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Identifying Key Drivers of Technology Transfer Success in IT Using Jollys Subprocess Approach

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Abstract – Technology Transfer (TT) is the movement of technology, know-how and skills from one organization to the other so as to facilitate developing new technologies that would be commercialize. In information technology particularly, TT constitutes a critical impact to competitiveness and growth. In this paper, we establish factors affecting TT projects' success based on a survey of 135 project managers of 277 TT projects. To measure different influencing factors, a 5-point Likert scale is used whereas the success of project is measured by Jolly's subprocess model. The findings showed that the "Channels of Communication" were the largest predictor in the level of TT effectiveness, followed by the "Management Support," and "Technology Concreteness." However, the factors such as 'Sense of Common Purpose' and 'TT Awareness' which were considered as less important by the respondents also proved significant on the statistical level. 52.59% of TT initiatives transitioned to commercialization while the rest were either stunted at other stages or completely dead. This study stresses the need for communication, management support, and specific attention to the issues of organizational awareness and cooperation in order to achieve effective technology transfer.

Keywords – Knowledge, Information Revolution, Technology Transfer, Knowledge-Intensive Industries, Industry 4.0 Technology Transfer Relation.

I. INTRODUCTION

Knowledge has emerged as a crucial determinant of competitiveness for regional and national economies, signifying the rise of a "knowledge-based economy." Knowledge-based industries in the service and production sectors are leaders in this regard and might be seen as exemplars for business in the future. Knowledge sharing systems, innovation process and corresponding links in these businesses significantly vary from those in other industries. Regional knowledge spillovers and clustering are well acknowledged phenomena; nonetheless, the significance of regional knowledge connections and the precise mechanics of information flows remain ambiguous. There is a growing consensus that innovation varies significantly across different industries. Knowledge-based businesses seem to diverge from traditional sectors in their innovation processes concerning essential sources of knowledge, the significance of tacit and codified knowledge, and the nature of local clustering and knowledge connections.

The information revolution is a transformative era that may significantly impact individuals' lives. Computer technology underpins this transformation, and ongoing improvements in this field seem to guarantee that this revolution will impact individuals' lives. Computers are distinctive devices that augment cognitive capacity. Mechanized robots have started supplanting blue-collar workers; they might eventually start replacing white-collar jobs as well. Computer systems are machines, which are capable of executive instructions identified as computer software or programs, which are designed by individuals referred to as computer programmers. Computers provide several advantages; yet, they also present various risks. They might assist others in violating privacy or engaging in conflict.

They may transform individuals into mere button pushers, resulting in significant unemployment. Intuitive systems may be readily used by unskilled individuals. The fundamental advancement that enabled the creation of personal computers was the discovery of the microprocessor chip by Intel in 1971 [1]. The phenomena of digital innovation have garnered the interest of academics and professionals across several fields, including economics, strategy, and marketing. The prevalence of digital technology has transformed our approach to strategizing and organizing for innovation, while the execution of "new combinations of digital and physical components to generate novel products" has altered the essence of innovation itself. Nevertheless, despite a cross-disciplinary agreement that "digital innovations constitute a significant emerging phenomenon that fundamentally differs from the information systems traditionally examined," conceptual difficulties persist. The prefix digital is associated with a multitude of ideas, with many prominent academics contending that the ubiquity of digital technology fundamentally challenges established notions of innovation, strategy, and the very act of organization. Conversely, there are ongoing cautions about our comprehension of digital, as "digital technology is frequently represented in overly simplistic manners in Information Systems, and the discipline lacks sufficiently robust theories to adequately capture its uniqueness and diversity." Numerous cautions have been articulated, resulting in continuous discourse over the implications of the word "digital" itself. Consequently, in the absence of a definitive conceptual framework, "we, as a discipline, jeopardize rendering 'digital' a mere buzzword associated with various phenomena." The absence of a precise definition of innovation may undermine attempts to comprehensively grasp the sociotechnical aspects of digital innovation.

