Investigating Determinants of Technology Transfer in Thailand: A Comprehensive Methodological Framework Considering the Viewpoints of Adopters and Developers

Chothip Wisespongpand[1], Pornthipa Ongkunaruk[2], Thaweephan Leingpibul[3]*

Abstract

This study presents a systematic process to evaluate pivotal factors influencing technology transfer within the Thailand context, incorporating the perceptions of both technology adopters and developers. Utilizing a rigorous triangulation of methods, including preliminary assessments, extensive interviews, and a systematically structured questionnaire, the Evaluation Matrix of Technology Transfer (EMTT) was formulated. The EMTT encompasses six fundamental components: 1) Knowledge/Know-how, 2) Artifacts, 3) User Insight, 4) Marketing, 5) Intellectual Property, and 6) Technology Transfer Management. Notably, among these, Artifacts emerged as paramount. Divergences in perspectives between adopters and developers became evident. While adopters underscored the alignment of research outputs with user requirements, developers accentuated the importance of adept management in technology transfer. In addition, a discernable discrepancy was observed in six evaluative aspects; adop-ters placed a premium on the R&D prowess of researchers, whereas developers highlighted the value of research collaboration with the industrial sector. Collectively, this robust assessment paradigm offers pertinent insights, underscoring the imperatives for judicious decision-making and fostering efficacious technology transfer processes within Thailand.

Keywords: Technology Evaluation; Technology Transfer; Technology Readiness Level; Commercialization

Submitted: July 28, 2023 / Approved: October 20, 2023

Introduction

The enhancement of Thailand's competitiveness relies heavily on the pivotal role played by science, technology, and innovation. To achieve this objective, the Thai government has set an ambitious target of allocating 1.2% of the country's GDP, equivalent to an impressive 212.34 billion baht, to research and development by 2020. This investment will be distributed with 25% originating from the public sector and the remaining 75% from the private sector (Bangkokbiznewsonline, 2019).
Currently, in Thailand, extensive research activities have been conducted across approximately 200 departments, amounting to around 541,034 studies (Prachachartonline, 2020). Nonetheless, a considerable amount of these findings are yet to be fully leveraged (Estep & Daim, 2017). A mere fraction, less than 5%, show sincere enthusiasm in innovatively advancing new technologies, and of this segment, only a scant 1-1.5% manifest commercial viability (Blosch & Fenn, 2018). The underlying issue lies in researchers often prioritizing their interests when conducting basic research or developing technologies, rather than focusing on meeting the specific needs of users (Karaveg *et al.*, 2014).

Within the context of technology transfer, two primary stakeholder categories are identified: technology transferors (so-called developers in this study), the entities or individuals developing/holding the technological innovation, and technology transferees (so-called adopters in this study), those aiming to integrate and deploy the technology (Samtani, 2010). The transfer process may encounter impediments, particularly if the receiving party lacks the requisite competencies for proficient management (Ramanathan, 2011). Thus, the evaluation of capacity or preparedness for technology transfer stands as a pivotal step, aiming to alleviate potential risks tied to technology integration and possible failures (Mohannak & Samtani, 2014). Several evaluative methodologies are available, each fashioned to cater to distinct environmental contexts. Nonetheless, the absence of a singular, universally-applicable method underscores the importance of judiciously choosing an evaluation approach and relevant parameters based on the unique situational nuances (Porter, 2010).

The subsequent stage involves the complex process of commercialization, which is often susceptible to failure when transitioning research outcomes to a commercial scale (EARTO, 2020). Particularly within the initial 3-5 years, the venture faces significant investment requirements and high risks (Oosthuizen & Buys, 2003; Kam-Fai & Tsui, 2019). Meanwhile, beneficiaries seek technologies with a higher likelihood of success (Heslop *et al.*, 2001). However, a considerable portion of the research is not yet ready for effective technology transfer (Karaveg *et al.*, 2014), resulting in what is commonly referred to as the "valley of death." This phenomenon underscores the challenges faced during the technology transfer and collaboration between research units and business sectors (Chirazi *et al.*, 2019). Overcoming the valley of death necessitates cooperative efforts between these two sectors to successfully commercialize research findings (Hudson & Khazragui, 2013).

(1) Business Performance Development, at the Institute for Small and Medium Enterprises Development (ISMED), Thailand
(2) Department of Industrial Engineering, Faculty of Engineering at Kasetsart University, Thailand
(3) Food Marketing and Supply Chain Management Program, Haworth College of Business, Western Michigan University, USA.
*Corresponding author: pornthipa.o@ku.ac.th

ISSN: 0718-2724. (http://jotmi.org)

This study seeks to develop a systematic approach for evaluating the pivotal factors that shape the technology transfer process in Thailand. It is hypothesized that disparities exist between research beneficiaries and the research contributors concerning the significance ascribed to each facet of technology transfer. To achieve this objective, a rigorous examination of the extant literature on technology transfer evaluations is undertaken, furnishing an understanding of the prevailing academic discourse on the matter. This is complemented by comprehensive interviews with both technology adopters and developers to capture their perspectives. In addition, consultations with domain experts, research funding bodies, and research entities are organized to accumulate a spectrum of opinions.

Post the qualitative engagement, an empirical survey is deployed, leveraging a meticulously crafted questionnaire aimed at two distinct cohorts: the beneficiaries of research and the researchers themselves. The quantitative data, harmonized with qualitative insights, undergo a thorough analysis to derive the study's conclusions. These revelations then guide the creation of an evaluation framework for technology transfer, inherently aligned with Thailand's unique environment.

The core hypothesis suggests a variance in priorities and emphasis toward the facets of technology transfer between technology adopters and developers. This proposition is validated via the survey outcomes and a detailed comparative assessment of the dichotomous perspectives from the sampled populations. In summation, this investigation aspires to augment the comprehension and efficacy of technology transfer within Thailand's research ecosystem, spotlighting the contrasting viewpoints of technology adopters and developers, and forging a resilient evaluative framework to optimize technology transfer initiatives.

Literature Review

Definition of Technology

According to Herbert Simon, a prominent American economist, technology is not simply an object or a tangible entity, but rather a body of knowledge that is utilized to invent or create products (Simon, 1973). In this view, technology serves as a source of wealth, as it enables the production of goods and services (Dorf & Worthington, 1987). However, for technology to fulfill this function effectively, it needs to be widely disseminated to ensure maximum benefit (Simon, 1973). In academic discourse, the term "technology" can be extended to encompass "artifacts," which are defined as objects that have been either constructed or modified by human endeavors (Carroll, 2017; Wahab et al., 2009).

Technology Readiness Level (TRL)

The concept of Technology Readiness Level (TRL) originated from the US National Aeronautics and Space Administration (NASA) and has become a widely adopted framework for assessing the maturity levels of technologies (Goldense, 2017; Mankins, 2009). TRL serves as a valuable tool for communicating the developmental stage of new technologies (Mankins, 2009). Although each agency may define TRL in slightly different ways, the foundational model consists of nine levels, as established by NASA. Other agencies may then refine or expand upon this model according to their specific purposes and contextual needs. In certain instances, alternative terminologies such as "stages" may be employed to provide a more concise representation of the maturity progression.

The adoption of Technology Readiness Level (TRL) can be categorized into two main groups. The first group comprises agencies that utilize TRL to evaluate the level of technology readiness based on the stage of product development. Notable examples include NASA, the U.S. Department of Defense, Sandia National Laboratories (SNL) (Mitchell, 2007), the European Commission (EC) under Horizon 2020 (EARTO, 2014), and the National Science and Technology Development Agency (NSTDA). These agencies employ TRL to assess technological advancements and their progress toward becoming market-ready.

