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Modeling and ranking critical success factors in the transfer of emerging technologies: An industry 4.0 perspective

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Abstract The successful transfer of emerging technologies is a crucial enabler for strengthening technological capabilities and competitiveness in the era of Industry 4.0. This study develops an integrated framework for identifying and prioritizing the critical success factors (CSFs) that determine the effectiveness of international technology transfer projects. Using a survey of 90 experts from technology transfer facilitation firms, a combination of advanced decision-making techniques—including Fuzzy Delphi, Analytic Hierarchy Process (AHP), DEMATEL, and VIKOR—was applied, supported by MATLAB, Smart PLS, and Warp PLS. The findings reveal that effective communication, project team maturity, managerial competence, and feasibility assessment represent the most influential drivers of transfer success. Complementary factors such as strategic alignment, socio-cultural considerations, human resources, infrastructure readiness, and managerial support also exert significant impact. Moreover, the study highlights that the complexity of technology transfer varies with market and product novelty, underlining the necessity of context-specific strategies. This research contributes by proposing a ranked and integrative framework of CSFs and their interdependencies. The framework not only advances theoretical understanding of technology transfer under Industry 4.0 but also provides actionable guidance for practitioners to improve efficiency, minimize resource losses, and enhance sustainable competitiveness in international markets.

Keyword: Emerging Technology, Industry 4.0, Technology Transfer, Critical Success Factors, Multi-Criteria Decision-Making.

1 Introduction

The significance of technology as a primary driver of economic growth in the modern era has been recognized [1]. Emerging technologies such as artificial intelligence, IoT, blockchain, and quantum computing are reshaping global competitive landscapes [2]. Around 85% of the global population resides in developing nations [3], highlighting a distinct challenge in adopting and

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integrating new technologies within these regions [4]. Human capital development and culturally adaptive innovation strategies are essential for successful technology adoption in these regions [5]. Reports indicate that insufficient social and human resources, along with a significant digital divide, may impede the integration of technology. This, in turn, could stifle economic growth in the emerging knowledge-driven global society and exacerbate poverty and inequality in developing nations [5]. Various elements, including fundamental infrastructure, labor conditions, cultural perspectives, internal policies, and the lack of financial resources, impede the effective implementation of technology in developing countries [6]. Conversely, the onset of the fourth industrial revolution, also known as Industry 4.0, which is defined by the integration of various technologies, began quite some time ago. As a result, governments and countries must thoroughly analyze its elements, ready themselves to harness the opportunities it presents, and address the challenges it poses [7]. Governments must get ready to align with advancements in science and technology to effectively meet societal demands and tackle global issues [8]. They should also enhance their frameworks to achieve a level of transparency and efficiency that ensures they retain their competitive edge [9]. Governments in developing nations need to establish favorable conditions for the transfer of new technologies to promote economic growth within their borders [10]. To achieve this, they should facilitate the acquisition of global technologies and enable their transfer to local businesses that specialize in technology. These technology firms are crucial in assisting developing countries in advancing towards more sophisticated economies through innovation [11]. The organizations have been incorporated into the agenda and program to promote international technology transfer initiatives. Their focus includes executing projects related to technology oversight, fostering local research and development, and commercializing acquired technologies, all tailored to meet the specific conditions and requirements of the country [12]. In this study, it is utilized these companies to gather data via a questionnaire. Our world undergoes daily transformations, which simultaneously create new opportunities and pose risks to us [13]. The idea of revolution represents significant transformations, often taking considerable time to manifest and requiring thorough examination of their impacts [14]. One of the most significant transformations in human history that has impacted the entire world is the industrial revolution [15]. Among these revolutions is the Fourth Industrial Revolution, which involves the integration of automation and data exchange in manufacturing processes [16]. The subsequent phase, known as Industry 5.0, is an evolving concept that aims to enhance collaboration between humans and machines This approach seeks to empower individuals, making work safer, more efficient, and more fulfilling [17]. To facilitate the transfer of these emerging technologies, it is essential to identify the key success factors for international projects focused on the transfer of such technologies within the framework of the Fourth Industrial Revolution [18]. Additionally, it is understood the most efficient and effective processes and models for transferring international emerging technologies in this context. The fourth industrial revolution has brought about significant transformations in human societies, requiring governments and industrial sectors to adapt to these shifts. These changes encompass various technologies, including artificial intelligence, autonomous vehicles, 3D printing, nanotechnology, robotics, and quantum computing. It is anticipated that these advancements will reach their full impact by the year 2030 [19]. Given the significance of the fourth industrial revolution in today's world, it is crucial to focus on technologies that align with this transformation. To maintain a competitive edge on the global stage, it is essential to establish conditions that support the transfer of emerging technologies. Consequently, the significance of transferring emerging technologies and their associated models is clear within this platform. Recognizing the elements that elucidate these indicators and their interconnections can be regarded as the primary focus of this study.

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In the ongoing study, the focus lies on technology transfer research, with the researcher aiming to identify the key success factors and criteria for such projects. In this part, the study examines the research on the success factors and criteria of technology transfer projects, along with analyzing the success models of such projects. It then discusses the research background that aligns with the methods employed in the current study, ultimately addressing the research gap.