South Korea has emerged as a significant, if unexpected, success story from the recent digital information revolution. World Bank research determined that a significant amount of the development resulted from total factor productivity growth, or knowledge acquisition [2]. Multiple studies have shown the ICT sector's contribution to South Korea's economic expansion and its position as the principal driver of development since the beginning of the century. The ICT sector's contribution to GDP rose from 9.5% in 2000 to 16.9% in 2007. The astonishment over Korea's achievements arises in part from the same factors identified by Chalmers Johnson in his seminal analysis of Japan's extraordinary postwar economic growth. Spanning five decades, it extensively used Japanese language materials and highlighted the constraints of Western academic orthodoxy, as well as the imposition of Anglo-American ideas, issues, and standards of economic activity onto the Japanese context.

The aim of this study is to understand and define the factors that moderate the successful implementation of TT ventures in the IT industry. With survey data collected from different managers of completed projects, the study explores the influence of different organizational and process characteristics, including Channels of Communication, management support, and the objectivization of technology. It also examines some relationships that have not been extensively investigated, such as TT Awareness having a positive relationship with a sense of common purpose, in order to offer an exhaustive analysis of the factors that facilitate efficient technology transfer in this particular trade. The remaining sections of this research have been arranged as follows: Section II reviews relevant literature works on technology transfer, its factors and successes, and the Korean government IT approach. Section III provides a descriptive assessment on the research variables employed in this research. Section IV provides a detailed account of the results, which includes a descriptive assessment of the study variables, as well as the examination of the determinants of IT efficacy. Lastly Section V summarizes the findings and provides more emphasis regarding issues that go beyond the typical management and technical aspects.

II. RELATED WORKS

Technology Transfer

According to Chen, Looi, and Chen [3], technology refers to knowledge used to achieve a certain objective. Transfer refers to the conveyance of technology across different channels of communication from a single individual or firm to the other. A technical innovation refers to an ideology, activity, or thing seen as novel by a person or entity. Consequently, Technology Transfer (TT) refers to the implementation of knowledge (a technical breakthrough) into practical usage. The process of technology transfer often entails the transmission of a technical invention from a research and development agency to a recipient firm, like a private enterprise. A technological invention is completely transmitted when its marketed into a product available for sale in the market.

Khabiri, Rast, and Senin [4] argue that TT represents a distinct type of communication. Technological innovation and development are often characterized as a linear progression, including fundamental research, commercialization, applied research, dissemination, and the resultant impacts of the invention. A linear framework of the innovative-developmental procedure could inadequately include external environment elements, such as regulatory changes, or market demand, that might impact the technical innovation procedure. The process of TT encompasses the phases from research and development to commercialization, having a specific emphasis on the interaction between R&D, typically conducted by a institutional research center, governmental laboratory, or business division, and commercialization, which is generally executed by a private enterprise.

Factors Influencing Technology Transfer

Effective communication and knowledge are crucial for the successful transmission of technology. The faculty's incentive to engage in transfer activities is a key factor in enhancing licensing activity. Engagement in informal interactions with the industry enhances research cooperation. Wright et al. [5] emphasized the significance of individual players in academic entrepreneurship as facilitators of the transition from laboratory to market. The proficiency and motivation of a team significantly impact the assimilation of technology inside an innovative association. A market- and research-oriented Technology Transfer Office (TTO) positively influences licensing activities. Incubators are crucial for innovative product development and economic expansion. The licensor's understanding of the technology source inside the transferor favorably influences technology licensing. Bakker and Leiter [6] recognized management support as a crucial element, and its absence might hinder researchers' engagement in TT. Proper training is crucial for the adoption of technology in the business.

Technology Transfer (TT) positively influences both the quality and amount of research and community, and vice versa. The work quality in governmental institutions affects entrepreneurship, innovation, and competitiveness. Research and innovation are essential catalysts for the economic development of both business and country. Innovativeness is essential for academic entrepreneurship, resulting in research prospects. Proactive policies and measures enhance transfer efficiency. The return on investment from research and development entails a prolonged gestation period and need sustained governmental support. Technology licensing modalities are being investigated via both official and informal avenues, transcending conventional linear approaches for a more substantial influence on technology transfer. Financial assistance tools facilitate the development of investment-ready goods, therefore resulting in effective technology transfer. In the quintuple helix model, Redding [7] recognized social repercussions as catalysts for technological creation and adoption.