The second group encompasses agencies that employ TRL to evaluate technology readiness in conjunction with other factors that are essential for commercialization, extending beyond the technological aspects alone. For instance, the U.S. Department of Health & Human Services Public Health Emergency (2008), the U.S. Center for Engineering Research for Biochemicals (Buchner *et al.*, 2019), and the European Association of Research and Technology Organizations (EARTO) utilize TRL in combination with other critical elements required for successful commercialization. Table 1 provides a comparative analysis of the different TRL definitions employed by these agencies to classify the availability and readiness of technology.

Several investigators and funding units utilize the Technology Readiness Level (TRL) as a means to communicate the progress of the research and development (R&D) process. TRL evaluation has proven valuable in reducing the risk of budget wastage and aiding in research planning (EARTO, 2014). However, it is important to note that TRL alone may not suffice to effectively transfer research results into commercial applications (Fernandez, 2010), as its primary focus is on evaluating technology readiness.

Recognizing this limitation, certain agencies have developed additional readiness assessment models to complement the use of TRLs and support various objectives. For instance, the French National Research Agency has devised an assessment of demand readiness to examine market demand (Paun, 2011). The U.S. Department of Energy (DOE) has implemented a commercial readiness level assessment to gauge the readiness for commercial deployment (The Advanced Research Projects Agency-Energy, 2017). Similarly, the U.S. Department of Defense (DOD) has established a Manufacturing Readiness Level assessment to mitigate risks during the transition of technology into production (U.S. Department of Defense, 2020). The Australian Renewable Energy Agency has developed the Commercial Readiness Index as an evaluation tool (Animah & Shafiee, 2018; Australian Renewable Energy Agency, 2014). Furthermore, the Integration Readiness Level (IRL) and the System Readiness Level (SRL) are assessed to ensure comprehensive readiness evaluation (Fernandez, 2010). These additional assessment models complement the use of TRL, enabling a more comprehensive evaluation of technology readiness and its potential for successful commercialization.

Table 1. Comparison of TRL definitions used by different institutions.

TRL	The organization that uses TRL to evaluate the level of availability of technology by product development			The organization that uses TRL with other elements necessary for commercial leads		
	NASA and DOD	SNL and NSTDA	HORIZON 2020	HHS	CBiRC	EARTO
TRL1	Basic principles observed and reported	Basic principles obser-ved and reported	Basic principles obser-ved and reported	Review the scientific knowledge base	Basic research	Basic principles observed
TRL2	Technology concept and/or application formulated	Technology concept and/or application formulated	Technology concept and/or application formulated	Development of hypothesis and experi-mental designs	Technology application	Technology concept formulated
TRL3	Analytical and experimen-tal critical function and/or characteristic proof-of-concept	Concepts demonstrated analytically or experi-mentally	Experimental proof of concepts	Target/candidate identification and cha-racterization of preli-minary candidates	Feasibility demonstration	First assessment of the feasibility of the concept and tech-nology
TRL4	Component and/or breadboard validation in a laboratory environment	Key elements demons-trated in a laboratory environment	Technological validity in a lab	Non-GLP in vivo de-monstration of activity and efficacy	Lab-Scale Development	Validation of inte-grated prototype in a laboratory
TRL5	Component and/or bread-board validation in the relevant environment	Key elements de-monstrated in relevant environments	Technology validated in relevant environments	Advanced characteri-zation of candidates and initiation of GMP process development	Technology develo-pment	Testing of the prototype in a user environment
TRL6	System/ subsystem model or prototype demonstrated in a relevant environment (ground or space)	Representative of the de-liverable demonstrated in relevant environ-ments	Technology demons-trated in relevant environments	GMP pilot lot produc-tion, Investigate New Drug submission and phase 1 clinical trial(s)	Viability demons-tration	Pre-production of the product, including testing in a user environment
TRL7	System prototype de-monstration in a space environment	The final development version of the delivera-ble demonstrated in the operational environment	System prototype demonstration in an operational environ-ment	Scale-up initiation of GMP process validation and phase 2 clinical trial(s)	Commercial t ransition	Lab-scale pilot production demons-trated
TRL8	The actual system is completed and "flight qualified" through test and demonstration (ground or flight	Actual deliverable qua-lified through test and demonstration	The system completed and qualified	GMP validation con-sistency lot manufac-turing, efficacy studies clinical trial three, and FDA approval	Commercial de-monstration	Manufacturing fully tested, validated, and qualified
TRL9	Actual system "flight-pro-ven" through successful mission operations	Operational use of deliverable	The actual system is proven in an operatio-nal environment	Post-licensure and post-approval acti-vities	Commercial deployment	Production and product are fully operational and competitive

Technology Potential Assessment (TPA)
Assessing the potential of technology requires a holistic view, factoring in multiple aspects and using varied assessment techniques. A prevalent approach is gauging the technology's innovativeness. In this context, Henderson and Clark (1990) introduced four categories of product innovation to elucidate the fresh value of pre-existing technologies. Russell *et al.* (2010) recommended assessments rooted in societal impact. Moreover, some analyses have factored in costs, delivery, and efficiency risks (Fernandez, 2010; Paulino, 2014). Emphasizing the significance of technology transfer potential, Estep and Daim (2017) made their mark. Blosch and Fenn (2018), on the other hand, advocate for assessment based on five tech cycles for investment decisions.

Given the plethora of available assessment frameworks and techniques, decision-makers often grapple with picking the one that resonates most with their situation (Heslop *et al.*, 2001). The array of assessment methodologies underscores the intricacy of gauging technological potential and accentuates the importance of meticulous selection and tailoring of the apt assessment technique or model.

Technology Transfer (TT)
In 1994, Gibson and Rogers presented a three-tiered model focusing on technology transfer from the standpoint of researchers: these tiers were technology development, technology adoption, and commercialization (Ramanathan, 2011). Following this, Heslop *et al.* unveiled the "Cloverleaf Model of Technology Transfer" in 2001. This model pinpointed four pivotal components for successful technology transfer: technology preparedness, market readiness, commercial preparedness, and administrative readiness (Heslop *et al.*, 2001). Oosthuizen and Buys (2003) later tailored the Cloverleaf Model to better suit the African research backdrop and juxtaposed the Technology Readiness Assessments of the U.S. Air Force and Florida State University. Notably, while the Cloverleaf Model covers four primary aspects, NASA's approach emphasizes three - technology, marketing, and utilization, leaving out the management evaluation (Oosthuizen & Buys, 2003). Advancing the discourse, Resende *et al.* (2013) launched a detailed instrument to bolster technology transfer via technology transfer offices. This apparatus comprised 43 facilitators, 271 guidelines, and a strategic blueprint. Out of these facilitators, seven were spotlighted as crucial for technology transfer but had scant implementation. These pivotal, yet under-implemented facilitators included: 1) Rapid adaptation to emerging competencies, 2) Robust online visibility, 3) Management of intellectual property through licenses and patents, 4) Advisory services, 5) Preliminary firms setup 6) Infrastructure like technology transfer networks, centers of excellence, innovation hubs, and scientific parks, and 7) Dissemination of information and knowledge.

Methodology

The primary objective of this research is to develop a systematic process for evaluating the key elements that impacted the technology transfer of research within the specific context of Thailand. The research methodology encompassed several stages, including in-depth interviews, brainstorming sessions with business development experts, and gathering feedback from research funding agencies and government research units. The resulting output was the creation of the Evaluation Matrix of Technology Transfer (EMTT). Additionally, questionnaires were employed as data collection tools to gather insights from two distinct sample groups: technology adopters and technology developers.

The research process was structured into three main parts. Part 1 focused on the development of the EMTT, involving steps 1 to 6. This phase included the compilation of inputs from interviews and brainstorming sessions to shape and refine the matrix. Part 2 encompassed steps 7 and 8, which involved the creation of the questionnaires for data collection. Finally, Part 3 involved steps 9 and 10, which encompassed the collection and analysis of data obtained through the questionnaires. A visual representation of the research process can be observed in Figure 1, illustrating the sequential flow of the research activities. This structured approach ensured a comprehensive and systematic evaluation of the technology transfer elements, promoting a rigorous and evidence-based understanding of the factors influencing technology transfer in the Thailand context.