Factors and success criteria of international technology transfer projects and barriers to the success of technology transfer can be described as the elements that influence the effectiveness of transferring technology across borders [20]. The study investigates the elements that influence the effectiveness of cross-border technology transfer [20]. It highlights the complex and multifaceted nature of success criteria for international technology transfer projects. These criteria generally include economic, market, and product performance, as well as the extent of technology acquisition and satisfaction with newly adopted technologies [22, 21].

The research also discusses advanced technologies in low-carbon materials and indicates that successful international technology transfer depends on the development of technological and innovation capabilities within the recipient organization. In addition, the sustainability of these capabilities after the transfer process is identified as a key factor. The study further emphasizes the significant role of commitment, motivation, and senior management strategies in ensuring successful technology transfer. [23, 24].

The study emphasizes the significance of the receiver's technological competence in the successful transfer and adoption of a specific technology. It also highlights the importance of other factors, including education, cultural compatibility, appropriate legal frameworks, and a supportive environment, in determining the success of technology transfer. Furthermore, the research indicates that organizational characteristics such as firm size, age, and departmental structure can influence the management of technology transfer processes [10, 25].

The study developed a framework for the prosperity of international technology transfer, which named the strategic process of international technology transfer. The research involved analyzing the experiences of over 150 companies involved in international technology transfer. The factors were categorized impacting success into three main categories: establishing goals, choosing partners, and executing the transfer [26, 27].

Research conducted by multiple scholars indicates that technology transfer initiatives often encounter numerous challenges, leading to instances where the finalized projects may not prove beneficial to the recipient organization or nation [28].

The study conducted a review of previous research and highlighted the challenges faced by developing countries in technology transfer projects from developed nations. Some key obstacles identified in the research include [29]:

Lack of necessary infrastructures and institutions.

Insufficient human capacities**.**

Supplier exclusivity and buyer bargaining power.

Weakness in technological capabilities and failure to establish indigenous technological capabilities.

Selection of inappropriate technologies.

Small market size in recipient countries.

Provision of outdated technologies by sellers.

Inadequate understanding of technology nature and success requirements.

Absence of comprehensive plans for technological development in developing countries.

Resistance from industrialized countries.

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These obstacles underscore the complexities involved in technology transfer processes between developed and developing nations, impacting the successful implementation and outcomes of such projects [30].

The study analyzed and evaluated effective frameworks for global technology exchange initiatives and formulated a framework for developing nations by examining government-backed international technology transfer programs within the Indonesian manufacturing industry. The proposed framework comprises four key components: Technology dissemination, technological infrastructure, technical proficiency, and economic efficacy. According to this framework, the technology transfer process enhances a company's technical competencies, which in turn leads to improved economic outcomes. Furthermore, the framework indicates that the effectiveness of technology transfer is influenced by organizational learning culture, absorption capacity, governmental support, and the chosen method of technology dissemination. [29, 31].

The study highlights the delineation and actualization of diverse technological competencies. Nonetheless, the model's design lacks precision in defining conceptual aspects, variable types, positions, and interrelationships. A notable strength of the model lies in the thorough examination of "government support" as an independent variable alongside other factors [32, 33].

The proposed framework is based on numerical and empirical evidence, with structural equation modeling serving as a key feature and exploratory factor analysis being emphasized. In this research, the term "transfer performance" is used as a broad indicator of achievement. The study also explores the relationships between the variable "learning organizations" and other factors [34, 35].

The framework scrutinized a limited set of factors and combined the recipient and the source into a single variable. However, the recipient and the source exhibit distinct characteristics, suggesting that analyzing their impacts individually would be more informative. By considering cultural variances, this model holds greater research significance, although it lacks depth in other variables [36].

Another study conducted a case study within the automotive supplier sector and formulated a multi-criteria decision-making framework to facilitate digital transformation. This model, designed for technology transfer purposes, was tailored to assess Industry 4.0 innovations capable of enhancing operational processes within the investigated organization [37].

The research also presented a new approach integrating the Delphi-DEMATEL-ELECTRE technique using gray numbers to evaluate technology providers. By employing the DEMATEL method, the study analyzes the interrelationships among selected criteria and prioritizes them according to the obtained results [38].

Further research explores the utilization of Multiple Criteria Decision-Making (MADM) techniques in technology transfer processes, emphasizing their role in reducing ambiguity, imprecision, and uncertainty in decision-making. The study examines the evolution and current applications of MCDM in sectoral technology transfer, highlighting the importance of determining technology transfer strategies, selecting appropriate technologies, and identifying barriers and drivers as key research perspectives [39].

Finally, the study introduced a comprehensive evaluation framework aimed at enhancing supply chain intelligence through a combination of multi-criteria decision-making techniques. This model emphasizes the prioritization of assessment standards and suggests evaluating intelligent enhancement solutions using the VIKOR method [40].

They introduced a framework and a methodological proposal for technology selection in the field of Industry 4.0 production. The outcomes derived from the FAHP and FANP

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algorithms empower decision-makers to effectively oversee and opt for the most suitable technology amidst the diverse array of choices prevalent in contemporary markets [41].