The global success of TT has been thoroughly analyzed across several aspects, including diffusion, commercial viability, political impact, environmental advantages, replacement benefits, human resources, and economic factors, among others. Recently, public value has attracted significant attention, consequently encompassing the whole domain of sustainability. The literature emphasizes the need for research evaluating the intersection of analytical levels from micro to macro and their influence on commercialization. An effective TT necessitates the collaborative engagement of several stakeholders to achieve complex and demanding objectives from a knowledge standpoint. It encompasses the whole process of imagining, incubating, representing, promoting, and maintaining a technology, which falls under institutional sustainability. The above literature analysis outlines the elements affecting the effective technology transfer from publicly sponsored agricultural research institutions to small and medium-sized enterprises. We conducted a study of models to determine the causal link among components. An examination of the current literature reveals that most models are either conceptual or theoretical, with the majority lacking empirical testing and validation. Furthermore, the majority of current models have concentrated on a single dimension or a limited number of components in TT. The viewpoints of technology recipients need empirical investigation.

Success of Technology Transfer

Industry 4.0 TT Relations

The trajectory of TT has evolved throughout time, as shown in [8]. Prior to 1980, the majority of technology transfer studies focused on international TT. In the early 1980s, research efforts transitioned to local TT. In the United States, multidisciplinary research has significant potential for innovation and creativity, now serving as the primary emphasis of TT with an objective of commercializing university results. Inter-linkages between industry, governments, and universities are fundamental. These three parties should communicate harmoniously to establish an effective process. This connection must be contextualized because of significant transformations in production and organizational systems in Industry 4.0. The technological transfer process in Industry 4.0 will activate the whole nation according to Dalenogare et al. [9]. Focus on technology-driven innovation in Industry 4.0. Companies must to exhibit more adaptability and flexibility in addressing fluctuations in consumer demand and market requirements. The adaptive process is facilitated by emerging technologies of Industry 4.0, including 3D printing. Consequently, TT is visualized as a means to provide small enterprises and nations with less developed sectors an equitable opportunity.

Centers of Innovation and Excellence

Technology transfer is essential for the implementation of Industry 4.0, particularly in developing nations. According to Hasbullah, Bareduan, and Hasibuan [10], emerging nations do not possess the attributes of I4.0. A continuous and progressive procedure for technology transfer is essential for the adoption of new technologies. Technological resources may originate from specialist vendors or their headquarters. Developed nations generate knowledge and technology by engaging research institutes, enhancing internal capabilities, and investing in research and development. Conversely, innovation has significantly contributed to technology transfer in the contemporary age of Industry 4.0. Frank, Dalenogare, and Ayala [11] discusses the distinctions between closed innovation techniques and the increasingly prevalent worldwide concept of open innovation, particularly in the context of Industry 4.0. Conversely, the commercialization of patents facilitated by open innovation enhances the likelihood of commercialization through TT. The authorization derives from the economic and technological merits of patents.

The discussion in [12] about the function of excellence centers in Industry 4.0 indicates that the majority of SMEs lack dedicated R&D components to facilitate their study endeavors. Substantial actions are underway to elevate the qualifications of students through specialization and the strengthening of regional institutions and excellence centers. They are collaborating with regional firms to identify the graduates' most pressing issues. Two essential factors include (a) the quality of universities and technology centers to establish a robust basis for both fundamental and applied researches, and (b) an effective transfer of study results to industry in order minimize disruptions in production activities and reduce transfer costs and duration. This notion, endorsed by Madu [13], concentrated on small enterprises and less industrially developed nations. The enhanced innovation approach prioritizes technology, particularly TT. Technological acquisition enables these firms to access the technology frontier and function inside Industry 4.0. I4.0 technologies, conversely, enlarge the search field by formalizing the idea of dispersed networks and enhancing a prior open innovation paradigm.

TT in Open Innovation and the 4.0 Industrial Revolution
A key catalyst for open invention and eventual TT represents an innovative ecosystem that emphasizes co-evolution and dynamism. Open innovation enables enterprises to create a systematic innovation environment, which utilizes external partner connections while concentrating on enhancing key internal strengths. Despite the term "open innovation" being used in the previous decade, the underlying principle is not novel. Open innovation is partially represented by concepts like as distributed, open source, user-centered, and user co-creation innovation. Dynamic open innovations rely on collaborations that cross organizational limits. Certain concepts and information are derived externally, whilst others are licensed to external parties for commercialization. Companies may use external opportunities and constrained internal resources to improve innovation rates in rapidly changing markets. Companies must access the resources of other organizations alongside their own. Companies pursue external innovations and cultivate interdependent partnerships with other businesses.