Part 1 The development of the EMTT
Step 1) Literature Review: This initial step involved conducting a thorough examination of the existing literature to synthesize various models and elements utilized in the Technology Readiness Level (TRL) assessment and technology transfer, specifically tailored to the unique context of Thailand. The review encompassed relevant theories and models, such as the customer-oriented theory (Sharabi, 2015), technology acceptance theory (Kalayou *et al.*, 2020), knowledge-based models, and organizational learning in technology transfer (Wahab *et al.*, 2009). Moreover, TRL models and technology transfer models (Ramanathan, 2011) were also considered to extract pertinent insights.

By delving into these diverse theoretical frameworks, the research aimed to construct a robust and contextually relevant Evaluation Matrix of Technology Transfer (EMTT) that effectively captured the critical factors impacting technology transfer in the Thai setting.

Step 2) Model Selection: The research team opted for three pertinent models to inform the development of the Evaluation Matrix of Technology Transfer (EMTT). Firstly, the Cloverleaf Model for technology transfer was chosen due to its extensive study involving 168 technology research and development agencies in the United States and Canada. The model analyzed key criteria for successful technology transfer and ranked them based on their Importance Scale and Importance Rank (Heslop *et al.*, 2001). This empirical foundation ensured that the Cloverleaf Model genuinely reflected the perspectives of stakeholders involved in technology transfer. Secondly, the researchers incorporated SNL's Technology Readiness Level (TRL) model, which enhanced the assessment of technology readiness. This inclusion aimed to mitigate any potential bias from respondents (Mitchell, 2007). Additionally, the adoption of EARTO's TRL further contributed to the research by serving as a risk management tool for research funding

from HORIZON 2020, the European Union's major fund supporting the practical application of research on an industrial scale (EARTO, 2014). This alignment with the context of Thailand's research funding strengthened the relevance and applicability of the chosen models.
Step 3) Reality Check with Practitioners: The research team conducted in-depth interviews with 20 experienced researchers with a background in technology transfer. This process aimed to gather factual insights and ascertain the research problem's specific aspects. Additionally, 22 business entrepreneurs with expertise in implementing research findings were interviewed to gain further understanding of the challenges and barriers encountered in research utilization.

Step 4) Expert Verification: The research team thoroughly analyzed the elements that impacted technology transfer, encompassing both technological and business-related aspects. To further refine the structure of EMTT and evaluate the elements, the team collaborated with four experts specializing in business development, marketing, research, policy, and research planning. This collaborative approach allowed for a well-rounded and comprehensive framework.

Step 5) EMTT Fine-Tuning: To ensure the integrity and coherence of the EMTT structure, the team rigorously tested it with the perspectives of all three subjects: researchers, entrepreneurs, and experts. This iterative process aimed to fine-tune the model for its optimal functionality.

Step 6) Outreach for Feedback from Research Funding and Government Research Units: The research team sought feedback from six research funding units and three government research units. This feedback served as valuable input to further enhance and refine the EMTT, making it more responsive to the specific needs and context of technology transfer in Thailand.

By following these steps, the research successfully established a robust and contextually relevant Evaluation Matrix of Technology Transfer (EMTT), facilitating a more comprehensive understanding and assessment of technology transfer in the Thailand context.

Part 2) Creating a Questionnaire comprises two pivotal steps:

Step 7) Questionnaire Design: In this stage, a comprehensive questionnaire was crafted to elicit respondents' perspectives on the Importance Scale and Importance Rank of the issues concerning key elements in technology transfer. The questionnaire was thoughtfully structured to encompass essential aspects, ensuring a comprehensive assessment of technology transfer factors. The 10-point Likert scale was employed to optimize the quality and accuracy of the feedback. Certain pre-existing questions were adapted to align with the Likert scale. Furthermore, as recommended by Chakrabartty (2014), Norman (2010), and McCrum-Gardner (2008), the Likert scale, being an ordinal measurement instrument, is well-suited for quantitative analysis using various statistical techniques.

Step 8) Reliability and Content Validity Verification: To ensure the questionnaire's reliability, Cronbach's Alpha Coefficient was employed to assess internal consistency. This statistical measure determined the extent to which the survey items within each construct were interrelated, thus ensuring the questionnaire's reliability.

Moreover, Content Validity was assessed using the Index of Item-Objective Congruence (IOC) formula. By employing this method, the research team examined the alignment between the survey items and the research objectives, verifying the questionnaire's appropriateness in capturing the intended aspects of technology transfer.

Together, these rigorous steps in questionnaire creation and validation serve to establish a robust tool for gathering reliable and pertinent data on the evaluation of key elements in technology transfer.

$$IOC = \frac{\sum_{i=1}^{N} R_i}{N},$$

where Ri is the appropriate score of the respondent i

N is the number of respondents.

Part 3: Data Collection and Analysis of the Importance of Elements in Technology Transfer involve two crucial steps:

Step 9) Data Collection: In this stage, data was collected from two distinct target groups - technology adopters and technology developers. Each group consisted of no fewer than 30 individuals, ensuring a substantial sample size for robust statistical analysis. The survey allowed respondents to assess the importance of elements in technology transfer across six key areas. The positions of the respondents are shown in Table 2.

Table 2. Positions of respondents

Position	Tech adopters		Tech developers		Sum	
	persons	%	persons	%	persons	%
TOP Management	35	71.4	8	23.5	43	51.8
Middle Management	10	20.4	13	38.2	23	27.7
Operational level	3	6.1	13	38.2	16	19.3
Others	1	2.0	0	0.0	1	1.2
Sum	49	100.0	34	100.0	83	100.0

ISSN: 0718-2724. (http://jotmi.org)

Step 10) Data Analysis with Statistical Methods: To evaluate the research hypothesis concerning the mean discrepancies between two groups, there are typically three tests employed by researchers for comparing two separate samples: the t-test, the t-test for unequal variances, and the Mann-Whitney U test, as delineated by Ruxton (2006). The analysis also involved determining skewness and kurtosis values to identify the characteristics of the data distribution and determine its conformity to a normal distribution, as advised by De Winter and Dodou (2010). The literature indicates that the Shapiro-Wilk test stands out as a superior method for assessing normality (Liang *et al.*, 2009; Mohd Razali & Bee Wah, 2011; Yap & Sim, 2011). As such, normality checks were executed using the Shapiro-Wilk test, in tandem with Levene's Test for Equality of Variances. IBM SPSS 23.0 was utilized to conduct these examinations.

To utilize a t-test, specific prerequisites need to be fulfilled. These include data measured on a ratio or interval scale, simple random sampling, compliance with a normal distribution, adequate sample size, and homogeneity of variances, as expounded by Kim and Park (2019). When the data doesn't fit a normal distribution, the Mann-Whitney U test serves as a nonparametric substitute, as outlined by Dexter (2013). Several studies, such as those by Rochon *et al.* (2012), De Winter and Dodou (2010), Fay and Proschan (2010), Meek *et al.* (2007), and Bridge and Sawilowsky (1999), have investigated the relative effectiveness of the t-test and the Mann-Whitney U test. The consensus from these studies typically shows similar statistical power between both tests in most situations. It is important to note, however, that the Mann-Whitney U test is particularly advantageous for analyzing Likert scale data, as indicated by McCrum-Gardner (2008). Moreover, recent work by ŞİMŞEK (2023) emphasizes the greater efficacy of the Wilcoxon-Mann Whitney test (also known as the Mann-Whitney U test) over the t-test in conditions featuring small and unevenly sized groups. This observation underscores the Mann-Whitney U test's value, particularly when dealing with such data constraints. The research hypotheses were set forth as follows:

H0: Technology developers and adopters perceive the importance of each technology transfer component in the same way.

H1: Technology developers and adopters do not perceive the importance of each technology transfer component in the same way.