According to the research conducted in the field of emerging technology transfer, the common thread among the current studies is their focus on the effectiveness of international technology transfer projects. These studies examine and rank the key factors that contribute to the success of technology transfer initiatives. However, the previous research in this area has identified the following research gaps:

1. Previous investigations in technology transfer have predominantly concentrated on structural frameworks, with limited utilization of sophisticated decision-making methods like Analytic Network Process (ANP) to explore technology transfer models
2. In previous studies, there has been a greater emphasis on the impact of restricted indicators on the efficacy of technology transfer, with a lesser exploration of a diverse array of indicators for facilitating technology transfer.
3. In previous studies, the primary emphasis has been on examining the pros and cons of technology dissemination within individual sectors, with limited attention given to exploring technology transfer across industries. This approach involves initially conceptualizing technology transfer in a broad context before tailoring it to specific industries for further analysis and implementation.
4. In previous studies, the focus on technology transfer primarily revolved around indicators and alternatives, while the elements that clarify these indicators received less attention.

Finally, the present research addresses these questions based on a comprehensive analysis of all relevant cases and gaps:

1. What elements contribute to the success of international projects focused on transferring emerging technologies?
2. How are the success factors ranked in the context of transferring emerging technologies within the framework of the Fourth Industrial Revolution, utilizing a fuzzy methodology?
3. Which indicators influence the success of international projects for emerging technology transfer, and what mechanisms facilitate this influence? Additionally, how do the relationships and interactions among these indicators manifest, and what are the primary components that elucidate the success factors associated with project transfer?

The purpose of this research is to present various scenarios to optimize international technology transfer models in order to enhance the success rate of transfer projects. Therefore, in terms of the implementation method, this research employs a survey approach. It is a survey because in this study, questionnaires and interviews were designed to identify the factors of technology absorption by the receiver, the readiness of technology transfer by the source, and the ability to exchange technology in the project. These instruments were used to gather the opinions of experts from facilitating companies in the field of information technology. Therefore, at this stage, the research has a quantitative orientation, and in terms of data collection, the research method is descriptive-survey. These surveys were then administered to information technology experts within facilitating companies. Consequently, this phase of the study adopts a quantitative methodology. Data collection primarily follows a descriptive-survey approach. In the qualitative part of this research, the methods used include decision-making techniques, specifically the fuzzy Delphi method, to screen and analyze the indicators of emerging technology transfer. Additionally, the AHP (Analytic Hierarchy Process) and DEMATEL (Decision Making Trial and Evaluation Laboratory) methods are employed to identify the process model of emerging technology transfer and determine the importance and ranking of these indicators. The rationale for using these approaches, compared to similar

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methods, is the ability to consider the network and intra-network relationships of the indicators, which allows for a more thorough examination of their effectiveness and leads to more accurate results. Furthermore, the VIKOR technique is utilized to investigate the role of facilitating organizations in relation to the indicators of emerging technology transfer. MATLAB software will be used to solve both the VIKOR technique and the DEMATEL method. The research population consists of individuals specializing in companies that facilitate the transfer of emerging technologies. The sample size is determined based on the fuzzy law. In this study, a random sampling method is employed, ensuring that each company has an equal and independent chance of being included in the sample. The statistical population comprises active managers in facilitating companies, and using Morgan's table, the sample size for this research is set at 90 participants.

2 Data collection tools

This study collected the required data from questionnaires or direct interviews with experts. A questionnaire as a direct method is one of the standard measurement tools. The questionnaire contains different questions related to the research variables, which are filled out by the participant directly or indirectly. The data necessary for this study were gathered through questionnaires or direct interviews with subject matter experts. The carefully crafted questionnaire pinpoints the optimization metrics of international technology transfer frameworks. Additionally, another set of required data can be collected directly through expert interviews. It should be noted that expert opinions on the subject were given at each stage through an interview to confirm and validate the results.

3 Data analysis method

At the outset, to scrutinize the results of individual studies and identify fundamental aspects utilizing open coding technique, the initial step involves evaluating and organizing all significant points and factors derived from the materials as codes. Subsequently, to integrate the outcomes and establish connections between categories and strategies, the axial coding method is employed to interrelate the information in a novel manner. To apply the fuzzy Delphi method, a survey was created and circulated to specialists. Within this survey, experts were tasked with indicating the significance of each factor. Through multiple rounds of the survey and reaching an agreement on the criteria, the fuzzy Delphi procedure was successfully carried out. In this survey, the experts were asked to assess the significance of each of the criteria, and through multiple stages of the questionnaire and consensus on 26 criteria, the fuzzy Delphi process was concluded. By optimizing while considering 95 points, 11 criteria progressed to the subsequent stages. The weighting of the criteria selected by AHP was determined through a questionnaire in which the criteria were compared in pairs. Subsequently, a pairwise comparison matrix was constructed, introducing 5 indicators labeled A1 to A5. Then these 5 indicators are ranked by calculating the preference function using the Promethea method and the fuzzy Delphi method. The Promethea method is one of the multi-criteria decision making (MCDM) methods whose purpose is to rank the alternatives. The resulting matrix was then inputted into the FCMapper software. This software serves as an international online platform for analyzing and visualizing fuzzy cognitive maps. In this software, the level of impact, influence and centrality of each variable is determined as depicted in the figure below. Positive

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and negative causal linkages can be observed in this model. The size of the circles corresponding to each factor indicates the degree of centrality of that factor. The larger its size, the greater the influence and impact of that factor on other factors, and consequently, its centrality is higher.

