2025

Universiti Sains Malaysia (USM), Universiti Teknologi Malaysia (UTM), Universiti Kebangsaan Malaysia (UKM), Universiti Putra Malaysia (UPM) and Universiti Malaya (UM). Documents were purposively selected from verified government portals and institutional databases.

Stakeholder Interviews: As per **Table 10**, comprehensive interviews with TTO personnel from all Malaysian research universities achieved 100% coverage. Data collection ensued in May-June 2025. Sessions lasted 2.5-3.0 hours.

3.3 Innovation Gaps Analysis Process

As presented by **Figure 2**, a structured three-tier validation process as per Malodia et al.'s (2023) method, progressively refined findings: 1. Zero Order List: Combined gaps from policy analysis and initial Tier 1 TTO feedback; 2. First Order List: Validated and expanded gaps from comprehensive Tier 2 TTO interviews. This used weighted scoring (16 points to 1st place, down to 1 point for 16th place); 3. Second Order List: Final gaps after considering government support availability.

3.4 Conceptual Framework

The Pre-Transfer Market Readiness Gaps Conceptual Framework (**Figure 3**) provides multi-theoretical analysis addressing theoretical fragmentation in technology transfer research. Building on Romanowski's (2019) three-dimensional success model, the framework introduces sphere of control analysis distinguishing controllable pre-transfer activities from uncontrollable post-transfer outcomes. The framework integrates six complementary perspectives from Dzakiy et al. (2023): Institutional Theory, Resource-Based View, Organisation Theory, Social Network Theory, Dynamic Capabilities Theory, and Resource Orchestration Theory.

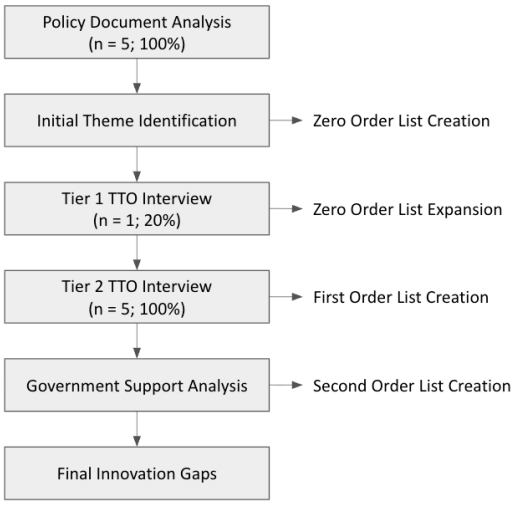

Figure 2. *Innovation Gaps Development Process*

4. RESULTS

4.1 Policy Analysis: Systematic Thematic Analysis of Malaysian Research Universities

This section presents systematic thematic analysis of commercialisation policies from five Malaysian research universities (UTM, UKM, UM, UPM, and USM) using Braun and Clarke's (2006) thematic analysis methodology, identifying patterns, similarities and gaps across institutional approaches to intellectual property commercialisation.

4.1.1 Thematic Mapping of Institutional Policies

The systematic analysis followed Braun and Clarke's (2006) three-step methodology. Step 1 (Thematic Map of Institutional Policies) established seven primary themes as the foundational framework (see **Figure 4**). Step 2 (Initial Thematic Analysis) created preliminary thematic analysis for each theme (**Figures 5-10**), analysing relationships between current commercialisation practices and established themes. Step 3 (Final Thematic Analysis) transformed the approach by enhancing the thematic framework to focus on innovation gaps, reassigning analysis from theme-based to gap-based codes (RU1-RU5), illustrated in final thematic maps (**Figures 11-16**).

4.1.2 Analysis of Seven Institutional Themes

The initial seven themes (**Figures 5-11**) provided the foundation for understanding policy variations. Theme

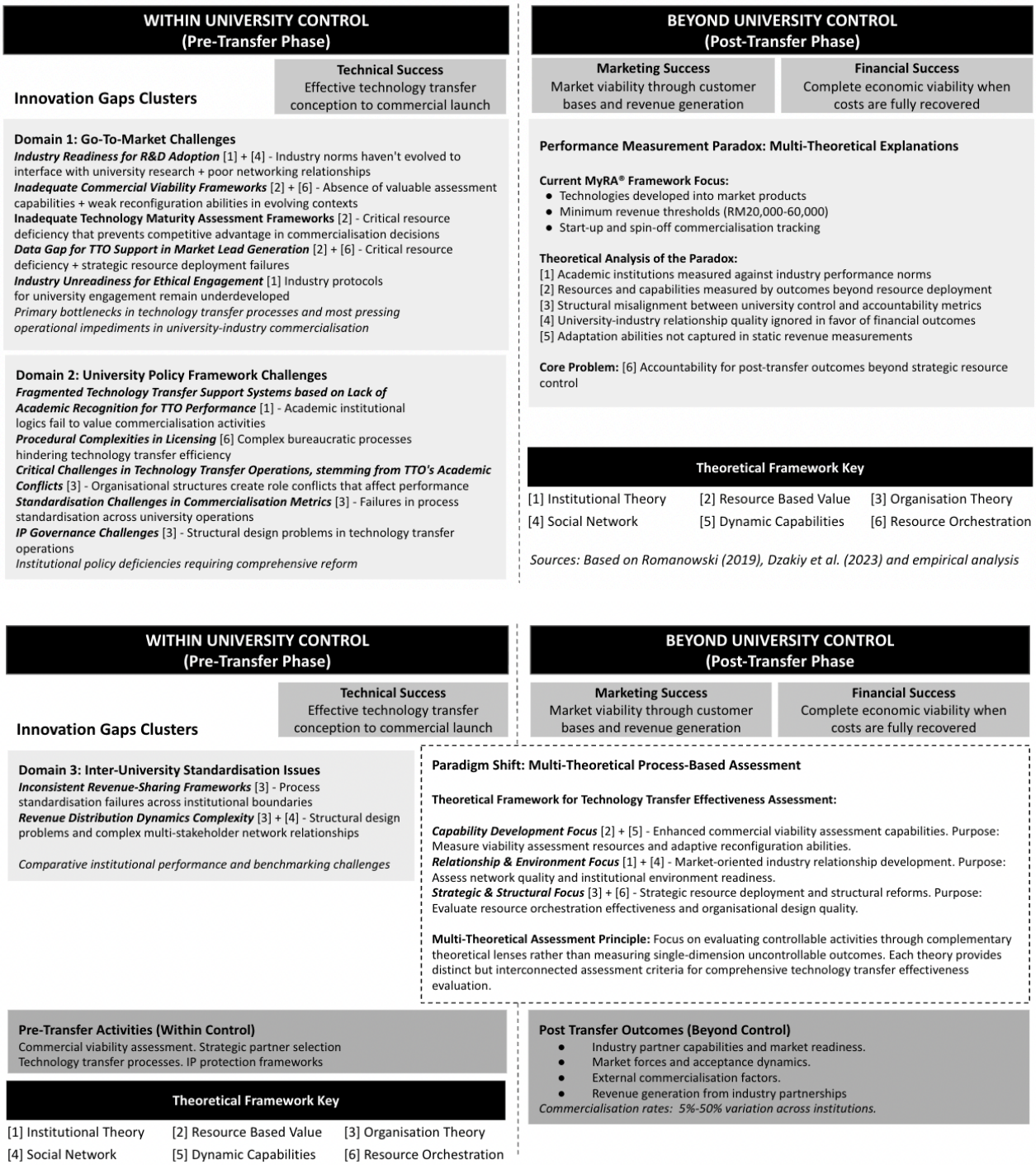

Figure 3. *Pre-Transfer Market Readiness Gaps Conceptual Framework*

1 (Definition of Commercialisation) shows that most universities lack clear definitions, with only UM offering clarity as "taking of an idea to an outcome – whether a product, service, process or organisation system to market by way of licensing, assignment, spin-off or joint ventures" (UM Centre of Innovation and Enterprise, 2014).

Theme 2 (IP Ownership) illustrates varied approaches, from UM's conditional ownership (UM Centre of Innovation and Enterprise, 2014) to USM's worldwide ownership policy (Universiti Sains Malaysia, 2020). Theme 3 (Commercialisation Processes) reveals diverse approaches. UTM implemented an integrated ecosystem combining ICCubeX incubator, Radis and Innocomms platforms (Innovation and Commercialisation Centre, 2022), while UKM manages IP through INOVASI@UKM (Pusat Inovasi Kolaboratif, 2018).

Theme 1: Definition of Commercialisation

UTM

Not specified by policy document.

UKM

Not specified by policy document.

UM

"Taking of an idea to an outcome – whether a product, service, process or organisation system to market by way of licensing, assignment, spin-off or joint ventures".

UPM

Not specified by policy document.

USM

Not specified by policy document.

Theme 2: IP Ownership Models

UTM

- No specific ownership requirements.
- Uses: patents, copyright, trademark, integrated circuit layout design, industrial design, trade secrets.

UKM

- No specific ownership requirements.
- Uses: patent, copyright, trademark, integrated circuit layout design, industrial design.

UM

- Conditional/Collaborative Ownership: UM typically retains sole ownership but allows joint ownership when external collaborators make substantial contributions.
- Default: UM solely owns IP, others have first right to negotiate commercial license.

UPM

- Full university ownership: UPM holds ownership rights to all IP created by teachers, students or staff.
- Committed to protect these rights under the law.

USM

- Full university ownership: USM claims worldwide ownership of all IP by staff, students, fellows including commissioned projects.
- Assigns IP back when university decides against protection/commercialisation.