Statistical tests were conducted as a thorough examination of significant differences in the perceived importance of technology transfer elements between technology adopters and technology developers. Additionally, the data analysis revealed the relative importance of these elements within the specified six areas. By implementing rigorous data collection and statistical procedures, the research successfully captured the perspectives of both technology adopters and technology developers, providing valuable insights into the critical factors influencing successful technology transfer and research outcome utilization. The findings shed light on the varying perspectives of these stakeholder groups, offering valuable information to enhance technology transfer practices.

Respondents participated in rating the importance of 56 key elements related to technology transfer assessment issues, with each item scored on a scale of 1 to 10 points. To assess the relative significance of each element, priority scores were assigned in descending order, ranging from 1 to 56. Additionally, a comparison was made between the rankings of the top 5 elements within each group to ascertain any divergent opinions on the importance of the assessment issues. Subsequently, the average importance scale for each element (Average Importance Scale) was calculated, allowing for a comparison between the two respondent groups. By analyzing the average importance scales, it was possible to determine which elements were perceived as more or less important by each group. Overall, these rigorous statistical analyses provide valuable insights into the perceptions and priorities of the two respondent groups, shedding light on the key factors driving technology transfer and the assessment of research outcomes.

Results and Discussions

Evaluation Matrix of Technology Transfer: EMTT

The design of EMTTs went beyond a purely technological focus, encompassing two main structures. The first structure, Structure One, comprised two components (Singh, 2019). Component 1, "Knowledge or know-how" (Technology) (Carroll, 2017; Wahab *et al.*, 2009; Simon, 1973), included 9 assessment issues. Component 2, "Artifacts," (Carroll, 2017; Wahab *et al.*, 2009), comprised 10 assessment items.

The second structural aspect encompassed business-related elements concerning utilization and was comprised of four distinct components. Component 3, denoted as "Consistency of Research Output with User Needs (User Insight)," was characterized by the inclusion of eight assessment criteria. Component 4, labeled "Marketing System for Research Product Utilization (Marketing)," encompassed a total of seven assessment items. It was noteworthy that User Insight and Marketing were distinguished due to their distinct focuses: the former concentrated on comprehending user needs before commencing research, while the latter centered on the strategic targeting of users, alongside the planning, establishment, and supervision of marketing and support for commercialization efforts. Component 5, termed "Protection of Rights and Intellectual Property Safeguards," incorporated seven assessment criteria. Lastly, Component 6, designated as "Technology Transfer Management," encompassed a comprehensive set of 15 assessment issues.

The Cloverleaf model underscored the significance of factors such as speed to market and market potential, which could be realigned to harmonize with user insights and marketing strategies. For instance, within the realm of market potential, several pivotal components emerged, including 1) Clear and Identifiable Benefits (similar to U1) 2) Distinct Competitive Advantage 3) Major Quantifiable Benefits 4) Future Utilization (resembling U4) 5) Solvability of Remaining Issues. Simultaneously, the domain of speed to market encompassed the subsequent key components: 1) Immediate Market Applicability (akin to U5) 2) Addressing Current Market Dissatisfaction 3) Being Pioneers in Market Entry 4) Possessing a Functional Prototype (resembling

U6) 5) Minimizing Competitor Presence 6) Feasibility for Manufacturing. Nonetheless, a notable gap persisted in terms of understanding how to ensure product stability within the market or harness the full potential of the market. In response, our research endeavored to bridge this gap by categorizing these considerations under the broader domains of user insight and marketing strategies. This alignment was designed to harmonize with the nine-step framework outlined in the Technology Readiness Level, thereby providing a structured approach to enhance technology transfer and market stability.

By adopting this comprehensive approach, EMTTs were thoughtfully designed to encompass both technological and business-related aspects, ensuring a holistic evaluation of elements impacting technology transfer and research utilization processes. When devising guidelines for assessing technology transfer readiness, it was observed that assessment questions present in all three selected models had been effectively utilized. This incorporation ensured that the EMTT showcased the essential structure of key elements in technology transfer, aligning with its objectives. Consequently, EMTT facilitated a comprehensive assessment of both technology readiness and technology transfer readiness simultaneously.

EMTT encompassed six stages and nine levels, with each level thoroughly explained by applying EARTO's Technology Readiness Level (TRL) definition and explanation, as outlined in Table 3. Moreover, EMTT encompassed 56 technology transfer readiness assessment issues derived from the Cloverleaf Model, SNL's TRL, and EARTO's TRL, as illustrated in Table 4.

By integrating multiple models and perspectives, EMTT served as a robust framework to assess technology transfer readiness comprehensively. Its structured approach enabled researchers and stakeholders to evaluate technology readiness and its successful transfer, providing valuable insights for informed decision-making and effective technology commercialization.

The Creation of The Questionnaires for Data Collection

The construction of the questionnaire was informed by Table 4, which served as the foundational framework. It comprised six distinct sections, namely knowledge/know-how, artifacts, user insight, marketing, intellectual property, and technology transfer management, containing 9, 10, 8, 7, 7, and 15 questions, respectively, or a total of 56 questions. The survey items inquired about respondents' perspectives regarding the provided descriptions, and participants were asked to rate their opinions on a 10-point scale from (1) strongly unimportant to (10) strongly important.

ISSN: 0718-2724. (http://jotmi.org)

Table 3 The Evaluation Matrix of Technology Transfer (EMTT) is categorized into six stages, nine levels, and 56 assessment items

EMTT Readings	6 Steps	I. Invention / Discovery of Ideas		II. Concept confirmation		III. Prototype /Incubator	IV. Pilot Production /Market Testing		V. Market Entry	VI. Market Expansion
Component	9 levels	1. Find ideas	2. Create ideas	3. Test concept	4. Integrated key elements	5. Produce prototype + incubator	6. Pilot production/ market test	7. Open market	8. Production stability in the early market	9. Expand the market
Technology Readiness	1) Knowledge/ know-how	T1[S, E, C] Technology Exploration	T2[S, E, C] Research Design	T3[S, E] Key Element Characterization	T4[S, E] Integrated Key Element	T5[E, C] Prototype	T6[S, E] Scaleup	T7[S, E, C] Pilot Implementation	T8[S, E, C] Capable to Commercial	T9[S, E] Consistency in Commercial Scale
	2) Artifacts	A1 Better Solution	A2[S] Meet Requirement	A3[S] Key Element Meet Requirement	A4[S, E] Integrated Key Element Compatibility	A51[S, E] Prototype Alignment A52[S, E, C] Prototype Meet Requirement	A6[S, E] Practical Pilot	A7[S, E] Pilot Meet Requirement	A8[E] Market Acceptance	A9[E] Commercial Product Meet Requirement
Non-Technology Readiness	3) User Insight	U1[S] Gap Identification	U2 User Driven Research	U3[S, E] Understand User Need	U4[S, E] Long Term Need	U5[S, E, C] Early Adoption	U6[S, E] Majority Acceptance	U8[S, E] User Acceptance		U9[S, E] User Expansion
	4) Marketing	M2[E, C] Targeting		M3[E, C] Explore Target Need	M4[E] Target Testing	M5[S, E, C] Marketing and Support Planning	M6[S, E, C] Marketing and Support Establishment	M8[E, C] Marketing and Support Meet Requirement		M9[C] Sales and Scope Expansion
	5) Intellectual Property	I1[C] Degree of Novelty	I2[C] Difficulty to Replicate	I31[C] Publication Landscape I32[C] Patent Landscape	I4[C] Public Disclosure	I7 Domestic IP		I9 International IP		
Transferable Technology	6) Technology Transfer Management	R11[C] R&D Skill R12[C] Team Leadership	R2[E, C] Commercialization Evaluation	R31[E] Management Skills R32[E] Industry Cooperation R33[E] Research Publication R34 E Real World Application	R41[C] Expert Collaborative Improvement R42[C] Product Validation	R5[C] User Engagement	R61[E, C] Adopter in Kind R62[E, C] Adopter in Cash	R7[C] Long Term Business Plan	R8[C] Adopter Cooperation	R9[C] Practical Use