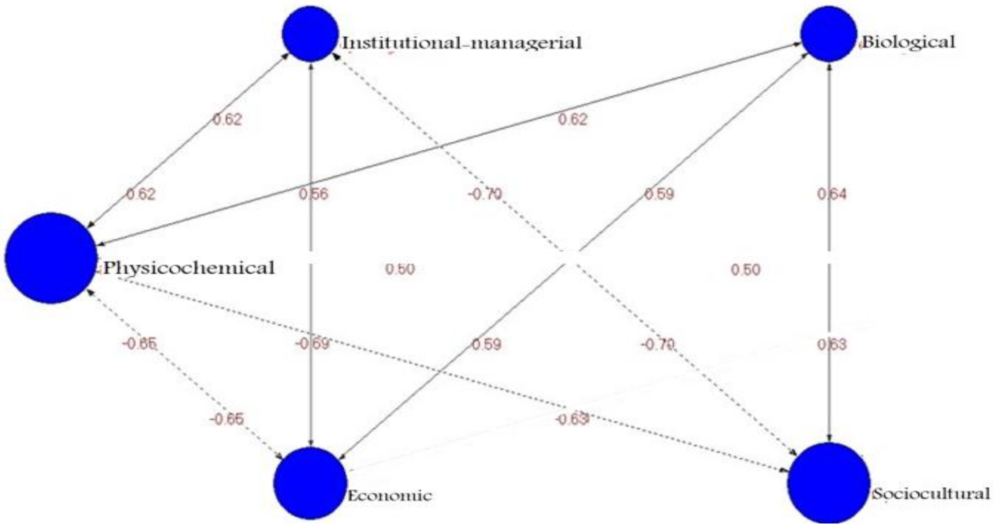

Fig. 1 Fuzzy cognitive map model of engineering factors of the success model of emerging technology transfer projects with the approach of the fourth industrial revolution

4 Results

4.1 Defining the acceptable limit for selecting criteria

$$Nw_k = Nw_i \times Nw_{ip} \tag{1}$$

Table 1 The final average of the criteria

RAW	criterion (option)	Final average	Condition
1	Transmission capacity and technical ability of the source	9/25	confirmation
2	Adaptation and indigenization of technology	9/25	confirmation
3	Experience in transfer projects with a similar method	9/25	confirmation
4	Repeat purchase from the source	5/5	rejection
5	Willingness to transfer technical knowledge	5/5	rejection
6	Technological complexity	9/25	confirmation
7	Implicitness of technology	5/5	rejection
8	The newness of the technology	9/25	confirmation
9	Dynamics and uncertainty of technology	9/25	confirmation
10	Nature and nature of technology	5/5	rejection

12	The amount and intensity of support for technology transfer	5/5	rejection
13	Financial support and provision of project resources	5/5	rejection
14	The degree of internationalization of technology	9/25	confirmation
15	The organization's relations with other government institutions and supporters	5/5	rejection
16	The amount of effective control and supervision of the project supporter	5/5	rejection
17	Organization's commitment, experience and capability	5/5	rejection
18	Familiar and proven technology	9/25	confirmation
19	The level of support of the senior manager of the organization for the project	3/66	rejection
20	The way of communication, interaction and coordination between the source and receiver	9/25	confirmation
21	The amount of cultural distance between the source and receiver	4/66	rejection
22	Features of transfer contracts	3/25	rejection
23	Industry characteristics (market scale, product life cycle and government)	5/5	rejection
24	Transfer profitability rate (cost reduction, income increase, foreign exchange income generation)	5/5	rejection
25	The purpose of transfer (penetration in the domestic market, penetration in the foreign market, response to intense competition)	3/25	rejection
26	Creating endogenous development capabilities	9/25	confirmation
27	Provision of complementary and intermediary infrastructures and institutions	5/48	rejection

The share of the domain score is 7.83, and by adding it with the lowest value (1), the acceptable value is 8.83. The numbers that fall within the specified range are confirmed and the numbers that are outside the range are rejected.