Manufacturing Cultures
Industries serve as the beneficiary of the transfers in the process of TT. The culture of manufacturing is a determinant of the efficacy of technology transfer. Manufacturing culture comprises the behaviors, practices, rules, and attitudes of a business that define it. Culture functions as the connection including social conventions, traditions, and norms within 'soft' or informal institutions. The culture profoundly influences technical transitions, particularly the shift towards Industry 4.0. This necessitated synchronization across various corporate organizations, industries, and technological goals. The manufacturing culture is a crucial element for a successful technological transition. According to studies conducted by Licht, Goldschmidt, and Schwartz [14], formal institutions and culture (regulations, laws, and rules) generated distinct institutional frameworks. Culture is identified as the principal factor influencing geographical disparities in economic performance and activity. National acceptance can only be achieved if top management is unequivocally dedicated to executing I4.0 industrial revolution. It is important to expedite and enhance decision-making processes. Interdepartmental and intergroup collaboration, extending beyond organizational boundaries, is crucial for the success of Industry 4.0. A well-defined plan and well-educated personnel may enhance employee acceptability and reduce concern over the unfamiliarity of new media.

Korean Government IT Strategy
Shin [15] examines the Korean government's role in guiding Korea into the subsequent revolution of information civilization, based on this fundamental concept as a normative framework. The emphasis is on the procedures related to the design of National Information Infrastructure (NII) projects and assesses its potential by examining diverse perspectives from various stakeholders. It analyzes the trajectory, characteristics, and prospects of IT839 by concentrating on the political economics of informatization. Gupta et al. [16] used theoretical frameworks from the Social Construction of Technology (SCOT) to gather qualitative data, largely via comprehensive interviews with various stakeholders, including governmental and regulatory bodies, user groups, industry representatives, and academic institutes. This study included interviews and evaluated archive records from several sources to corroborate the conclusions.

IT839 is a significant initiative just begun by Korea. The Korean government has provided comprehensive support for IT839, recognizing its potential effect and significance. More than USD 69 billion is allocated to IT839, along by significant regulatory assistance for the associated sector. In society at large, societal aspirations are sufficiently elevated to lead some to assume that IT839 facilitates the development of a pervasive information civilization. The results, nonetheless, suggest that NII do not meet ontologically defined responsibility required for functioning as an information infrastructure. The NIIs in this research are mostly structured to cater to the needs of big firm distributors and sectors, sometimes at the cost of public interests. Furthermore, the principal impetus for the development of NII is the allocation of technical resources to enhance procedural proficiency.

Gap in Research
The research gap that this paper seeks to fill, relates to the lack of knowledge on individual factors, which affect the effectiveness of TT ventures in the context of Information Technology (IT). Though previous trend investigations are concerned with diverse aspects influencing TT in numerous industries and fields, there is still a lack of studies investigating the factors related to the IT sector and the less apparent factors like "Sense of Common Purpose" and "TT Awareness." This study aims at addressing this gap with an exploration of several understudied factors such as Channels of Communication and management support besides the research focusing on the importance of these factors in influencing successful technology transfer.

III. DATA AND METHODS

Research Design
We aim to determine the variables affecting TT within the IT sector and to assess the significance of key factors to the success of TT, with the TT project serving as the basis of analysis. Target participants were project executives involved in TT initiatives across 9 growth engines, 3 infrastructures, and 8 services within the IT sector. Participants were requested to assess the significance of every aspect influencing the effectiveness of TT using a 5-point Likert scale. The scale was employed rather than a seven-point scale, since it has been noted that responders prefer to eschew the two extreme endpoints. This inclination renders the seven-point scale less appropriate in social science study contexts. The effectiveness of TT was assessed using Jolly's 5 subprocesses. Respondents were requested to evaluate the technology transfer initiative based on the

following criteria. In the event that a technology transfer project concludes at the imaging phase, effectiveness is assessed as follows: '1' for imaging, '2' for incubating, '3' for showing, '4' for promoting, and '5' for maintaining.