Theme 3: Processes and Methods

UTM

- 6-Stage Commercialisation Ecosystem: 1. Fundamental research; 2. Translational research; 3. Translation; 4. Showcase; 5. Licensing; 6. Spin-offs & Commercialisation.
- Platforms: ICCubeX incubator, Radis, Innocomms.

UKM

- IP Management: Central TTO INOVASI@UKM™ .
- Methods: Licensing to start-ups, foreign companies, joint ventures and partnerships.
- Uses deeds of assignment and diverse commercialisation models.

UM

Comprehensive commercialisation methods - Exclusive/non-exclusive licensing, assignment, spin-offs, joint ventures and other legal means.

UPM

- Methods determined by University from time to time.
- Establishes commercialisation methods to obtain suitable pecuniary returns for wealth creation.

USM

- Licensing Types - Exclusive, non-exclusive, sole, cross-licensing with geographical, temporal and field limitations.
- Decision Body: Commercialisation and Licensing Committee.

Theme 4: Revenue Distribution and Wealth Sharing

UTM

Not specified by policy document.

UKM

- Income Sources: Commercialisation revenue + company dividends.
- Inventor Benefits: Receivable as long as the commercialisation revenue is generated, beyond employment & transferable upon death (subject to approval).

UM

Two revenue sharing models:

- Internal grants: 50%/50% for first RM100K, then sliding scale.
- Federal grants: 100% originator (first RM250K), then tiered: 80%/20%, 60%/40%, 50%/50%, 40%/60%.
- After deducting development, protection and marketing costs.

UPM

- University obtains suitable pecuniary returns for wealth creation.
- Benefits derived for common advantage without detriment to university.

USM

Dual Income Structure:

- Gross Income: 30% originators, 70% university.
- Net Income Tiers: 70%/30%, 65%/35%, 60%/40%, 50%/50% based on revenue thresholds
- Multiple originators need written agreements.

Theme 5: Spin-offs and Start up Companies

UTM

- 15-step establishment process: Application → Discussion → Endorsement → Certification → JPU approval → Company registration → Recognition certificate issuance.
- Support: Entrepreneurship Encouragement Scheme - special leave for academic staff.

UKM

- Company Formation: UKM supports start-up and spin-off companies by staff and students.
- UKM accommodates university start-up companies for IP commercialisation.

UM

Business Entity Structure:

- UM establishes companies with originator and UM equity.
- UM offers minimum 20-30% equity in spin-offs.
- Researchers may request higher equity.
- Factors: IP value, patent strength, researcher commitment, service length and business potential.

UPM

Not specified by policy document.

USM

Multiple Entity Types:

- Start-ups: Founder-established with founder and university equity.
- Spin-offs: USM-established with licensing agreements.
- Joint Ventures: With third parties for IP commercialisation.
- Equity considers IP value, patent strength and commitment.

Theme 4 (Revenue Distribution and Wealth Sharing) demonstrates significant variations, with UM offering sliding scales (UM Centre of Innovation and Enterprise, 2014) and USM adopting tiered systems from 70%/30% to 50%/50% (Universiti Sains Malaysia, 2020). Theme 5 (Spin-offs and Start-up Companies) features UTM's fifteen-step establishment process and Entrepreneurship Encouragement Scheme (Innovation and Commercialisation Centre, 2022).

Theme 6 (Collaborative Arrangements) highlights UTM's Quadruple Helix Model, integrating education, research, government and community sectors

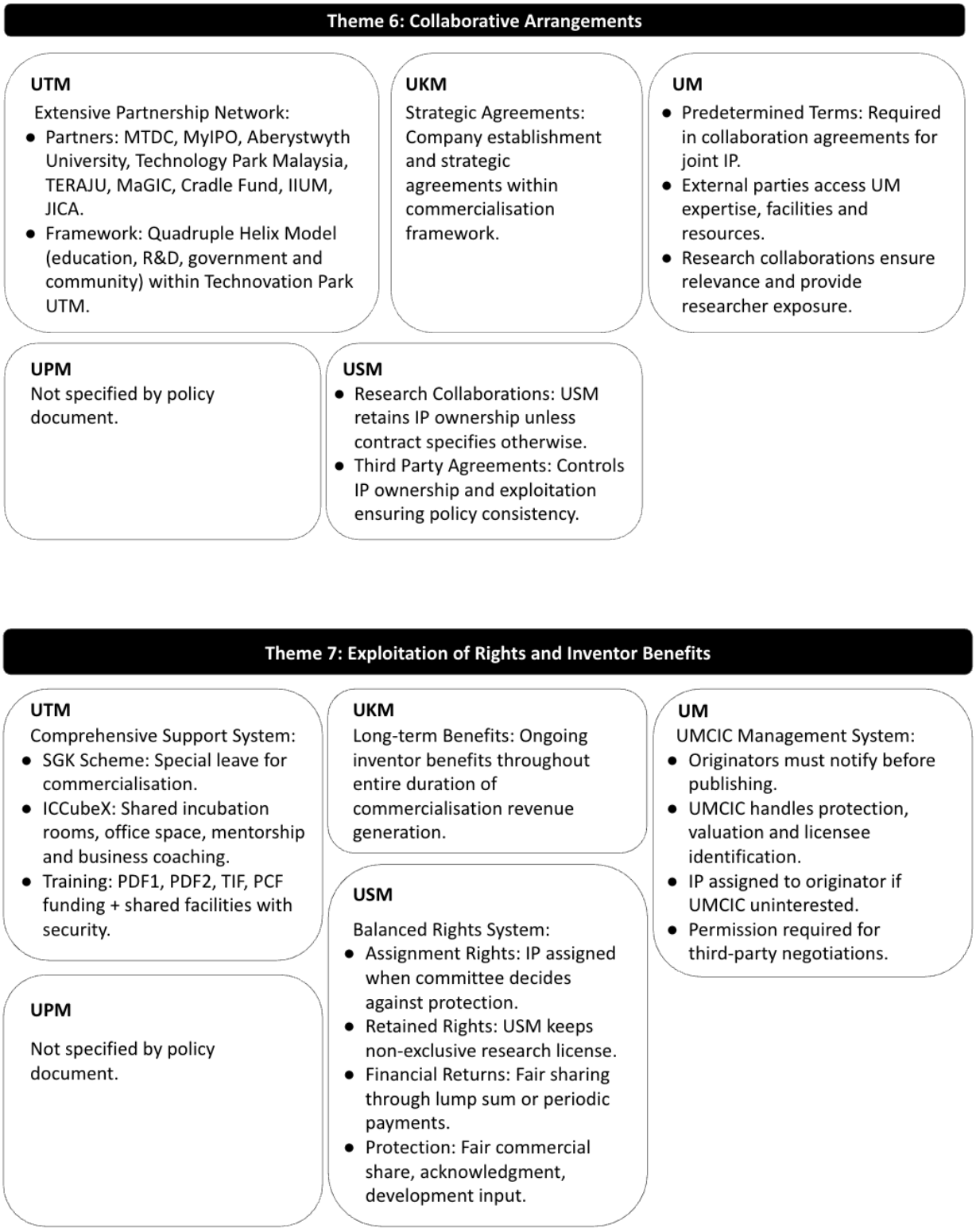

Figure 4. *Thematic Map of the Malaysia Institutional Commercialisation Policies*

Note: The above information was extracted from the commercialisation policies of all Malaysian public universities as follows:-
a) UTM - Innovation and Commercialisation Centre (2022)
b) UKM - Pusat Inovasi Kolaboratif (2018)
c) UM - UM Centre of Innovation and Enterprise (2014)
d) UPM - Universiti Putra Malaysia (2013)
e) USM - Universiti Sains Malaysia (2020)

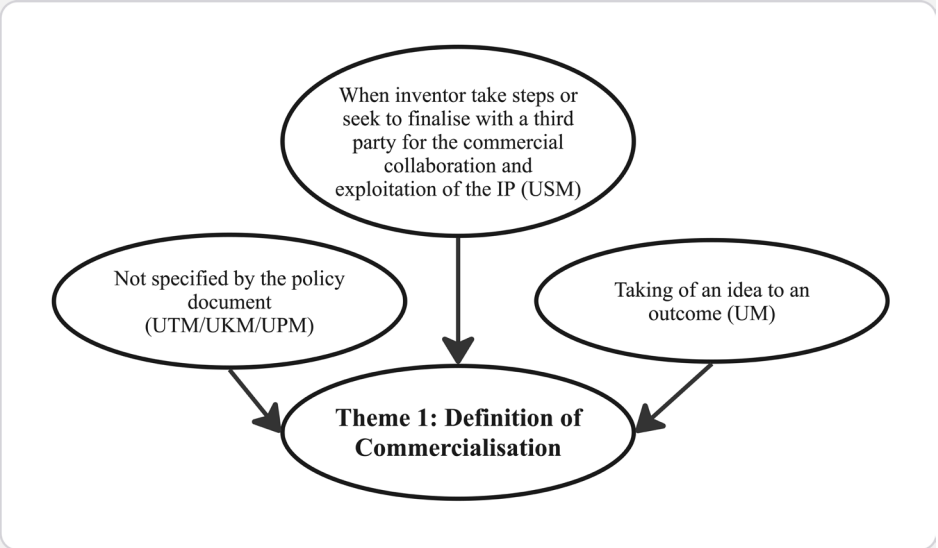

Figure 5. *Initial Thematic Analysis of Theme 1: Definition of Commercialisation*