4.2 Weighting the criteria selected by the fuzzy AHP technique

Triangular fuzzy values were employed in the dataset. Subsequently, the collective expert opinions were amalgamated into a comprehensive matrix. In this matrix, the leftmost fuzzy number represents the lowest opinion value, the rightmost fuzzy number represents the highest opinion value, and the middle fuzzy number is the geometric mean of experts' opinions. Following the computation of the z-score for each criterion using equation 2, the ultimate weight for each criterion (expressed in fuzzy terms) was determined. This fuzzy weight was then converted to a crisp value using equation 3, and the scaling factor for the criteria's weights was established based on the guidelines outlined in Table 2.

$$W_i^- = Z_i \otimes (Z_1 \oplus Z_2 \oplus \dots \oplus Z_n)^{(-1)} \quad (2)$$

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$$W_i = (W_{\alpha i} + W_{\beta i} + W_{\delta i}) / 3 \quad (3)$$

Table 2 Normalized weight of each criterion

Row	Criterion	The normalized weight of each criterion
1	Transmission capacity and technical ability of the source	14/0
2	Adaptation and indigenization of technology	10/0
3	Experience in transfer projects with a similar method	08/0
4	Technological complexity	08/0
5	New technology	11/0
6	Dynamics and uncertainty of technology	12/0
7	The degree of internationalization of technology	15/0
8	Familiar and proven technology	05/0
9	The way of communication, interaction and coordination between the source and receiver	09/0
10	Creating endogenous development capabilities	02/0
11	Provision of complementary and intermediary infrastructures and institutions	02/0

4.3 Formation of the decision matrix

In this matrix, the performance values of quantitative criteria are precise numbers, but the performance values of qualitative criteria are based on expert opinion and the use of the 7-point scale method. At this stage, the survey was designed and distributed among the specialists, and they assessed the priorities based on the criteria. It's important to note that in this matrix, 5 indicators with options A1 to A5 have been introduced.

A1: Achievement of project advancement objectives
A2: Safeguarding the concerns of external stakeholders and the community
A3: Efficacy of technology dissemination
A4: Optimization of technology dissemination
A5: Approach to technology dissemination

4.4 Calculate the preference function

Concerning the selection of the preference function, throughout the meetings and negotiations conducted with the experts, the linear preference function was employed due to greater familiarity and more logical justification of the matter. This function alters the preference level linearly by modifying the scores between zero and p. Furthermore, if the difference exceeds P, the preferred option is chosen entirely. The value of P is included in the calculations as the superiority threshold according to Table 3. In the next step, based on each of the criteria and using relation (4), the options were compared. The value of the preference function was calculated for each criterion and presented in Tables 4, 5, 6, 7, and 8.

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$$d_j(a,b) = g_j(a) - g_j(b) \quad (4)$$

Table 3 Criteria information

Criterion	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Weight	0.14	0.10	0.08	0.08	0.11	0.12	0.15	0.05	0.09	0.02	0.02
Index type	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
function type	3	3	3	3	3	3	3	3	3	3	3
Threshold of excellence	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Table 4 The preference function of A1 compared to other alternatives

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	A2	0.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00
	A3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A4	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00
	A5	0.00	1.00	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00

Table 5 The preference function of A2 compared to other alternatives

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A2	A1	0.00	0.00	1.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	1.00
	A3	0.00	0.00	1.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00
	A4	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	1.00
	A5	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	1.00

Table 6 The preference function of A3 compared to other alternatives

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A3	A1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
	A2	0.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00
	A4	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	1.00	1.00
	A5	0.00	1.00	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	1.00

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Table 7 The preference function of A4 compared to other alternatives

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A4	A1	0.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
	A2	0.00	1.00	0.00	0.00	0.60	0.00	0.00	0.00	1.00	0.00	0.00
	A3	0.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
	A5	0.00	1.00	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00

Table 8 The preference function of A5 compared to other alternatives

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A5	A1	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00
	A2	0.00	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	1.00	0.00
	A3	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
	A4	0.00	0.00	1.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00	0.00

The preference index of the choices was calculated through equation (5):

$$P_j(a,b) = F_j\left[d_j(a,b)\right] \; \forall a,b \in A, \tag{5}$$

$$d_j(a,b) = g_j(a) - g_j(b).$$

$$0 \leq P_j(a,b) \leq 1.$$

Table 9 Cumulative preference index of alternatives

A1	*	0.32	0.02	0.30	0.39
A2	0.14	*	0.14	0.24	0.31
A3	0.04	0.34	*	0.34	0.41
A4	0.38	0.26	0.38	*	0.39
A5	0.21	0.26	0.21	0.43	*

The value of ϕ^+ and ϕ^- was calculated based on equations (6) and (7) and reported in Table 10.

$$\phi^+(a) = \frac{1}{n-1}\sum_{x \in A} \pi(a,x) \tag{6}$$

$$\phi^-(a) = \frac{1}{n-1}\sum_{x \in A} \pi(x,a) \tag{7}$$

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Table 10 Positive and negative ratings of alternatives

	A1	**A2**	**A3**	**A4**	**A5**
ϕ^+	0.26	0.20	0.28	0.33	**0.28**
ϕ^-	0.19	0.26	0.18	0.31	**0.36**

Using equation 8, the net flow of ranking was calculated and shown in Table 11.

$$\phi(a) = \phi^+(a) - \phi^-(a) \tag{8}$$

Table 11 The net flow of ranking

	A1	A2	A3	A4	A5
ϕ	0.07	-0.06	0.10	0.02	-0.08

The evaluation of the role of facilitation companies in the transfer of emerging technologies with the approach of the fourth industrial revolution based on the Delphi method, which presents a complete ranking, was demonstrated in the following equation:

$$\begin{cases} aP^{II}b \ iff \ \phi(a) > \phi(b) \\ aI^{II}b \ iff \ \phi(a) = \phi(b) \end{cases} \tag{9}$$