Note: [S] refers to SNL-based TRL, [E] refers to EARTO-based TRL, [C] refers to the Cloverleaf model

Table 4 Components of EMTT and its assessment items

Components	Elements	Issues assessing critical components of technology transfer	
		Code	**Description**
Technology Readiness	1. Knowledge / Knowhow	T1	Our work explored advanced technology for better solutions.
		T2	We designed our work to include critical key features for production.
		T3	We used various laboratory analyses to help define all key elements.
		T4	Our work integrated all key elements.
		T5	We had prototypes ready for market testing.
		T6	Our work was scalable for commerce.
		T7	We implemented a pilot plant testing.
		T8	Our work was capable of expanding commercially.
		T9	Our work was optimized for commercial consistency.
	2. Artifacts	A1	Our work had a competitive advantage over existing technologies.
		A2	Our work effectively met end users' needs.
		A3	Our work contained all key elements that met end user requirements.
		A4	Our integrated key elements were compatible with each other.
		A51	Our prototype matched our research goals.
		A52	Our prototype hit the performance marks.
		A6	We tested pilot products practically.
		A7	Our pilot products achieved set targets.
		A8	The market favored our commercial product.
		A9	Our commercial product satisfied user requirements.
Non-Technology Readiness	3. User Insight	U1	We identified the gaps between the end users' needs and the existing solutions.
		U2	Our research was led by end user needs.
		U3	We understood the needs of targeted end users.
		U4	Our market lifespan promised long-term gains.
		U5	Early adopting end users loved our full-featured prototypes.
		U6	The early majority of end users preferred our prototypes.
		U8	End users approved our pilot and commercial versions.
		U9	The number of end users from different segments grew fast.
	4 Marketing	M2	We effectively identified our target adopters.
		M3	We adequately studied adopter needs in context.
		M4	We tested products with target adopters.
		M5	We planned all aspects of marketing and support.
		M6	We executed marketing and support well.
		M8	Our marketing operations matched market needs well.
		M9	We increased the sales volume.
	5. Intellectual Property	I1	Our research was groundbreaking.
		I2	Our work was difficult to replicate.
		I31	We did extensive research on current publications for this project.
		I32	We scanned all existing patents related to this project.
		I4	We disclosed information publicly.
		I7	We secured IP (Intellectual Property) rights in Thailand.
		I9	We protected IP (Intellectual Property) internationally.
Transferable Technology	6. Technology Transfer Management	R11	Our researcher excelled in R&D.
		R12	The research team was highly qualified.
		R2	Our research team understood commercial opportunities.
		R31	Our researcher adeptly managed business-centric research.
		R32	Our research team worked well with the industry.
		R33	The research team was experienced in publicizing research.
		R34	Our research team implemented technology practically.
		R41	Our R&D team collaborated effectively with field experts.
		R42	Our R&D team developed user-centric products.
		R5	Technology adopters participated in our research.
		R61	Technology adopters offered in-kind support, such as machinery, equipment, and raw materials.
		R62	Technology adopters provided financial support to our work.
		R7	We crafted a long-range business strategy with the adopter.
		R8	The research unit engaged with adopters for cooperation and support.
		R9	Our research team pushed the real-world use of our R&D.

Reliability and Content Validity Analysis

Cronbach's alpha provided a straightforward measure of the reliability of the scores, assuming that the multiple assessment items captured the same sub-construct. Each sub-construct comprised various questions, each inquiring about distinct aspects but ultimately contributing to the evaluation of the same sub-construct. The obtained results in Table 5 revealed Cronbach's alpha coefficients ranging from 0.797 to 0.926 for the six sub-constructs, all surpassing the threshold of 0.7, indicating a high level of reliability. Moreover, the correlation coefficients of the respondents' significance scores (Inter-Item Correlation Matrix) were all positive, indicating that the 83 participants' importance ratings for the assessment items were consistent in the same direction.

Table 5. Cronbach's Alpha coefficients of the Questionnaire

Key elements in assessing readiness for technology transfer	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	# of Items	Inter-Item Correlation Matrix
1. Knowledge/ Know-How	.776	.797	9	Positive, all pairs.
2. Artifacts	.882	.888	10	Positive, all pairs.
3. User Insight	.872	.873	8	Positive, all pairs.
4. Marketing	.888	.889	7	Positive, all pairs.
5. Intellectual Property	.832	.837	7	Positive, all pairs.
6. Technology Transfer Management	.917	.926	15	Positive, all pairs.

The Statistical Analysis

The study encompassed a total of 83 participants, consisting of 49 technology adopters (59%) categorized as participants and 34 (41%) as technology developers. Within the organizational structure, 43 held senior executive roles, 23 were in supervisory positions, 16 worked in operational capacities, and 1 belonged to a distinct category, representing 51.8%, 27.7%, 19.3%, and 1.2%, respectively. Analysis of the IOC score survey involving these 83 respondents revealed that the average IOC scores ranged from 0.59 to 0.99. All scores exceeded the 0.5 threshold, affirming the appropriateness of all 56 survey questions under the research objectives.

Ranking the Importance and Priority of Evaluating Elements in Technology Transfer

The outcomes of the normality test, as determined by the p-values obtained from the Shapiro-Wilk test (SW) as shown in Table 3, demonstrate that none of the components within either group conform to a normal distribution. Additionally, the analysis of skewness and kurtosis values as shown in Figure 1 provided evidence suggesting that the data did not conform to a normal distribution, as indicated by De Winter and Dodou (2010). Skewness is utilized to assess data symmetry, and in this study, both groups exhibited skewness values that categorized 2 and 8 components as nearly symmetric, 29 and 23 as moderately skewed, and 25 and 25 as highly skewed for technology adopters and developers, respectively. In summary, the majority of the data displayed asymmetry, with all skewness values being negative, implying that the mean is less than the median. Kurtosis, conversely, serves as an indicator of whether the data distribution exhibits a heavy-tailed or light-tailed profile compared to a normal distribution. In the realm of kurtosis, it was observed that 51 and 47 components demonstrated characteristics aligned with a normal distribution, while 5 and 9 components exhibited deviations from the typical normal distribution patterns among technology adopters and developers, respectively. This implies that, in the absence of consideration for the type of data, the majority of components are conducive to t-test analysis. Additionally, the results of Levene's Test for Equality of Variances identified three instances of unequal variances, specifically for components T6 Scaleup, I9 International IP, and R32 Industry Cooperation. Figure 2 provides an analysis of the average and median importance scores for 56 components, discerning distinctions between technology adopters and developers. The figure demonstrates that across most of the components, there is a notable phenomenon where the median surpasses the average, a pattern that aligns with the observed negative skewness in the data. Notable disparities are evident in multiple components, particularly in U1 Gap Identification, I31 Publication Landscape, R32 Industry Cooperation, R61 Adopter in kind, R62 Adopter in Cash, and R31 Management Skills. These variations align with the outcomes of the three statistical tests, which will be elaborated upon below.