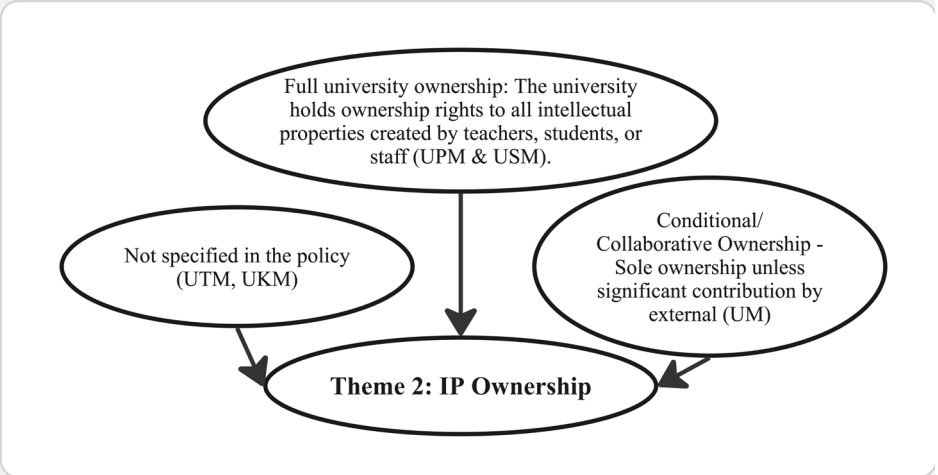

Figure 6. *Initial Thematic Analysis of Theme 2: IP Ownership*

(Innovation and Commercialisation Centre, 2022). Theme 7 (Exploitation Rights and Inventor Benefits) shows notable disparities in institutional support mechanism for inventors, ranging from UTM's entrepreneurship comprehensive incubation support to USM's flexible IP.

This disparity based on policy analysis suggests lack of institutional isomorphism, with universities operating in isolation rather than adopting common practices. The absence of clear definitions indicates weak institutional legitimacy, potentially undermining stakeholder confidence. Diverse IP ownership approaches and revenue distribution models reflect institutional uncertainty about optimal resource orchestration strategies.

4.1.3 Critical Innovation Gaps Identified

Step 3 progressed analytical focus from seven themes to five critical innovation gaps recognising that identified issues transcended individual themes and required gap-specific coding (**Figures 12-16**). Gap Code RU1 (Constraints in Inventor Participation), emerged from institutional variations in researcher engagement frameworks. UM's policy requires notification before publication and mandatory permission-seeking (UM Centre of Innovation and Enterprise, 2014) contrasted with UTM's Entrepreneurship Encouragement Scheme, enabling special leave, revealing inconsistent approaches to balancing academic and commercial responsibilities.

Gap Code RU2 (Absence of Standardised Definitions, **Figure 13**), was evident as most institutions lack explicit commercialisation definitions, hampering ecosystem communication and coordination. Gap Code RU3 (Fragmented Technology Transfer Support Systems, **Figure 14**), demonstrates universities providing support for the researchers but not for the TTOs. Gap Code RU4 (Inconsistent Revenue-Sharing Frameworks, **Figure 15**) reflects diverse inventor compensation, creating complexity in the revenue distribution. Finally, Gap Code RU5 (Inadequate Commercial Viability Assessment Frameworks,

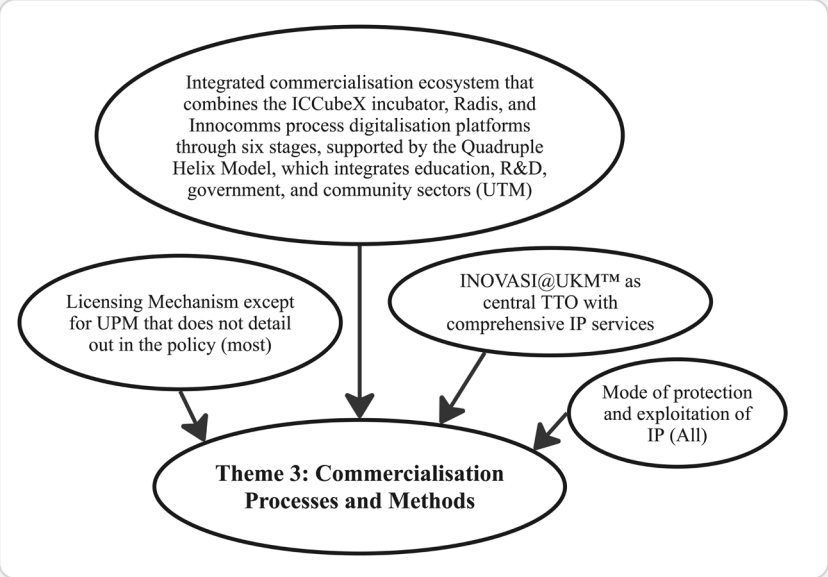

Figure 7. *Initial Thematic Analysis of Theme 3: Commercialisation Processes and Methods*

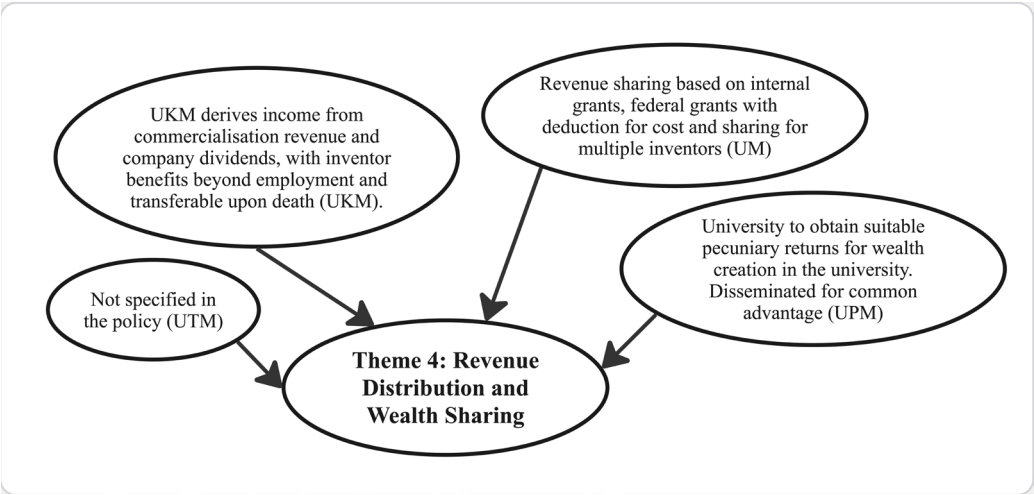

Figure 8. *Initial Thematic Analysis of Theme 4: Revenue Distribution and Wealth Sharing*

Figure 16), highlights absence of standardised evaluation metrics for assessing technology maturity and commercial potential.

This analytical exercise enabled precise identification of systemic barriers that collectively impede Malaysia's research commercialisation effectiveness. Rather than isolated policy flaws, challenges in technology transfer stem from institutional misalignments. "Constraints in Inventor Participation" (RU1) reflect weak organisational cultures that fail to bridge academic and commercial domains, consistent with institutional theory's prediction of conflicting logics. Meanwhile, the "Absence of Standardised Definitions" (RU2) reveals an institutional void, where the lack of shared frameworks hampers inter-organisational coordination and knowledge transfer. The final point to note is that while certain issues remain localised in scope, the critical innovation gaps identified as Gap Code RU2 and Code RU4 have far-reaching implications that significantly impact the national commercialisation rate.

4.2 Stakeholder Interview Results

4.2.1 Tier 1 TTO Insights - Framework Expansion

Tier 1 TTO interviews expanded the framework from five policy gaps to sixteen challenges, revealing complex operational realities beyond policy matters. Key restructuring occurred: RU2 shifted from standardisation issues to "Constraints in Inventor Participation - Lack of Recognition", with standardisation moving to RU3. The

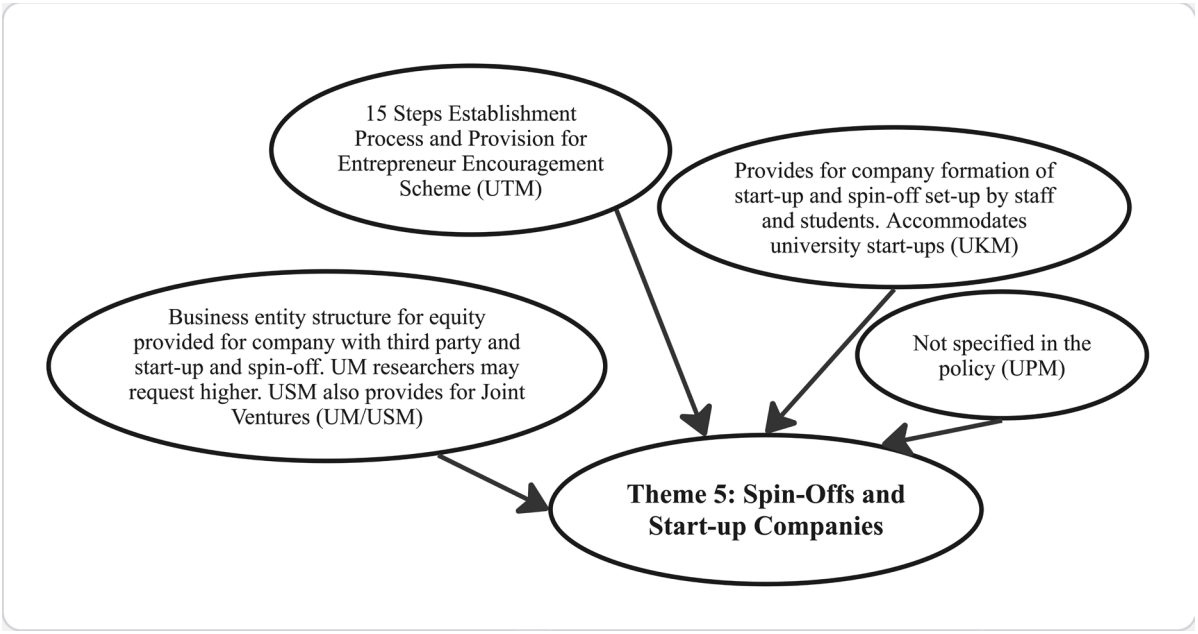

Figure 9. *Initial Thematic Analysis of Theme 5: Spin-offs and Start-up Companies*