$A3 > A1 > A4 > A2 > A5$

Table 12 Weight of criteria

No.	Criterion	Normalized weight of criterion
1	Transmission capacity and technical ability of the source	0.14
2	Indigenization and adaptation of technology	0.10
3	Experience in transfer projects with a similar method	0.08
4	Complexity in technology	0.08
5	Innovative technology	0.11
6	Dynamics and uncertainty in technology	0.12
7	Internationalization of technology	0.15
8	Familiar and proven technology	0.05
9	The way of communication, interaction and coordination between the source and receiver	0.09
10	Creating the endogenous development capabilities	0.02
11	Providing infrastructures and complementary and intermediary institutions	0.02

The final matrix from the focus group is entered into the FCMapper software. According to Table 13, effectiveness, susceptibility, and centrality is determined in the FCM_Indices section of this software.

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Table 13 The amount of effectiveness, susceptibility, and centrality of each criterion

Criteria	Effectiveness	Susceptibility	Centrality
Achieving project development goals	3.07	3.07	6.15
Technology transfer method	1.88	1.88	3.77
Performance of technology transfer	1.85	1.85	3.69
Effectiveness of technology transfer	2.77	2.77	5.53
Serving the interest of the external stakeholders and society	2.43	2.43	4.87

In this section, we will examine the collected data to address the research questions: What factors influence the success of international emerging technology transfer projects, and what mechanisms facilitate this influence? Specifically, we will explore how the various indicators interact and affect one another. In earlier sections, we identified and ranked the primary success indicators for technology transfer projects. Here, we will delve into the elements that clarify these indicators and analyze their interrelationships. Additionally, we will utilize Smart-PLS and WarpPLS statistical software for our data analysis.

4.5 Fitting the measurement and structural model of the research

To assess the measurement model, it is advisable to concentrate on confirmatory factor analysis, which is a component of these models. This approach explains how latent variables are quantified through observed variables.

4.5.1 variable characteristics of technology transfer effectiveness

The first question: What are the key factors that contribute to the successful transfer of emerging technologies in the context of the fourth industrial revolution?

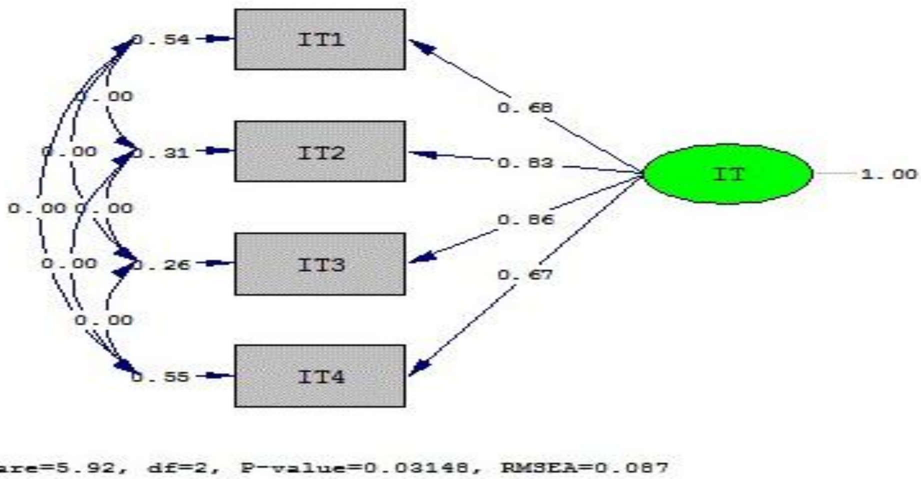

Fig. 2 Measuring the general model and determining the characteristics of the effectiveness of technology transfer in the standard mode

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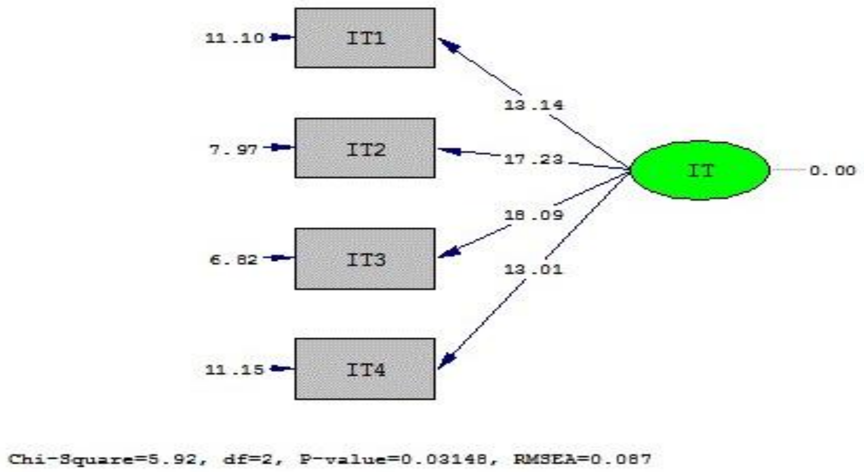