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Figure 1: Comparison of the skewness and kurtosis between technology adopters and developers in 56 components

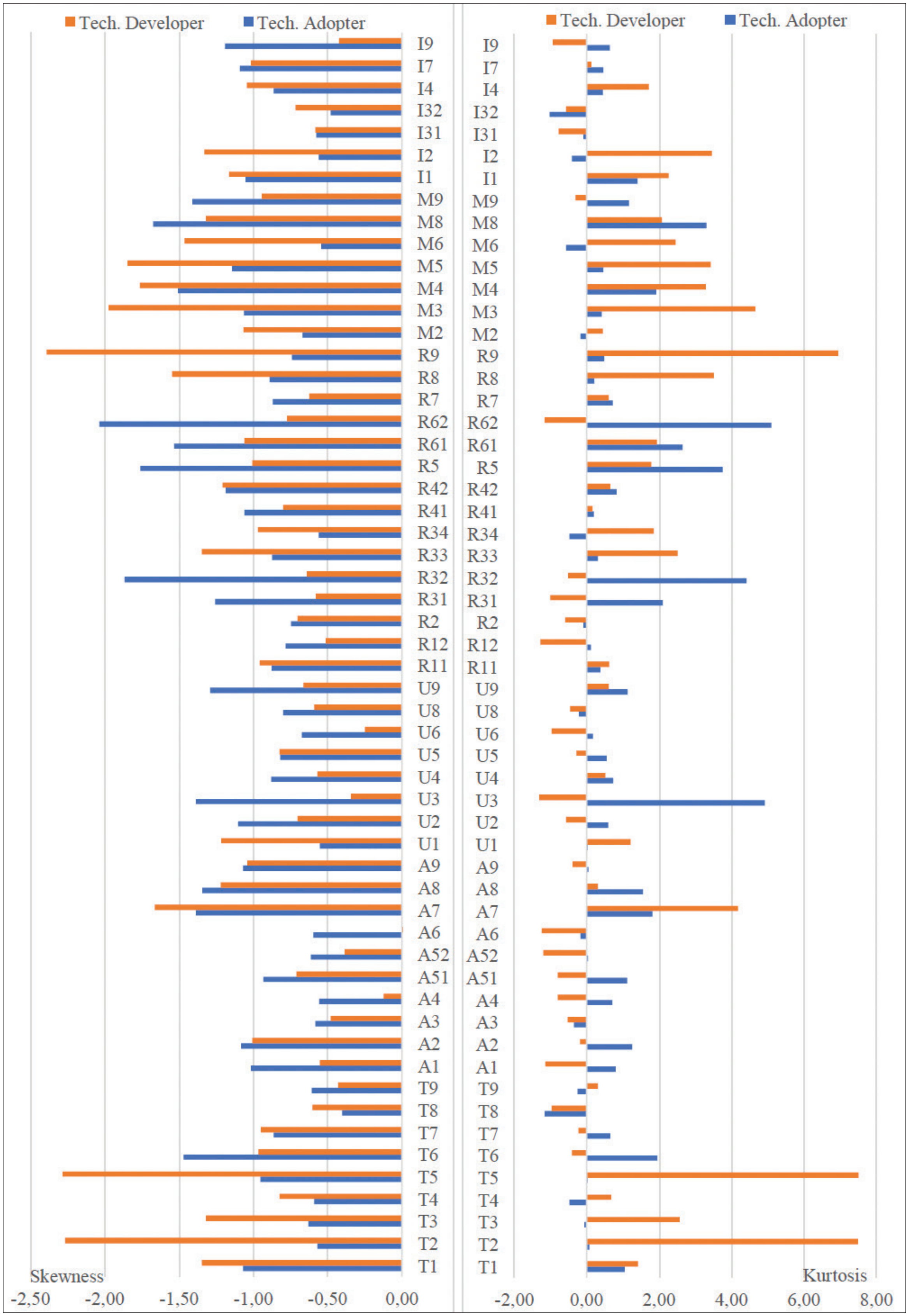
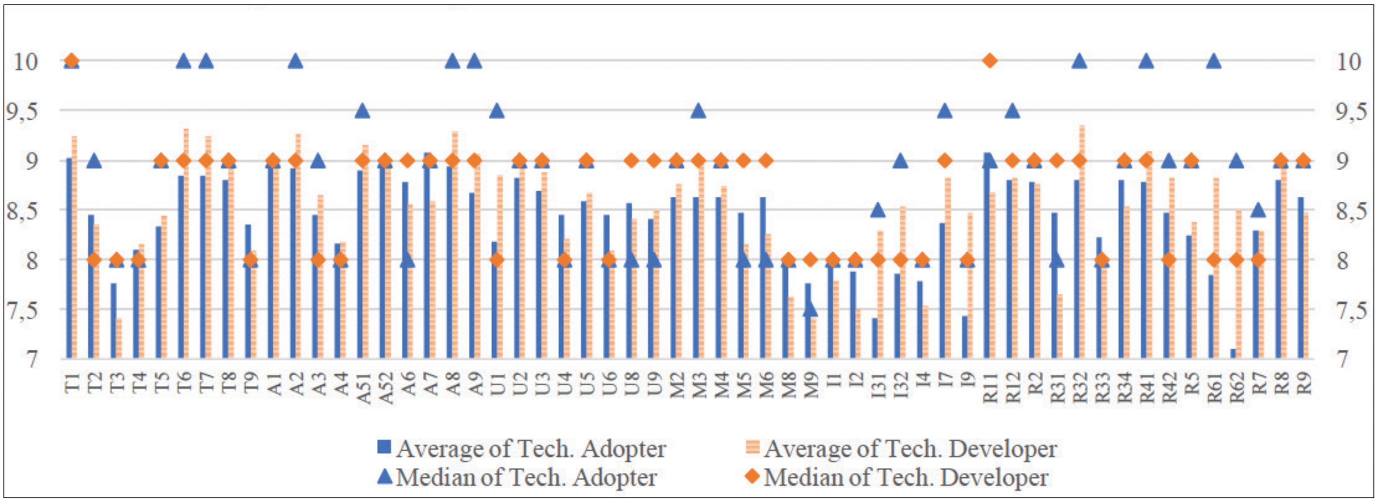


Figure 2: Comparison of the average and the median of importance score between technology adopters and developers in 56 components



The results of the three tests yielded fairly consistent outcomes. Both the standard t-test and the t-test for unequal variances (UV t-test) led to identical conclusions, with the latter exhibiting slightly lower p-values, indicating a significant difference among the six components at a confidence level of 0.05. Conversely, no statistical evidence emerged to suggest distinctions between the two groups across 50 components. Specifically, six items stood out where technology developers rated higher than technology adopters. These areas highlighted concerns or discrepancies between user needs and existing solutions (U1 Gap Identification), the potential for collaborative research efforts with industry (R32 Industry Cooperation), support for research projects through machinery, materials, equipment, raw materials, output testing, or pilot production lines (R61 Adopter in kind), contributions to research project funding by a group of technology adopters (R62 Adopter in cash), an exploration of publication landscape (I31 Publication Landscape), and overseas intellectual property protection (I9 International IP), as detailed in Table 6. Conversely, upon employing the Mann-Whitney U test (MWU), no statistically significant evidence emerged to indicate differences between the two groups across 51 components. Nonetheless, the MWU test did reveal five notable distinctions in the areas of U1 Gap Identification, I31 Publication Landscape, R31 Management Skills, R61 Adopter in Kind, and R62 Adopter in cash. Interestingly, the sole inconsistency between the MWU test and the other tests pertained to R31 Management Skills and R32 Industry Cooperation. Notably, it was surprising that technology developers rated R31 Management Skills lower than technology adopters. It is pertinent to note that the choice of the MWU test aligns with the suitability of the Likert scale, as suggested by McCrum-Gardner (2008).

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Table 6. Importance score and importance rank of the assessment items in transferable technology.