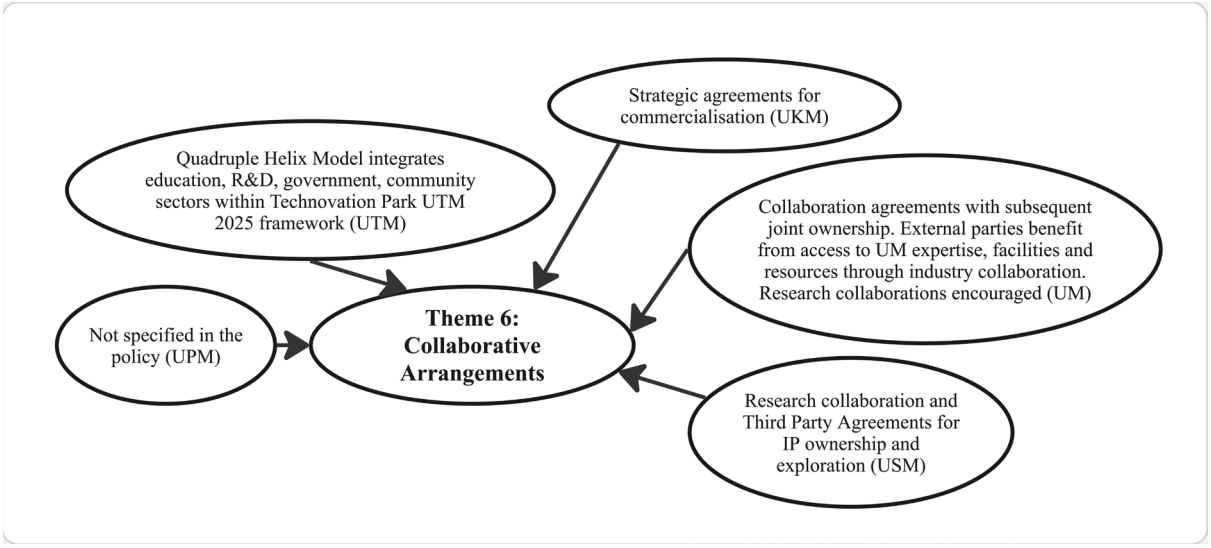

Figure 10. *Initial Thematic Analysis of Theme 6: Collaborative Arrangements*

TTO noted "methodology variance across institutions obfuscated direct comparisons due to absence of standardised protocols".

Nine new gaps (RU8-RU16) emerged, previously unseen in policy analysis such as RU8 (Data for TTO Market Lead Generation Support) due to "current limitations in deal tracking with data analytics capabilities". Resource allocation concerns include RU9 (Inadequate Commercial Viability Framework) and RU10 (Inadequate Technology Maturity Assessment), with universities using "Technology Readiness Level (TRL) scale as self-assessment tool" with no standardised protocols.

Critical industry challenges emerged: RU14 (Lack of Industry Readiness for R&D Adoption) evidenced by industry reluctance towards trial costs and workforce expansion, and RU16 (IP Governance Challenges) where industrial partners bypassed university protocols through direct researcher compensation via honoraria.

4.2.2 Tier 2 TTO Validation and Ranking

The systematic three-tier approach identified and prioritised sixteen innovation gaps using weighted scoring by perceived importance, assigning 16 points to 1st place, down to 1 point for 16th place. The weighted scoring system ranked 16 innovation issues by perceived importance, with SurveyMonkey's algorithm assigning 16 points to 1st place, 15 points to 2nd place, and so on, sequentially down to 1 point for 16th place. Final

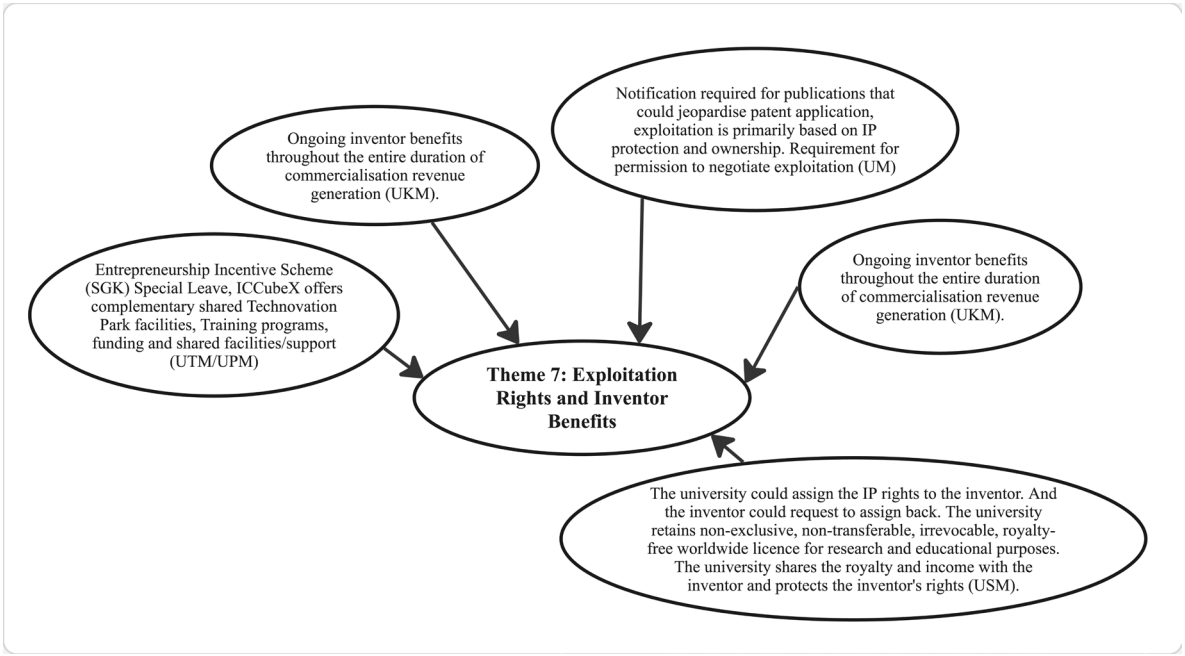

Figure 11. *Initial Thematic Analysis of Theme 7: Exploitation Rights and Inventor Benefits*

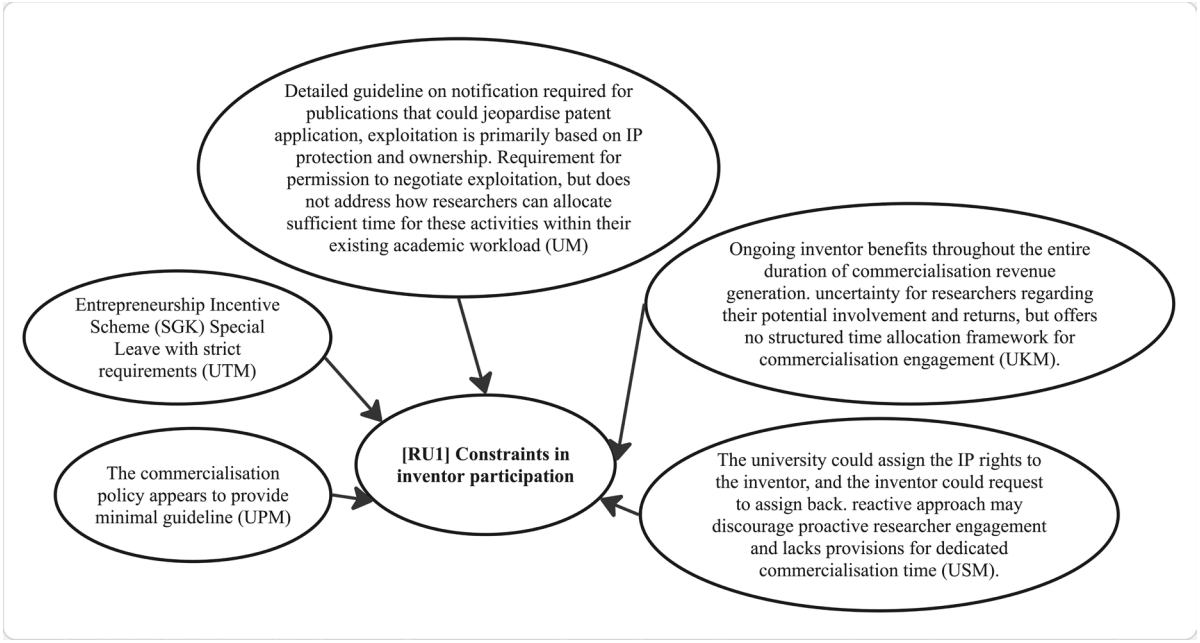

Figure 12. *Final Thematic Analysis of Gap Code RU1*

scores were calculated by multiplying the percentage of respondents who ranked each issue at each position by the corresponding point values for that position, then summing these weighted values across all ranking positions as presented in **Table 11**.