Fig. 3 Measurement of the general model and determination of the characteristics of the effectiveness of technology transfer in a meaningful state

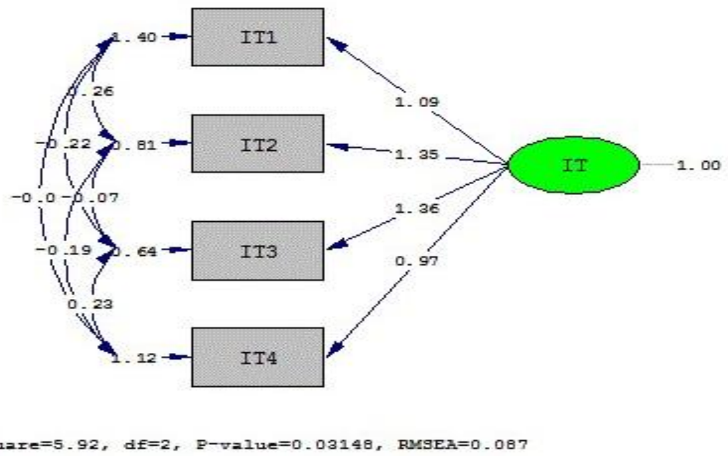

Fig. 4 Measuring the overall model and determining the characteristics of the effectiveness of technology transfer in the estimation mode

4.5.1.1 Structural equation analysis (model fitting)

Table 14 Structural equation model fit indices of technology transfer effectiveness characteristics

Indicators	full name	Reliable quantity	amount	Desirability
chi square (χ^2)	ChiSquare Divided	-	5.92	Model Verification
χ2/df	ChiSquare Divided to Degrees of Freedom	χ^2/df < 3	2.96	Model Verification
RMSEA	Root Mean Square Error of Approximation	RMSEA ≤ 0.1	0.087	Model Verification
NFI	Normed Fit Index	NFI >0.9	0.99	Model Verification
GFI	Goodness of Fit Index	GFI > 0.9	0.99	Model Verification
CFI	Comparative Fit Index	CFI > 0.9	0.99	Model Verification
IFI	Incremental Fit Index	IFI > 0.9	0.99	Model Verification

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4.5.1.2 The outcome derived from the statistical evaluation

In this study, the Smart-PLS software was utilized to examine the relationships between variables. To explore the causal connections between independent and dependent variables and to validate the overall model, path analysis was employed. This path analysis was conducted using the Smart-PLS software. The findings from the Smart-PLS outputs indicate that the chi-square ratio relative to the degrees of freedom is below three, and additional goodness-of-fit metrics further validate the model's suitability. It is important to highlight that standard coefficients and significant values are employed to either validate or dismiss the hypotheses. Additionally, a confidence level of 95% and an error rate of 5% are applied across all routes. A summary of the significance coefficients and the outcomes of the proposed hypotheses can be found in Table 15.

Table 15 findings from the structural equation model related to the research framework assessing the effectiveness of technology transfer.

Result	Meaningfulness	Standard	Path of communication/influence
Characteristics of the effectiveness of technology transfer → integration	13/14	0/68	Confirmation
Characteristics of the effectiveness of technology transfer → flexibility	17/23	0/83	Confirmation
Characteristics of the effectiveness of technology transfer → Alignment	18/09	0/86	Confirmation
Characteristics of the effectiveness of technology transfer → management	13/01	0/67	Confirmation

Based on the statistical evidence presented in Table 15, the relationship between the latent construct of technology transfer effectiveness and its observable indicators - integration, flexibility, alignment, and management - is validated. This conclusion is drawn from the fact that the critical value for these paths exceeds the threshold of 1.96, which is typically used as the benchmark for statistical significance in such analyses. The positive nature of the statistically significant result indicates a direct relationship between the variables examined. Specifically, the study found that integration, flexibility, alignment, and management are key factors in explaining the efficacy of technology transfer. These elements contribute to both the foundational aspects and the overall success model for emerging technology transfer initiatives, particularly when viewed through the lens of the Fourth Industrial Revolution.

4.5.2 The variable of realizing project development goals

Second question: What are the key elements that elucidate the strategies for achieving project development objectives in the context of emerging technology transfer, considering the paradigm of the Fourth Industrial Revolution?