Data Collection

The u-I839 and IT839 approached focused on 9 growth engines, 3 infrastructures, and 8 services, which resulted in 277 completed technology transfer initiatives (113 firms) between 2004 and 2007. Finished projects refer to those that have either completed the process of technological transfers (regardless of effectiveness or failures) or have been halted owing to inadequate performance throughout the transfer procedure. The criterion omits any active TT initiatives. In May 2007, surveys were sent to project executives of 277 TT initiatives. Of the 277 surveys, 84 were unanswered and 58 were unreturned because project leaders departed from their firms. One hundred thirty-five questionnaires were submitted, resulting in a response percentage of 48.7%. The rate of response is deemed very good in the area of social research. No discernible occurrences indicated bias in the questionnaire replies.

IV. RESULTS AND DISCUSSION

Descriptive Assessment on Study Variables

Participants assess “Technology Concreteness” as the paramount aspect influencing TT, followed by “Incentive for Transfer,” “Governmental Support,” “Management’s Support,” “Collaborations among Respondents,” and “Channels of Communication.”

Conversely, “TT Awareness” is identified as the least important component, followed by “Demand-Pull Technology,” “Sense of Common Purpose,” “Comprehending Nature of Business,” “Attitudes and Value,” and “Product Champions” (see **Table 1**). Among 135 TT programs, participants classified 28.4% of the projects (i.e. 33), 28.2% of the promoting (i.e. 38), 19.3% of exhibiting (i.e. 26), 20% of incubating (i.e. 27), and 8.2% of imaging (i.e. 7). The values indicates that 28.2% (38/135) of TT initiatives did not go to the manufacturing stage, which might be seen as a failure. However, slightly more than 50% (71/135) of initiatives progressed beyond the manufacturing phase and effectively started the technology of commercialization. The rest 26 proposals reached the manufacturing phase but failed to enter the market. The rate of success of TT in the IT sector is stated to be 52.59%.

Examination of Determinants Affecting the Efficacy of TT

Regression analysis was conducted to assess the impact of each component on the effectiveness of technology transfer (see **Table 7**). A total of twelve variables provides substantial explanatory power regarding the effectiveness of technology transfer, accounting for 58.66% and demonstrating statistical significance at a .010 alpha level. “Frequencies of Communication” is considered statistically relevant at 0.01 in elucidating the effectiveness of TT. “Technology Concreteness” and “Management Support” exhibit statistical significance at a .051 alpha level, whereas “TT Awareness” and “Common Purpose Sense” demonstrate statistical significance at 0.10. It is somewhat unexpected that the primary explanatory variables for the effectiveness of technology transfer identified in **Fig. 1** is not in alignment with the key characteristics assessed by participants in the descriptive assessment (see **Table 1**). Although “Technology Concreteness,” “Management Support,” and “Channels of Communication,” deemed minimally influential by project managers, emerged as significant contributors to the effectiveness of TT.

Table 1. Descriptive Statistics of Different Variables

Variables	*Mean*	*Cronbach’s α*	*Std. dev.*
Product champion	3.21	0.7820	0.6425
Demand-pull technology	3.56	0.7764	0.5542
Concreteness of technology	4.20	0.7956	0.5950
Attitude and values	3.39	0.8267	0.4485
Government support	3.67	0.8172	0.5092
Collaboration among Participants	3.89	0.8573	0.3750
Awareness of technology transfer	3.09	0.8182	0.5659
Comprehending business nature	3.47	0.8389	0.4809
Common purpose sense	3.54	0.8088	0.6102
Incentives for technology transfer	3.66	0.7659	0.6122
Management support	3.77	0.7874	0.5255
Communication Channels	4.18	0.8356	0.3366

N = 135.