4.2.2.1 First Order List: Complete TTO Priority Ranking

The interview responses from the five Tier 2 TTOs strongly validate the top-ranked innovation gaps, particularly RU1 (Lack of Industry Readiness for R&D Adoption, score: 14.8) and RU2 (Inadequate Commercial Viability Framework, score: 12.4). TTO A explicitly stated they are "looking for more direct engagement with potential markets," while TTO B reported unsuccessful attempts with currently available private or public sector matching platforms.

RU2's commercial viability framework's inadequacy is starkly demonstrated through the dramatic variation in commercialisation rate calculations across TTOs: TTO A reports 10%, TTO B shows 3.94%, TTO C claims 49%, and TTO E indicates <5%. This inconsistency unveils both RU2 and standardisation gaps (RU11 and RU12), as five

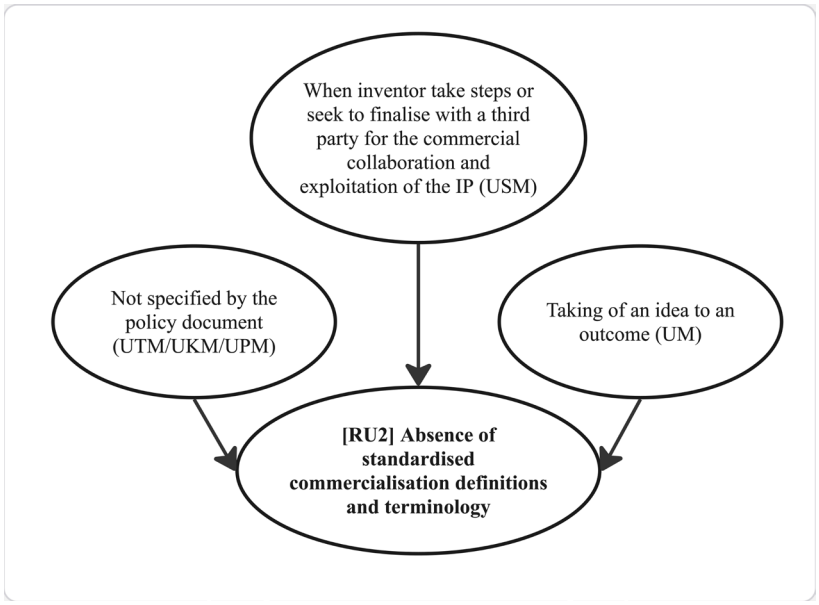

Figure 13: *Final Thematic Analysis of Gap Code RU2*

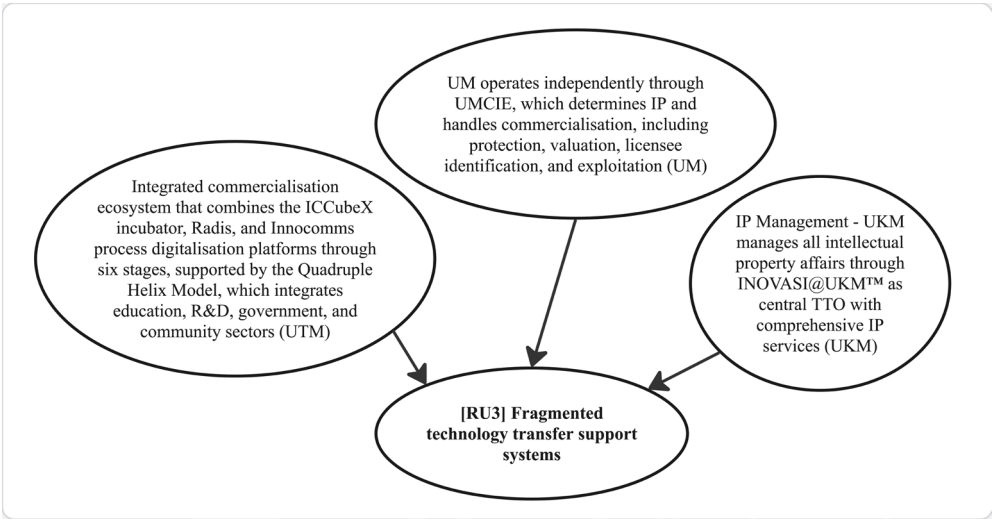

Figure 14. *Final Thematic Analysis of Gap Code RU3*

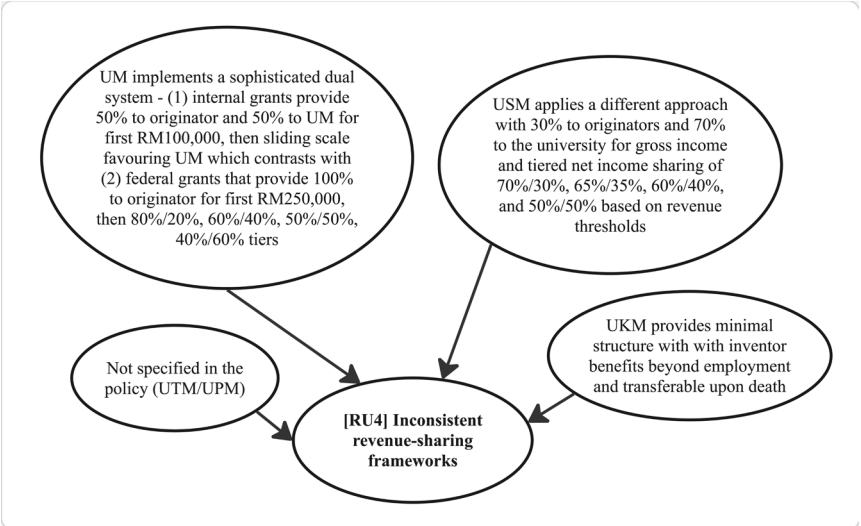

Figure 15. *Final Thematic Analysis of Gap Code RU4*

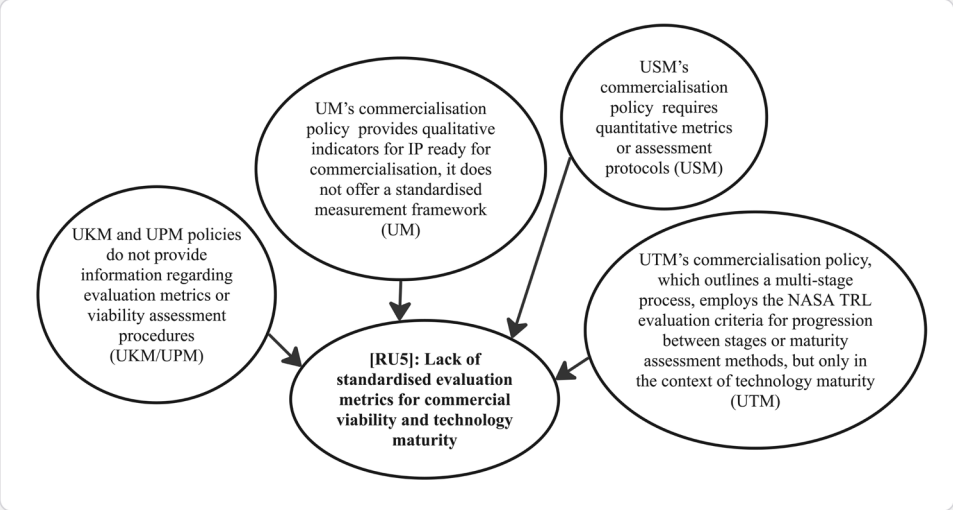

Figure 16: *Final Thematic Analysis of Gap Code RU5*

TTOs indicate five completely different approaches to measuring commercialisation success, verifying the absence of standardised definitions and unified measurement protocols.

Interestingly, the analysis reveals that RU3 (Inadequate Technology Maturity Assessment Frameworks, Score: 12.0) may be less problematic than its ranking suggests, as most interviewed TTOs have included some form of Technology Readiness Level (TRL) framework. TTO A conducts "IP profiling where we profile the IP and determine the TRL level." TTO B uses "NASA TRL (customised)," and TTO D provides a detailed TRL assessment from "basic research (TRL 1) to fully commercialised technology (TRL 9)."

However, the fragmentation challenges (RU5) are evident in TTO B's reliance on multiple disconnected support mechanisms, including government agencies, private and public sector patent platforms, as well as exhibitions. The practical experiences of these TTOs align remarkably well with the theoretical gaps identified, particularly the top-ranked issues around industry engagement and measurement standardisation.

This suggests that the gap prioritisation methodology as presented in **Table 12** accurately reflects real-world challenges facing Malaysian university technology transfer operations.

4.2.2.2 Government Intervention Perceptions: The Critical Filter

Government intervention perceptions served as filter between First and Second Order lists in **Table 12**. "Absence of Standardised Commercialisation Definitions and Terminology" received the highest recognition (60%, n = 3) due to perceived government intervention. This explains its exclusion from the Second Order, despite its significance for government intervention. "Procedural Complexities in Licensing" and "Lack of Industry Readiness for R&D adoption" each received 40% recognition (n=2).