Elements	Items	Tech. Adopter (N=49)				Tech. Developer (N=34)				P-Value		
		Avg. of IS	Med. of IS	Rank	SW	Avg. of IS	Med. of IS	Rank	SW	t-Test	UV t-Test	MWU
Knowledge/ Know-How	T1	9.02	10	3	0.000	9.24	10	5	0.000	0.396	0.386	0.435
	T2	8.45	9	32	0.000	8.35	8	39	0.000	0.783	0.794	0.832
	T3	7.76	8	52	0.003	7.41	8	55	0.001	0.426	0.448	0.581
	T4	8.10	8	45	0.000	8.15	8	45	0.005	0.902	0.904	0.824
	T5	8.33	9	39	0.000	8.44	9	36	0.000	0.775	0.776	0.793
	T6	8.84	10	9	0.000	9.32	9	2	0.000	0.071	0.071	0.205
	T7	8.84	10	9	0.000	9.24	9	5	0.000	0.106	0.094	0.125
	T8	8.80	9	12	0.000	8.94	9	12	0.000	0.578	0.571	0.672
	T9	8.35	8	38	0.000	8.09	8	47	0.006	0.400	0.394	0.306
	Avg.	***8.50***		3		8.58		3				
Artifacts	A1	8.94	9	5	0.000	8.94	9	12	0.000	0.993	0.993	0.914
	A2	8.92	10	7	0.000	9.26	9	4	0.000	0.163	0.148	0.191
	A3	8.45	9	32	0.000	8.65	8	27	0.002	0.507	0.495	0.601
	A4	8.16	8	44	0.000	8.18	8	44	0.006	0.966	0.966	0.886
	A51	8.90	9.5	8	0.000	9.15	9	7	0.000	0.305	0.293	0.349
	A52	8.96	9	4	0.000	8.94	9	12	0.000	0.936	0.937	0.957
	A6	8.78	8	17	0.000	8.56	9	29	0.000	0.372	0.368	0.255
	A7	9.08	9	1	0.000	8.59	9	28	0.000	0.099	0.116	0.1
	A8	8.94	10	5	0.000	9.29	9	3	0.000	0.168	0.152	0.147
	A9	8.67	10	21	0.000	9.06	9	9	0.000	0.240	0.223	0.249
	Avg.	***8.78***		1		8.86		1				
User Insight	U1	8.18	9.5	43	0.000	8.85	8	17	0.000	**0.039***	**0.039***	**0.022***
	U2	8.82	9	11	0.000	8.94	9	12	0.000	0.673	0.663	0.874
	U3	8.69	9	20	0.000	8.88	9	16	0.000	0.449	0.448	0.503
	U4	8.45	8	32	0.000	8.21	8	43	0.000	0.440	0.432	0.326
	U5	8.59	9	27	0.000	8.67	9	26	0.000	0.810	0.815	0.585
	U6	8.45	8	32	0.000	8.09	8	47	0.012	0.266	0.282	0.289
	U8	8.57	8	28	0.000	8.41	9	37	0.001	0.633	0.636	0.672
	U9	8.41	8	36	0.000	8.50	9	32	0.002	0.800	0.786	0.617
	Avg.	8.52		2		8.57		4		0		
Marketing	M2	8.63	9	22	0.000	8.76	9	22	0.000	0.662	0.662	0.593
	M3	8.63	9.5	22	0.000	9.03	9	10	0.000	0.165	0.148	0.229
	M4	8.63	9	22	0.000	8.74	9	24	0.000	0.727	0.729	0.662
	M5	8.47	8	29	0.000	8.15	9	45	0.000	0.399	0.410	0.508
	M6	8.63	8	22	0.000	8.26	9	42	0.000	0.324	0.321	0.209
	M8	7.98	8	47	0.000	7.63	8	52	0.000	0.405	0.419	0.447
	M9	7.76	7.5	52	0.000	7.41	8	55	0.000	0.420	0.426	0.441
	Avg.	***8.39***		5		8.28		5				
Intellectual Property	I1	8.00	8	46	0.000	7.79	8	50	0.003	0.612	0.625	0.729
	I2	7.88	8	48	0.000	7.50	8	54	0.001	0.364	0.365	0.341
	I31	7.41	8.5	55	0.004	8.29	8	40	0.002	**0.032***	**0.028***	**0.04***
	I32	7.86	9	49	0.000	8.53	8	30	0.000	0.101	0.089	0.132
	I4	7.78	8	51	0.000	7.53	8	53	0.007	0.584	0.586	0.549
	I7	8.37	9.5	37	0.000	8.82	9	18	0.000	0.227	0.208	0.297
	I9	7.43	8	54	0.000	8.47	8	34	0.001	**0.030***	**0.030***	0.164
	Avg.	***7.82***		6		8.13		6				
Technology Transfer Management	R11	9.08	9	1	0.000	8.68	10	25	0.000	0.148	0.159	0.149
	R12	8.80	9.5	12	0.000	8.82	9	18	0.000	0.933	0.934	0.859
	R2	8.78	9	17	0.000	8.76	9	22	0.000	0.973	0.971	0.519
	R31	8.47	8	29	0.000	7.65	9	51	0.001	0.053	0.060	**0.037***
	R32	8.80	10	12	0.000	9.35	9	1	0.001	**0.050***	**0.050***	0.187
	R33	8.22	8	42	0.000	7.91	8	49	0.002	0.405	0.409	0.344
	R34	8.80	9	12	0.002	8.53	9	30	0.011	0.404	0.421	0.488
	R41	8.78	10	17	0.000	9.09	9	8	0.001	0.295	0.319	0.069
	R42	8.47	9	29	0.000	8.82	8	18	0.000	0.264	0.264	0.205
	R5	8.24	9	41	0.000	8.38	9	38	0.001	0.752	0.757	0.585
	R61	7.84	10	50	0.000	8.82	8	18	0.005	**0.045***	**0.033***	**0.035***
	R62	7.10	9	56	0.000	8.50	8	32	0.000	**0.013***	**0.009***	**0.005***
	R7	8.29	8.5	40	0.000	8.29	8	40	0.006	0.982	0.983	0.653
	R8	8.80	9	12	0.000	9.00	9	11	0.000	0.520	0.501	0.731
	R9	8.63	9	22	0.000	8.47	9	34	0.000	0.686	0.686	0.629
	Avg.	***8.47***		4		8.61		2				

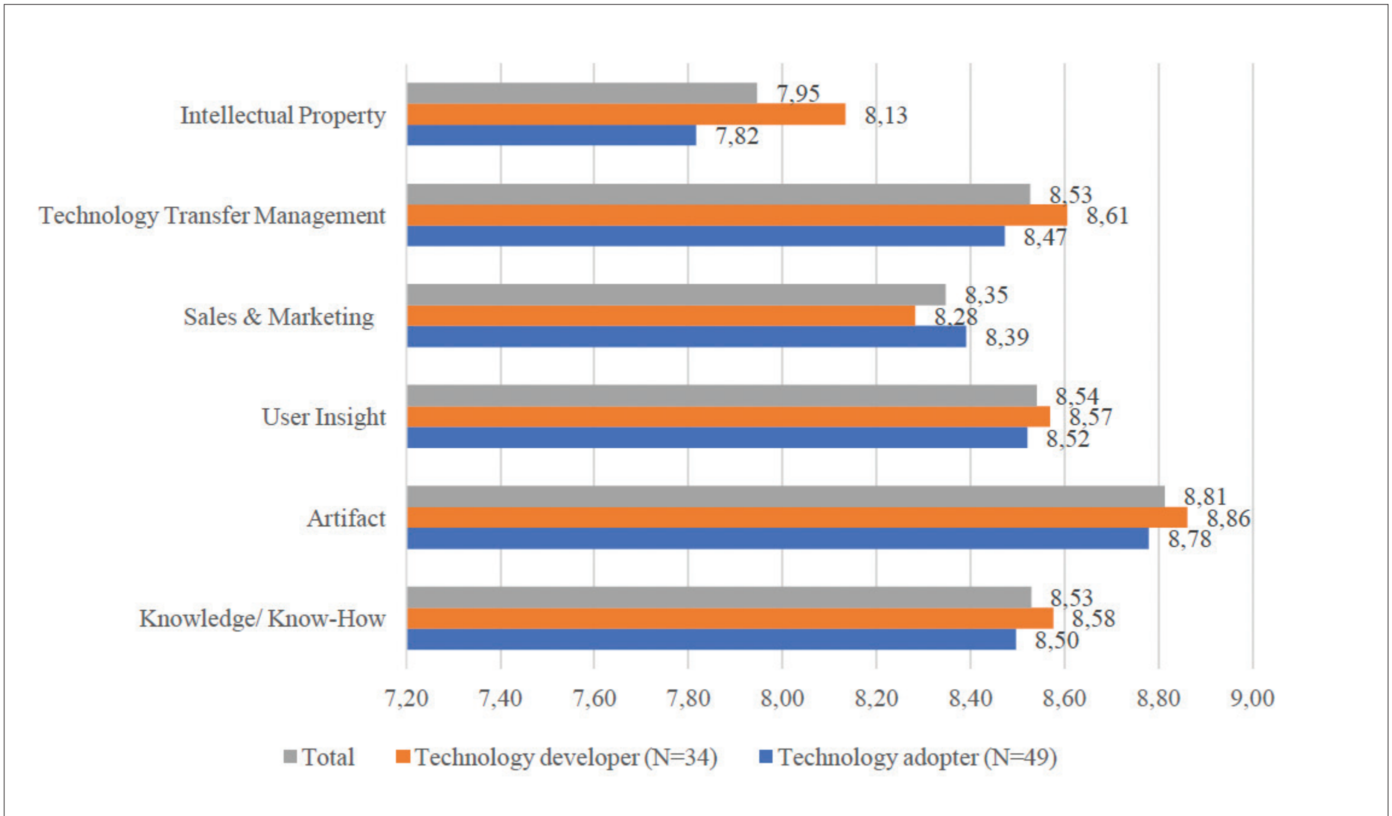
Note: *The importance score between the two groups of respondents was statistically significantly different at 0.05.