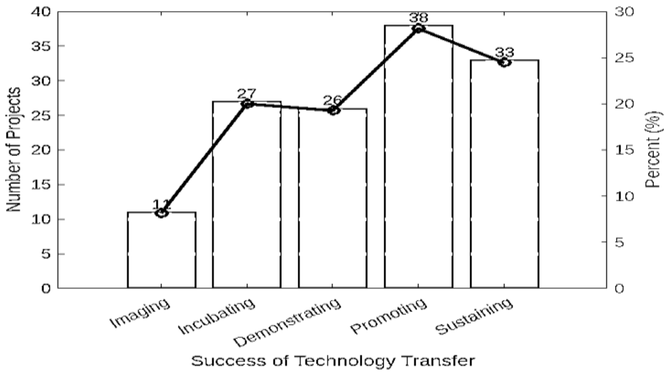

Fig 1. Technology Transfer Success Vs Number of Projects

The scores in **Table 1** are subjective and comparative, since project executives assess each component according to their individual experiences. Consequently, these personal assessments might not sufficiently represent the objective impact of variables on the effectiveness of TT. This irony might also make significant contribution to the observation that the effectiveness of TT is assessed by Jolly's 5 subprocesses, although project directors evaluate variables based on technology transfer itself, often neglecting the phases attained by technology transfer initiatives. Jolly (1997) presented a process approach on technology commercialization. He contends that technology commercialization entails executing a series of operations that together enhance the value of the technology throughout the commercialization process.

Fig. 2 illustrates that five of these actions represent the essential subprocesses in the commercialization of innovative technologies: (a) envisioning a techno-market perspective, (b) nurturing the technology to ascertain its commercial viability. (c) exhibiting it contextually in processes or/and products (d) advocating for the latter's implementation (e) ensuring commercialization sustainability. The four bridges connecting these subprocesses are equally significant. The seamless transition from a single subprocess to the subsequent processes is crucial in commercialization of technology. The interest, market transfer, diffusion, and technological transfer gaps represent four significant impediments to their corresponding bridges. The Jolly process model effectively delineates essential processes for effective technological commercialization; nevertheless, it lacks depth in addressing technology transfer.

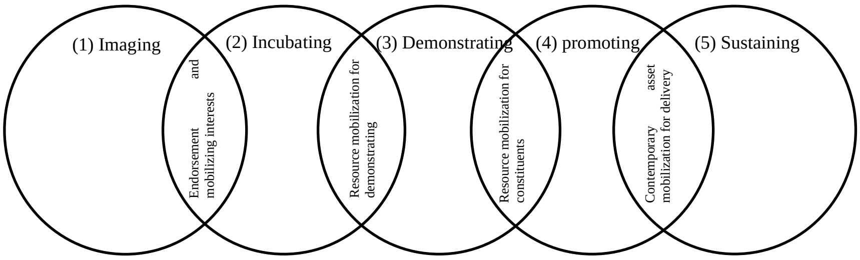

Fig 2. Technology Commercialization Process Model

Every sub-process has a defined result, requisite completion milestones, and a roster of primary stakeholders involved in that segment of the process. The conceptualization sub-process involves commercialization as a mechanism for value acknowledgement. This represents the possibility for a technological advancement coupled with a promising commercial opportunity. During the imaging sub-process, the notion of dual insight emerges, emphasizing the significance of considering both market and technical results. Peer rivalry starts from the outset, when concepts vie for financing, obtain resources, and contend with existing solutions to demonstrate their superiority and viability for progression to subsequent tasks. **Table 2** delineates the anticipated results, completion milestones, and primary shareholders of this sub-process.

Table 2. Imagining Sub-Process

Major stakeholders	Media, research partners, colleagues, peers
Completion points	Filing key patents, technical proofs of principle, preliminary technology vision
Expected outcomes	Exciting, probably novel technology-oriented idea connected to market requirements

Once the concept is acknowledged and deemed worthy of pursuit, it must be validated in a way that is both technologically feasible and satisfying in addressing the identified requirements. Incubating involves assessing the necessary elements both materially and metaphorically. Consequently, it is mostly a battle among technology rather than just concepts, as in the preceding phase. At this stage, it is essential to formulate a clear strategy for deriving value from the new technology to effectively present it to relevant grants, venture capitalists, and angel investors for project funding. **Table 3** delineates the anticipated results, completion milestones, and primary shareholder of this sub-process.