4.2.2.3 Second Order List: Critical Unaddressed Gaps

The Second-Order list in **Table 12** identifies ten critical gaps that require immediate policy attention. Gap Code RU1 "Lack of Industry Readiness for R&D adoption" maintains top ranking (Score: 14.80) despite 40% recognising government initiatives, indicating insufficient current interventions. Gap Code RU2 "Inadequate commercial viability assessment (Score: 12.4), Gap Code RU3 (Inadequate technology maturity assessment" (Score: 12.00) and Gap Code RU4 "Data for TTO market lead generation support" (Score: 11.20) highlight key information and assessment gaps explaining inconsistent assessment practices from TTO A's admission of no formal assessment to TTO E's confirmation of absence of evaluation mechanisms. Additional gaps include Gap Codes RU5-RU10, which address fragmented support systems, standardisation challenges, revenue disparities and procedural complexities.

4.3 Theoretical Integration of Innovation Gaps

Theoretical mapping reveals systematic alignment between established frameworks and empirically-derived commercialisation challenges (see **Table 13**). Resource-based theories address high-scoring technology assessment gaps (RU2, RU3), while Organisation Theory applies across structural and operational challenges (RU4-RU10). Institutional Theory explains gaps involving external pressures and academic-commercial conflicts (RU1, RU5-RU8, RU10), while Social Network Theory addresses relationship-dependent challenges (RU1, RU4, RU6, RU9). The integration demonstrates strong convergence between practitioner-identified gaps and literature-documented barriers across six distinct clusters, with stakeholder &

Table 11: *Scoring of the Tier 2 TTO's Validation and Ranking of Innovation Gaps.*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Score
Constraints in Inventor Participation – Academic conflict	0%	0%	20%	20%	0%	0%	0%	40%	0%	0%	0%	0%	20%	0%	0%	0%	9.8
Constraints in Inventor Participation – Lack of Recognition	0%	0%	0%	0%	20%	0%	60%	0%	0%	0%	0%	20%	0%	0%	0%	0%	9.4
Data for TTO to support the inventor in market lead generation.	0%	20%	20%	0%	0%	20%	0%	0%	40%	0%	0%	0%	0%	0%	0%	0%	11.2
Absence of Standardised Commercialisation Definitions and Terminology.	0%	0%	0%	0%	0%	20%	0%	20%	20%	0%	0%	20%	0%	0%	20%	0%	7
Fragmented Technology Transfer Support System due to the need for TTO's capabilities at a certain standard to support commercialisation	0%	20%	0%	0%	20%	0%	40%	0%	0%	20%	0%	0%	0%	0%	0%	0%	10.8
Fragmented Technology Transfer Support System based on TTO's academic conflict.	0%	0%	0%	0%	0%	25%	0%	25%	0%	25%	25%	0%	0%	0%	0%	0%	8.25
Fragmented Technology Transfer Support System based on lack of academic recognition for TTO performance.	0%	0%	25%	0%	0%	0%	0%	25%	25%	25%	0%	0%	0%	0%	0%	0%	9.5
Inconsistent Revenue-Sharing Frameworks from the need for streamlining and accuracy of institutional performance reporting.	0%	0%	0%	0%	0%	20%	0%	0%	0%	20%	40%	0%	0%	0%	0%	20%	6.2
Inadequate Commercial Viability Framework from the need to avoid misallocating resources to commercially unviable and projects that lack technology maturity.	20%	20%	0%	20%	20%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	12.4
Inadequate Technology Maturity Assessment Frameworks the need to avoid misallocating resources to commercially unviable projects lacking technological maturity.	20%	0%	20%	20%	20%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	12
Standardisation Challenges in Commercialisation Metrics absence of unified measurement protocols in research commercialisation to calculate the commercialisation rate.	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	20%	20%	40%	0%	0%	0%	6.4
Revenue Distribution Dynamics in Technology Transfer from the multi-stakeholder nature of commercialisation revenue distribution.	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	20%	20%	40%	0%	0%	4.4
Procedural Complexities in Licensing as the licensing process encounters significant temporal challenges due to institutional governance requirements.	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	20%	20%	40%	0%	3.8
Lack of Industry Readiness for R&D adoption.	60%	0%	20%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	14.8
Critical Challenges in Technology Transfer Operations from lack of industry readiness in ethical dealing with the university.	0%	40%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	20%	20%	0%	9.2
IP Governance Challenges from governance breaches where industrial partners circumvented institutional protocols through direct researcher compensation via honoraria for IP development.	0%	0%	0%	20%	0%	0%	0%	0%	20%	0%	0%	0%	0%	20%	0%	60%	3.8

Source: Authors, 2025

Note: An example of the calculation for the scoring, "Constraints in Inventor Participation – Academic Conflict" scored 9.8: 20% ranked it 3rd (14×0.20=2.8), 20% ranked it 4th (13×0.20=2.6), 40% ranked it 8th (9×0.40=3.6) and 20% ranked it 13th (4×0.20=0.8).

Table 12: *Ranking of TTOs' Innovation Gaps – Zero, First and Second Order.*

Gap Code	Innovation gaps (Zero Order)	Gap Code	Innovation gaps (Expanded Zero Order)	Gap Code	Innovation gaps (First Order)	Score	Final Gap Code	Innovation gaps (Second Order)	Score
RU1	Constraints in Inventor Participation - Academic conflict	RU1	Constraints in Inventor Participation - Academic conflict	RU1	Lack of Industry Readiness for R&D adoption.	14.8	RU1	Lack of Industry Readiness for R&D adoption*	14.8
RU2	Absence of Standardised Commercialisation Definitions and Terminology.	RU2	Constraints in Inventor Participation - Lack of Recognition	RU2	Inadequate Commercial Viability Framework from the need to avoid misallocating resources to commercially unviable and projects that lack technology maturity.	12.4	RU2	Inadequate Commercial Viability Framework from the need to avoid misallocating resources to commercially unviable and projects that lack technology maturity.	12.4
RU3	Fragmented Technology Transfer Support System	RU3	Absence of Standardised Commercialisation Definitions and Terminology.	RU3	Inadequate Technology Maturity Assessment Frameworks the need to avoid misallocating resources to commercially unviable projects lacking technological maturity.	12	RU3	Inadequate Technology Maturity Assessment Frameworks the need to avoid misallocating resources to commercially unviable projects lacking technological maturity.	12
RU4	Inconsistent Revenue-Sharing Frameworks	RU4	Fragmented Technology Transfer Support System due to the need for TTO's capabilities at a certain standard to support commercialisation	RU4	Data for TTO to support the inventor in market lead generation.	11.2	RU4	Data for TTO to support the inventor in market lead generation.	11.2
RU5	Lack of standardised evaluation metrics	RU5	Fragmented Technology Transfer Support System based on TTO's academic conflict.	RU5	Fragmented Technology Transfer Support System due to the need for TTO's capabilities at a certain standard to support commercialisation*	10.8	RU5	Fragmented Technology Transfer Support System based on lack of academic recognition for TTO performance.	9.5
		RU6	Fragmented Technology Transfer Support System based on lack of academic recognition for TTO performance.	RU6	Constraints in Inventor Participation - Academic conflict*	9.8	RU6	Critical Challenges in Technology Transfer Operations from lack of industry readiness in ethical dealing with the university.	9.2
		RU7	Inconsistent Revenue-Sharing Frameworks from the need for streamlining and accuracy of institutional performance reporting.	RU7	Fragmented Technology Transfer Support System based on lack of academic recognition for TTO performance.	9.5	RU7	Fragmented Technology Transfer Support System based on TTO's academic conflict.	8.25
		RU8	Data for TTO to support the inventor in market lead generation.	RU8	Constraints in Inventor Participation - Lack of Recognition*	9.4	RU8	Standardisation Challenges in Commercialisation Metrics absence of unified measurement protocols in research commercialisation to calculate the commercialisation rate.	6.4

Gap Code	Innovation gaps (Zero Order)	Gap Code	Innovation gaps (Expanded Zero Order)	Gap Code	Innovation gaps (First Order)	Score	Final Gap Code	Innovation gaps (Second Order)	Score
		RU9	Inadequate Commercial Viability Framework from the need to avoid misallocating resources to commercially unviable and projects that lack technology maturity.	RU9	Critical Challenges in Technology Transfer Operations from lack of industry readiness in ethical dealing with the university.	9.2	RU9	Revenue Distribution Dynamics in Technology Transfer from the multi-stakeholder nature of commercialisation revenue distribution.	4.4
		RU10	Inadequate Technology Maturity Assessment Frameworks the need to avoid misallocating resources to commercially unviable projects lacking technological maturity.	RU10	Fragmented Technology Transfer Support System based on TTO's academic conflict*	8.25	RU10	IP Governance Challenges from governance breaches where industrial partners circumvented institutional protocols through direct researcher compensation via honoraria for IP development.	3.8
		RU11	Standardisation Challenges in Commercialisation Metrics absence of unified measurement protocols in research commercialisation to calculate the commercialisation rate.	RU11	Absence of Standardised Commercialisation Definitions and Terminology.	7			
		RU12	Revenue Distribution Dynamics in Technology Transfer from the multi-stakeholder nature of commercialisation revenue distribution.	RU12	Standardisation Challenges in Commercialisation Metrics absence of unified measurement protocols in research commercialisation to calculate the commercialisation rate.	6.4			
		RU13	Procedural Complexities in Licensing from the licensing process encounters significant temporal challenges due to institutional governance requirements.	RU13	Inconsistent Revenue-Sharing Frameworks from the need for streamlining and accuracy of institutional performance reporting.	6.2			
		RU14	Lack of Industry Readiness for R&D adoption.	RU14	Revenue Distribution Dynamics in Technology Transfer from the multi-stakeholder nature of commercialisation revenue distribution.	4.4			

Gap Code	Innovation gaps (Zero Order)	Gap Code	Innovation gaps (Expanded Zero Order)	Gap Code	Innovation gaps (First Order)	Score	Final Gap Code	Innovation gaps (Second Order)	Score
		RU15	Critical Challenges in Technology Transfer Operations from lack of industry readiness in ethical dealing with the university.	RU15	Procedural Complexities in Licensing as the licensing process encounters significant temporal challenges due to institutional governance requirements*	3.8			
		RU16	IP Governance Challenges from governance breaches where industrial partners circumvented institutional protocols through direct researcher compensation via honoraria for IP development.	RU16	IP Governance Challenges from governance breaches where industrial partners circumvented institutional protocols through direct researcher compensation via honoraria for IP development.	3.8			

Source: Authors, 2025

Note: For the Second Order list, the Innovation gaps with government intervention based on perceptions of TTOs which are marked with (*) under the First Order list were removed. This is with the exception of "Lack of Industry Readiness for R&D adoption" due to the high score of 14.8 as issue rank.