The researcher rated the importance score of 56 assessment items in descending order. The results showed that the technology developers rated the importance score of the assessment items from 1-56. The top 5 of the rated importance score were R32 Industry Cooperation (9.35), T6 Scaleup (9.32), A8 Market Acceptance (9.29), A2 Meet Requirement (9.26), T1 Technology Exploration (9.24), and T7 Pilot Implementation (9.24), respectively. In contrast, the fifth lowest-rated importance scores were M8 Marketing and Support Meet Requirement (7.63), I4 Public Disclosure (7.53), I2 Difficulty to Replicate (7.50), M9 Sales and Scope Expansion (7.41), and T3 Key Element Characterization (7.41), respectively.

Compared with the other group, the technology adopter rated 56 assessment items in descending order with the importance score. The top 5 of the rated importance score were A7 Pilot Meet Requirement (9.08), R11 R&D Skill (9.08), T1 Technology Exploration (9.02), A52 Prototype Meet Requirement (8.96), and A1 Better Solution (8.94), respectively. In contrast, The fifth lowest-rated importance scores were T3 Key Element Characterization (7.76), M9 Sales and Scope Expansion (7.76), I4 Public Disclosure (7.53), I9 International IP (7.43), I31 Publication Landscape (7.41), and R62 Adopter in Cash (7.10), respectively.

The average importance score of six sub-constructs was ranked to determine the perception discrepancy in technology transfer between technology developers and adopters in the other context. The results revealed that the adopters prioritized the Artifacts sub-constructs by ranking 1st. They were followed by the user insight sub-constructs by ranking 2nd. Then, the knowledge/ know-how, the technology transfer management, the marketing, and the IP sub-constructs were ranked 3rd -6th, respectively. Meanwhile, the technology developer prioritized the Artifacts sub-constructs by ranking 1st too. They were followed by the technology transfer management sub-constructs by ranking 2nd. Then, the knowledge/ know-how, User insight, marketing, and the IP sub-constructs were ranked 3rd -6th, respectively as shown in Figure 3.

Figure 3: Comparison of the importance score in 6 elements



Conclusion

The journey from research to commercialization via technology transfer is hampered by a lack of a universal evaluation approach. Various organizations use different tools and methodologies to review research, making it difficult to choose the best evaluation method. By combining the Evaluation Matrix of Technology Transfer (EMTT) with the Technology Readiness Level (TRL) system, the study refined the assessment process of technology transfer. This merger offers crucial insights to bridge the gap between research innovations and their real-world applications.

Using the EMTT to solicit feedback from both the developer and adopter groups about the core aspects of technology transfer revealed intriguing results. Both groups concurred on the top-rated aspects of research deliverables, signifying a mutual value placed on tangible research outcomes. This consensus indicates that both the research community and end-users prioritize results that cater to market demands. However, differences arose when evaluating preparedness for technology transfer: adopters emphasized alignment between research outcomes and their unique requirements, while developers stressed the importance of efficient technology transfer management. This discrepancy mirrors Heslops *et al.*'s 2001 research, where technology developers measure success by the effectiveness of transfer, while adopters focus on the technology's alignment with user needs and its profitability.

On evaluating readiness for technology transfer, the two groups showcased distinct preferences. Adopters considered product development capabilities paramount, echoing Pandia's 1989 findings. Conversely, developers favored a closer tie with the industry, reflecting Hagedoorn's 1993 assertion that partnerships between academic and industrial sectors can enhance mutual knowledge exchange. This contrast in views highlights the need to bridge the understanding gap between developers and adopters to enable effective technology transfers and foster industry-academic collaborations.

Practical Implication

The endeavor to utilize research findings necessitates the navigation of a multifaceted matrix of both intrinsic and extrinsic variables. These encompass the nature of technological innovation, allocation of resources, temporal considerations, and financial constraints, among others. In this intricate milieu, the potential risks associated with unsuccessful transfer, especially when research derivatives are not primed for dissemination, are magnified.

Considering these complexities, the conceptualization of the EMTT is not confined to the Research and Development (R&D) phase; rather, it spans the continuum to the technology transfer phase. This matrix amalgamates quintessential facets intrinsic to technological development while concurrently integrating salient business dimensions relevant to the effective application of research derivatives.

For practitioners in the R&D sphere, the EMTT emerges as an invaluable instrument. It provides a scaffold for conceiving research funding propositions that adopt a comprehensive purview, transcending the confines of mere technological innovation. By juxtaposing the competencies of researchers with germane business variables, stakeholders are better positioned to critically appraise the viability of research application endeavors.

Moreover, institutional research directorates can harness the EMTT as a heuristic blueprint for capacitating researchers and the scrupulous evaluation of research endeavors in the pre-funding phase. This meticulous stratagem amplifies the probability of efficacious technology transference, attenuating the perils associated with unsuccessful market entry. Such an approach augments the propensity for research derivatives to interface with their intended beneficiaries, culminating in a more tangible trajectory toward the commercial actualization of research outcomes. This evolution resonates with the aspirational mandates of research financiers and national policy-making bodies overseeing research and innovation, obviating the dissipative tendencies of both tangible and intellectual assets among the research and entrepreneurial communities. Consequently, this facilitates the optimal harnessing of a nation's research fiscal allocations, fostering a paradigm of judicious resource stewardship.

Theoretical Implication

The results unearthed from this investigation mark a seminal juncture, laying the groundwork for the ensuing phase of scholarly inquiry. The impending progression entails the formulation of the Technology Transfer Readiness Assessment Model (TTRM), which is intricately designed, drawing inspiration from the foundational architecture of the EMTT. TTRM is delineated into two principal constructs, aggregating six pivotal facets, and assimilates an ensemble of 56 evaluative queries pertinent to technology transfer readiness. An exhaustive empirical validation will be embarked upon to corroborate TTRM's congruence with tangible data and to decipher the interconnections spanning the six facets that play a pivotal role in facilitating technology transfer.

The ramifications of TTRM traverse beyond the immediate purview of this research endeavor. It is poised to manifest as a holistic blueprint, underpinning the deployment of Structural Equation Modelling (SEM) for the appraisal of quantitative research and innovation in various milieus. SEM, with its robust analytical prowess, equips scholars with the capacity to unravel intricate interrelations amongst variables, offering profound comprehension of the determinants shaping research and innovative trajectories. By anchoring on the TTRM as a bedrock schema, SEM can be quantitatively employed to gauge technology transfer preparedness and innovation dynamics across diverse contexts.

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