Table 3. Incubating Sub-Process

Major stakeholders	Development partners, potential technology users, venture capital providers
Completion points	Preparation of business plans and case studies for product platforms, crafting of technologies, commercialization, and testing with lead clients.
Expected outcomes	Definitions of concept's feasibility, commercial plans and potential for taking it further.

Demonstration is the subprocess linked to product development. The primary difficulty of this sub-process is to exhibit a process or/and product, which is financially viable, appealing to consumers, and feasible for effective implementation with the current technology. **Table 4** delineates the anticipated results, milestones of completion, and major shareholders of this sub-process.

Table 4. Demonstration Sub-Process

Major stakeholders	Potential clients, distributors of modern technologies, internal staffs in different functions (such as manufacturing) and organizational partners
Completion points	Launching of commercial versions of process or product
Expected outcomes	Integrating technologies in attractive, market-ready processes or/and products.

Promotion entails engaging the emotions and aspirations of customers, facilitating their transition from the first introduction of a product to the action of acquiring the technology. Approximately 27% of all novel processes and products are abandoned owing to "uncontrollable" marketplace conditions, while an additional 26% fail because of restricted sales potentials and an incapability to identify sufficiently interested consumers. **Table 5** delineates the anticipated results, completion milestones, and primary shareholder of this sub-process.

Table 5. Promoting Sub-Process

Major stakeholders	Opinion leaders, end-users, customers, and market constituents for delivery mobilization
Completion points	Capturing profitable market share quickly
Expected outcomes	Getting process or product rapidly acknowledged by different market constituents

Despite extensive consideration in this sub-process, marketplace acceptability is uncertain, and novel technologies often face the challenge of establishing a marketplace that did not previously exist before their advent. Sung and Gibson [17] elucidates that technology is not certain and may depend on factors such as trends for acceptance, shown by the zipper's success—" ...not due to the inadequacy of button flies, but rather cultural notions of modernity and fashion." Upon effective realization of a technology, the last phase in the commercialization process is to maintain its market competitiveness and secure an equitable portion of the created revenue. The ongoing emergence of new technologies, goods, and the consequent influx of rivals renders this aspect challenging. It is prudent to recognize that the ongoing commercialization of novel technology does not equate to achieving success at any cost; a technology may become intrinsically outmoded and must be forsaken until a novel process or product may be developed from it.

Table 6. Sustaining Sub-Process

Major stakeholders	Business partners, changing consumer segments, company management
Completion points	Adequate ROI made in infrastructure and technology for commercialization
Expected outcomes	Producing long-term value for expanding and entrenching the application of technology and maintaining lead

According to Kock et al. [18], the worth of every new technology is ultimately determined by the goods that use it and their sustainability in the market (see **Table 6**). Numerous innovations reach an intermediate phase and either experience excessive delays or fail. This may sometimes result from the inherent advantages of the technology, but it may also stem from an inability to adequately integrate the subprocesses. Every sub-process should provide outputs that are either an intangible or a physical product with economic value. It is essential to generate sufficient value in each sub-process to effectively transition to the next stage by encouraging shareholders to invest, based on the 4 bridges in **Fig 3**.

To address the constraints of the aforementioned models, four stages of technology transfer are proposed based on the technology transfer model in **Fig. 3**. At level 1, technology creation, people engage in cutting-edge research or refine best practices into knowledge, disseminating their findings via diverse channels such as research papers, anecdotes, personal communications, news media, teleconferences, and videotapes. At this level, TT is majorly a passive procedure, which necessitates minimal collaboration among the transceivers, despite researchers potentially working in teams or across organizational or national lines. Level 2 TT necessitates the initiation of shared accountability between the creators and consumers of technology.

Success transpires whenever technological advancement is disseminated across functional, organizational, or personal barriers and is comprehended and embraced by intended individuals. In level 3 TT, effectiveness is characterized by the prompt and effective execution of technology. For level 3 effectiveness to be achieved, technology users should use the necessary resources for implementation. Technology adoption may transpire inside the user organization about manufacturing or other processes, or it may pertain to best practices or services. Level 4 TT, technological use, focuses on commercialization. Level 4 develops cumulatively on the results attained in the goals of the preceding three levels, however market power is essential. Success is quantified by return on investment (ROI) or market share.