Table 13: *Mapping of Innovation Gaps to Existing Theories and Literature Review.*

Final Gap Code	Innovation Gaps (Second Order)	Applicable Existing Theories	Literature Review Alignment
RU1	Lack of **industry readiness** for R&D adoption.	**Institutional Theory** (external environment shaping industry-university interactions) **Social Network Theory** (industry-university relationship dynamics)	Cluster 5: Stakeholder Coordination and Collaboration Gaps - Weak Cooperation Between Stakeholders (Mudaa et al., 2021)
RU2	Inadequate **commercial viability assessment**	**Resource Based View** (identifying commercially valuable technologies) **Dynamic Capabilities** (developing assessment capabilities) **Resource Orchestration Theory** (strategic resource allocation)	Cluster 6: Market Orientation and Commercial Focus Gaps - Limited Market Research Capabilities (Khademi et al., 2015)
RU3	Inadequate **technology maturity assessment**	**Resource Based View** (assessing technology value and readiness) **Dynamic Capabilities** (adapting assessment methodologies) **Resource Orchestration Theory** (strategic technology selection)	Cluster 6: Market Orientation and Commercial Focus Gaps - Limited Market Research Capabilities (Khademi et al., 2015)
RU4	**Data** to support the inventor in market lead generation	**Resource Based View** (data as strategic resource) **Organisation Theory** (TTO support structures) **Social Network Theory** (market connection networks)	Cluster 3: Financial Constraints – Inadequate Infrastructure (Khademi et al., 2015)
RU5	Fragmented technology transfer support based on **lack of academic recognition for TTO performance**	**Organisation Theory** (support system structures) **Institutional Theory** (academic reward systems and recognition)	Cluster 4: Organisational and Cultural Barriers - Weak Control Systems (Yusof et al., 2012)
RU6	Critical Challenges in technology transfer operations from **lack of industry readiness in ethical dealing with the universit**y	**Institutional Theory** (ethical norms and industry standards) **Social Network Theory** (trust and relationship quality)	Cluster 5: Stakeholder Coordination and Collaboration Gaps - Stakeholder Coordination Issues (Othman et al., 2014)
RU7	Fragmented Technology Transfer Support System based on **TTO's academic conflict**	**Organisation Theory** (internal conflict resolution structures) **Institutional Theory** (competing institutional pressures)	Cluster 4: Organisational and Cultural Barriers - Organisational Culture Barriers (Yusof et al., 2012)
RU8	Standardisation Challenges in Commercialisation Metrics **absence of unified measurement protocols** in research commercialisation **to calculate the commercialisation rate**	**Organisation Theory** (measurement and evaluation processes) **Institutional Theory** (standardisation across institutions)	Cluster 1: Strategic and Policy Gaps - Lack of Policy Uniformity (Mudaa et al., 2021)
RU9	**Revenue distribution dynamics in technology transfer** from the multi-stakeholder nature of commercialisation revenue distribution	**Organisation Theory** (revenue allocation processes) **Social Network Theory** (multi-stakeholder coordination)	Cluster 5: Stakeholder Coordination and Collaboration Gaps - Stakeholder Coordination Issues (Othman et al., 2014)
RU10	IP governance challenges from **governance breaches where industrial partners circumvented institutional protocols** through direct researcher compensation via honoraria for IP development	**Organisation Theory** (governance and control mechanisms) **Institutional Theory** (institutional compliance and protocol enforcement)	Cluster 1: Strategic and Policy Gaps - Protective IP Strategy Limitations (Sarujee et al., 2022; Palfrey, 2011)

Source: Authors, 2025

coordination gaps (Cluster 5) emerging as most prevalent in practice. Notably, multiple theories could apply to each innovation gaps as per the case with Gap Code RU1.

The literature review validation confirms that strategic & policy gaps (Cluster 1) manifest as standardisation and IP governance challenges in practice (RU8, RU10). Organisational & cultural barriers (Cluster 4) translate directly into fragmented support systems and academic conflicts (RU5, RU7). Stakeholder & coordination gaps (Cluster 5) emerge as critical operational challenges across multiple dimensions of industry readiness and multi-stakeholder dynamics (RU1,

RU6, RU9). Market orientation deficiencies (Cluster 6) validate assessment capability gaps in both commercial viability and technology maturity evaluation (RU2, RU3).

This integration validates that stakeholder-identified challenges are multi-dimensional, requiring complementary theoretical perspectives spanning resource management, organisational design, institutional compliance, and network relationships to understand university-technology commercialisation dynamics. The convergence between empirical findings and established literature strengthens the theoretical foundation whilst confirming the practical relevance of documented innovation gaps in Malaysian university commercialisation contexts.

4.4 Global Benchmarking

This comparative analysis examines Malaysia's technology transfer performance against international best practices across Europe, Asia, and the United States. Resource orchestration theory is particularly well-suited for this comparative analysis because it provides a holistic framework that examines how organisations systematically coordinate and leverage multiple resource types simultaneously. The analysis reveals systematic resource orchestration gaps rather than isolated policy deficiencies across four critical dimensions: human resources, social networks, financial configuration, and technology management.

4.4.1 Key Performance Deficits Identified

Human Resource Orchestration: International leaders demonstrate systematic inventor engagement strategies. KU Leuven's 30% revenue distribution model generated more than 124 spin-offs over 50 years. KAIST's systematic training achieved comprehensive patent portfolio management. Malaysia shows fragmented revenue sharing, limited systematic training, and late-stage expert involvement constraining commercialisation to traditional licensing with poor outcomes.

Social Network Integration: EU Policy Support Framework enables KU Leuven's 23-city network with specialised expertise distribution. Japan's Society 5.0 integration achieved ¥230,504M systematic government support with 200+ company partnerships. US Bayh-Dole Act framework generated thousands of licensing agreements. Malaysia demonstrates policy fragmentation across agencies, limited collaborative infrastructure confining commercialisation to narrow sectors, and absence of direct market validation mechanisms.

Financial Resource Configuration: KU Leuven's sustainability model generated consistent revenue over 50 years. University of Florida's Gatorade achieved $300M+ cumulative returns from single innovation. Malaysia shows limited return on investment (ROI) despite substantial government R&D investment (1.5% of GDP), over-reliance on government funding, and narrow IP monetisation strategies missing alternative revenue streams.

Technology Resource Management: FAU's JOSEPHS Open Innovation Lab's direct market testing labs enable immediate market validation reducing development risks. Research Triangle Park supports hundreds of companies with systematic evaluation processes. It is unclear whether Malaysia's technology parks have similar systematic evaluation frameworks, sufficient institutional with capability accumulation, and adequate market intelligence to adopt reactive rather than proactive approaches.

4.4.2 Critical Gap Analysis

Malaysia exhibits performance deficits across resource dimensions, notably in: missing market validation infrastructure (Europe mitigates development risks via immediate feedback), weak evaluation protocols (Asia improves success through systematic filtering), delayed expert involvement (most international universities have recorded higher success with early verifying), and poor market intelligence (international leaders drive proactive technology marketing).

Malaysia's reactive orientation combined with significant institutional experience deficit suggests TTOs lack dynamic capabilities and accumulated organisational learning necessary for sophisticated market intelligence systems. This intrinsically limits ability to identify and cultivate commercial opportunities, constraining the ecosystem to suboptimal performance patterns without deliberate capability-building interventions.

4.5 Innovation Gaps Analysis: Three Challenge Domains

While the literature review identified two primary domains of university-industry innovation challenges, this study's empirical analysis reveals a more complex landscape requiring expansion to three distinct challenge domains. The innovation gaps analysis synthesises multi-theoretical perspectives and quantitative findings to categorise barriers across go-to-market readiness, institutional support systems, and the newly identified third domain of governance and standardisation challenges.

The three domains provide a comprehensive framework for understanding the multifaceted nature of university-industry innovation gaps and informing targeted intervention strategies for enhancing technology transfer performance.

4.5.1 Go-to-Market and Operational Readiness Challenges

The highest-priority domain centres on market preparation barriers. Industry's lack of R&D adoption

readiness (RU1, 14.8) represents the critical bottleneck. Multi-theoretical convergence validates this finding. Institutional Theory explains this through industry norms that have not evolved for university research interface. Social Network Theory explains this through weak university-industry relationships.

Inadequate commercial viability frameworks (RU2, 12.4) and technology maturity assessment frameworks (RU3, 12.0) highlight systemic resource allocation challenges. Insufficient market intelligence support (RU4, 11.2) stalls effective industry engagement.

4.5.2 Support System and Organisational Framework Challenges

Fragmented technology transfer support systems emerge from lack of academic recognition for TTO performance (RU5, 9.5). Internal academic conflicts contribute as well (RU7, 8.25). These represent controllable institutional policy areas requiring systematic reform.

4.5.3 Governance and Standardisation Issues

Standardisation challenges in commercialisation metrics (RU8, 6.4) create measurement paradoxes. Institutions optimise reported performance through strategic calculation choices rather than substantive improvements. Revenue distribution complexities (RU9, 4.4) and IP governance challenges (RU10, 3.8) affect broader ecosystem functioning.

Performance Measurement Paradox: Dramatic variations in commercialisation rates across institutions expose fundamental standardisation limitations. Rates range from <5% to 49%. This methodological latitude enables institutions to optimise reported performance. They use narrow ratio denominators rather than actual technology transfer effectiveness.

5. DISCUSSION

5.1 Theoretical Integration of Innovation Gaps

The innovation gaps require theoretical substantiation through integrated framework approaches rather than single-theory solutions. This study's empirical findings validate and extend the six literature-documented innovation gap clusters (Tables 1-6), demonstrating that persistent low commercialisation rates require interventions that must be addressed through multiple theoretical frameworks simultaneously. The convergence between practitioner-identified gaps (RU1-RU10) and established literature clusters confirms the enduring relevance of documented barriers whilst revealing new operational manifestations in Malaysian contexts.

Multi-Theoretical Convergence Analysis: Institutional Theory explains environmental barriers. Industry norms have not evolved for university research interfacing (RU1, 14.8). Academic institutional logics fail to value commercialisation activities (RU5, 9.5). Resource-Based View addresses capability deficits in commercial viability frameworks (RU2, 12.4). It also addresses technology maturity assessment (RU3, 12.0). These indicate absence of valuable assessment capabilities. Organisation Theory reveals structural failures in fragmented support systems (RU7, 8.25). It identifies standardisation challenges (RU8, 6.4) and governance problems (RU9, RU10). Social Network Theory explains relationship-based challenges in industry readiness (RU1). It also explains market intelligence gaps (RU4, 11.2). Dynamic Capabilities Theory addresses adaptation weaknesses in assessment methodologies (RU2, RU3). Resource Orchestration Theory guides strategic resource deployment effectiveness across all priority gaps.

This theoretical mapping reveals important insights as to how Malaysian public universities could address the gaps which are affecting their commercialisation rate. Single-theory approaches prove insufficient for addressing complex, interconnected innovation gaps. The field requires integrated models incorporating variables from multiple theories.

5.2 Sphere of Control Analysis

Romanowski's (2019) three-dimensional success framework clarifies university responsibility boundaries. This framework directly addresses the Financial Constraints (Cluster 3) and Market Orientation & Commercial Focus gaps (Cluster 6) documented in the literature review, recognising that marketing and financial success extend beyond university control. Universities bear primary responsibility for technical success through robust pre-transfer assessment capabilities, which directly relates to the Skills & Competency Gaps (Cluster 2).

This was identified by Mudaa et al. (2021) and Khademi et al. (2015). The reconciliation between success dimensions and six theoretical frameworks reveals complementary relationships. Success dimensions provide outcome frameworks. These frameworks supply processes for achieving outcomes within university control.

5.3 Global Benchmarking Insights

International comparison reveals Malaysia's systematic resource orchestration gaps across four dimensions, validating the Market Orientation and Commercial Focus Gaps (Cluster 6) identified by Khademi et al. (2015): **Commercial Viability Assessment Deficits:** International leaders employ sophisticated multi-layered

assessment systems, directly addressing the "Limited Market Research Capabilities" gap documented in the literature review. Europe's JOSEPHS lab enables real customer testing. This reduces development risks by 60%. Asia's systematic evaluation protocols achieve higher success rates through filtering mechanisms. Malaysia's ad-hoc processes and late-stage expert involvement create structural weaknesses. Resources are invested without systematic validation. This results in low ROI despite substantial R&D investment. **Systemic Performance Deficits:** Malaysia faces performance deficits across all resource management dimensions. The institutional experience deficit compared to global leaders creates compound disadvantages. These particularly affect assessment capabilities.

These findings extend beyond the literature-documented Financial Constraints (Cluster 3) and Organisational & Cultural Barriers (Cluster 4), revealing that Malaysia's challenges encompass systematic capability deficits that compound the individual gap categories identified by previous researchers (Yusof et al., 2012; Mudaa et al., 2021; Khademi et al., 2015).

5.4 Strategic Implications

Priority Focus for TTOs: Industry's limited R&D adoption capacity (RU1, 14.8) represents both simultaneous institutional failures and weak network connections, directly validating the Stakeholder Coordination and Collaboration Gaps (Cluster 5) identified by Mudaa et al. (2021) and Othman et al. (2014). TTOs should therefore develop enhanced commercial viability and technology maturity assessment frameworks, addressing the Market Orientation & Commercial Focus gaps (Cluster 6) whilst building the Skills & Competency capabilities (Cluster 2) identified as critical barriers in the literature review. This requires capacity development approaches combining Resource-Based View and Dynamic Capabilities Theory.

Measurement Reform Priorities: Significant methodological variations demonstrate urgent need for paradigm shift. The shift should move from outcome-based metrics to process-based assessment. This enables systematic evaluation of controllable pre-transfer activities and maintains appropriate accountability boundaries.

6. CONCLUSION

This study validates and extends the innovation gaps literature by empirically confirming all six gap clusters documented in previous research, whilst identifying specific operational manifestations in Malaysian public research universities. This study contributes to the technology transfer literature by identifying and prioritising ten critical innovation gaps that span three challenge domains in Malaysian public research universities which are affecting their commercialisation rates. The Pre-Transfer Market Readiness Gaps Conceptual Framework provides novel multi-theoretical analysis. This advance understanding beyond fragmented single-theory approaches. **Theoretical Contribution:** The study demonstrates that commercialisation challenges require simultaneous application of six complementary theoretical frameworks. Multi-theoretical convergence verifies the complex, multi-dimensional gap nature. The sphere of control analysis distinguishes controllable pre-transfer activities from uncontrollable post-transfer outcomes. This provides practical frameworks for appropriate institutional accountability. **Literature Validation and Extension:** The study confirms the persistent relevance of innovation gap clusters identified across multiple prior studies (Mudaa et al., 2021; Khademi et al., 2015; Yusof et al., 2012; Sarujee et al., 2022; Palfrey, 2011; Othman et al., 2014). The empirical findings demonstrate that Strategic & Policy Gaps (Cluster 1) manifest as standardisation and IP governance challenges in practice, whilst Stakeholder Coordination Gaps (Cluster 5) emerge as the most prevalent operational barriers. This validation strengthens the theoretical foundation whilst revealing that documented innovation gaps require integrated rather than isolated interventions. **Policy Synthesis:** Commercial viability assessment emerges as the highest-leverage intervention point, directly addressing the Market Orientation and Commercial Focus Gaps (Cluster 6) whilst intersecting with Skills and Competency Gaps (Cluster 2) documented by Khademi et al. (2015). The framework's process-based assessment paradigm offers policymakers systematic alternatives to outcome-focused metrics, moving beyond the measurement challenges inherent in Financial Constraints (Cluster 3) identified by Lim et al. (2016). This enables meaningful inter-institutional comparisons while maintaining accountability within appropriate boundaries.

Practical Application: Universities should focus limited resources on adopting systematic pre-transfer assessment capabilities. They should not attempt to influence post-transfer market dynamics beyond their control. **Future Research:** Future research should explore industry readiness factors from market perspectives and develop standardised process-based metrics that bridge outcome and process orientations. Additionally, longitudinal studies should examine how the six literature-documented gap clusters evolve as institutions implement integrated intervention strategies, particularly investigating whether addressing Stakeholder Coordination & Collaboration Gaps (Cluster 5) creates cascading improvements across other gap categories.

This research demonstrates that effective technology commercialisation requires recognising both the individual innovation gaps documented in prior literature and their complex interdependencies in practice. The validation of all six gap clusters (Strategic/Policy, Skills/Competency, Financial, Organisational/Cultural, Stakeholder Coordination, and Market Orientation & Commercial Focus) through empirical data confirms the comprehensive nature of commercialisation challenges whilst focusing institutional efforts on systematically improvable activities within universities' operational sphere. The study advances understanding by demonstrating that innovation gaps identified across different contexts and timeframes remain critically relevant, requiring integrated theoretical approaches rather than fragmented single-gap interventions.

Limitations

This study has several important limitations. First, it examines only public research universities' commercialisation policies. This excludes private universities that may adopt different approaches and face distinct constraints. Second, while TTO perspectives were comprehensively captured, government agency viewpoints were not systematically incorporated into the analysis. Third, relying on interview data introduces potential self-reporting biases. Participants may reflect institutional positions rather than actual practices. Lastly, the existing theoretical frameworks for university technology commercialisation are limited by their tendency to be applied in isolation rather than integrated approaches, their failure to capture the unique tensions between universities' academic and commercial missions, and their inadequate treatment of contextual factors such as timing, cultural differences, and the iterative nature of innovation. Resource-Based View and Institutional Theory are often too static and deterministic, while newer frameworks still struggle to explain how capabilities and networks evolve over time, overlook individual-level factors like academic motivation, and fail to address the complex interplay between technical, market, and organisational factors that determine commercialisation success.

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Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this manuscript, the author(s) employed Claude.ai for language refinement.

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