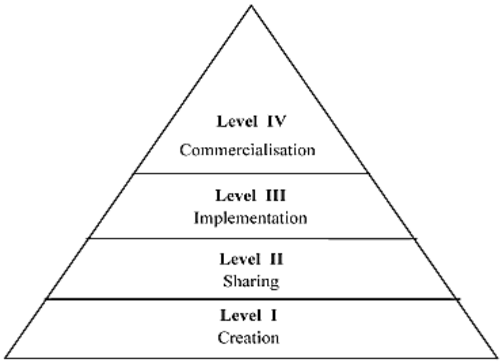

Fig 3. TT levels

Table 7. Regression Analysis of TT Success Factors

Factors	*Coefficients*	*p-value*	*t-statistics*
Product champion	0.2408	0.2073	1.2678
Demand-pull technology	0.0664	0.7027	0.3826
*Concreteness of technology***	0.3762	0.0427	2.0476
Attitude and values	0.3264	0.3952	0.8533
Government support	0.2885	0.1387	1.4904
Collaboration among participants	-0.24515	0.3267	-0.9847
*Awareness of technology transfer **	0.3114	0.0802	1.7644
Comprehending business nature	0.1472	0.6932	0.3954
*Common purpose sense****	0.5516	0.0029	3.0362
Incentives for technology transfer	0.01683	0.5047	0.6990
*Management support***	0.5382	0.0398	2.0779
*Communication Channels**	0.4453	0.0921	1.6978
Pr < F	0.0000		
F-Statistics	14.4244		
R^2	58.66%		

Coefficients denoted by ∗∗∗, ∗∗, and ∗ are statistically significant at 0.01, 0.05, and 0.10 levels, correspondingly.

An ANOVA (Analysis of Variance) was conducted to determine if project directors in effective TT initiatives assess every element distinctively from those in unsuccessful programs (see **Table 8**). The sample was partitioned into five subsamples for the purpose of this study. Each subsample comprises technological initiatives that have attained certain phases of “Sustaining,” “Promoting,” “Demonstrating,” “Incubating,” and “Imaging” according to Jolly's sub-processes [19]. The study indicates that project executives across 5 subsamples assess every element distinctively, with the exception of “Technology Concreteness.” This indicates that regardless of the outcomes of technology transfer efforts, the “Technology Concreteness” is a significant determinant of their success. A visual analysis was conducted to examine how project leaders in various subsamples assess every aspect.

Table 8. Variance Analysis by Technology Transfer Success

Factors	*p-value*	*F-statistics*
Product champion	0.0000	7.3622
Demand-pull technology	0.0016	4.6088
Concreteness of technology	0.6959	0.5547
Attitude and values	0.0083	5.6814
Government support	0.0000	8.9046
Collaboration among participants	0.0036	3.6902
Awareness of technology transfer	0.0000	9.3412
Comprehending business nature	0.0000	10.7033
Common purpose sense	0.0000	17.3286
Technology transfer incentives	0.0000	25.1657
Management support	0.0000	18.4274
Communication channels	0.0032	4.1763

V. CONCLUSION

This research focuses on the Information Technology (IT) industry to identify major factors that enable or hinder Technology Transfer (TT) success, with communication media, management encouragement/recommendation, and tangible expressions of technology as the critical factors for success in TT. Furthermore, which means that other factors like 'Sense of Common Purpose' and 'TT Awareness' are far more important than one could infer from conventional evaluation methodologies despite the fact that most people do not value organizational culture and awareness as much as they should. These results indicate that the promotion of technology transfer has issues more than the technical and management aspects, organizational identity awareness can also be an important factor. Several study limitations can be identified: the study concentrates on specific IT strategies; the results of the analysis are based on the subjective evaluations of the project leaders. To overcome these limitations, future research must examine how TT is affecting various industries, sectors and cultures, and must conduct retrospective research to establish the effect that the outlined factors have on projects' performance in the long run. Future research into antecedents of market conditions, government policies and emerging technologies will also be important in enhancing the understanding of technology transfer success factors.

CRediT Author Statement

The author reviewed the results and approved the final version of the manuscript.

Data Availability

The datasets generated during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interests

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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Competing Interests

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