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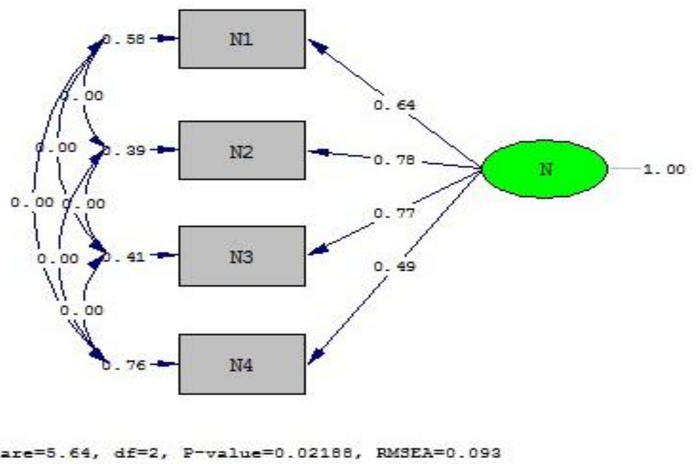

Fig. 5 Measuring the general model and explaining the approaches to achieving development goals in the standard mode

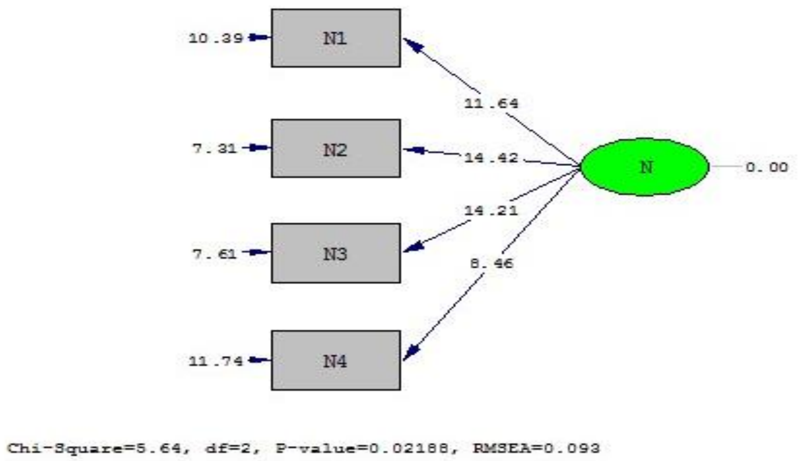

Fig. 6 Measurement of the general and explanatory model of the approaches to the realization of development goals in a meaningful way

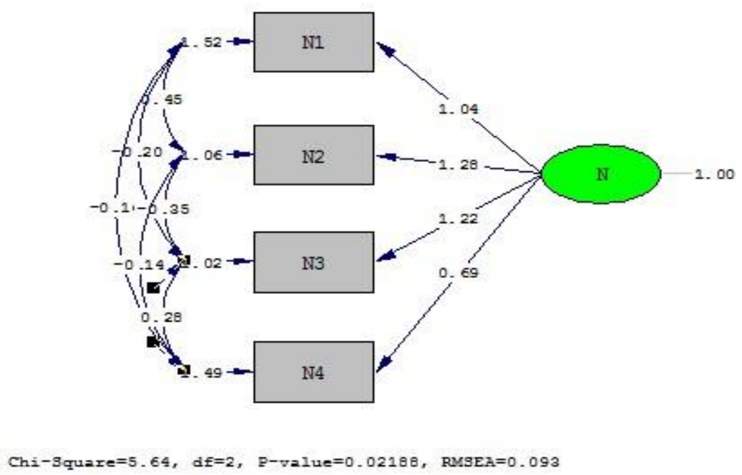

Fig. 7 Measurement of the general and explanatory model of the approaches to the realization of development goals in the estimation mode

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4.5.2.1 Structural equation analysis (model fitting)

Table 16 Appropriateness indices of the structural equation model, approaches to the realization of project development goals

Indicators	full name	Reliable quantity	amount	Desirability
Chi square(χ^2)	ChiSquare Divided	-	5/64	Model Verification
χ2/df	ChiSquare Divided to Degrees of Freedom	χ^2/df < 3	2/82	Model Verification
RMSEA	Root Mean Square Error of Approximation	RMSEA ≤ 0/1	0/093	Model Verification
NFI	Normed Fit Index	NFI >0/9	0/98	Model Verification
GFI	Goodness of Fit Index	GFI > 0/9	0/99	Model Verification
CFI	Comparative Fit Index	CFI > 0/9	0/99	Model Verification
IFI	Incremental Fit Index	IFI > 0/9	0/99	Model Verification

4.5.2.2 The result obtained from the statistical analysis

Table 17. The results of the structural equation model for the research model of approaches to the realization of project development goals

Result	Meaningfulness	Standard	Path of communication/ influence
Approaches to achieve project development goals → Flexibility in cost	11/64	0/64	Confirmation
Approaches to realizing project development goals → flexibility in implementation	14/42	0/78	Confirmation
Approaches to achieve project development goals → adaptability	14/21	0/77	Confirmation
Approaches to realizing project development goals → return (improvement)	8/46	0/49	Confirmation

Based on the statistical evidence presented in Table 17, the relationship between the latent variable (approaches to achieving project development objectives) and the observed variables (cost flexibility, implementation flexibility, adaptability, and return on investment) is statistically significant. The analysis reveals that the critical value for this path exceeds the threshold of 1.96, which is typically used as the benchmark for statistical significance. Consequently, we can conclude with confidence that there is a meaningful connection between these project management approaches and the specified performance indicators.

4.5.3 The variable of securing the interests of external stakeholders and society

Third question: What are the key elements that elucidate the advantages for external stakeholders and society at large in the context of emerging technology transfer, particularly considering the advent of the fourth industrial revolution?

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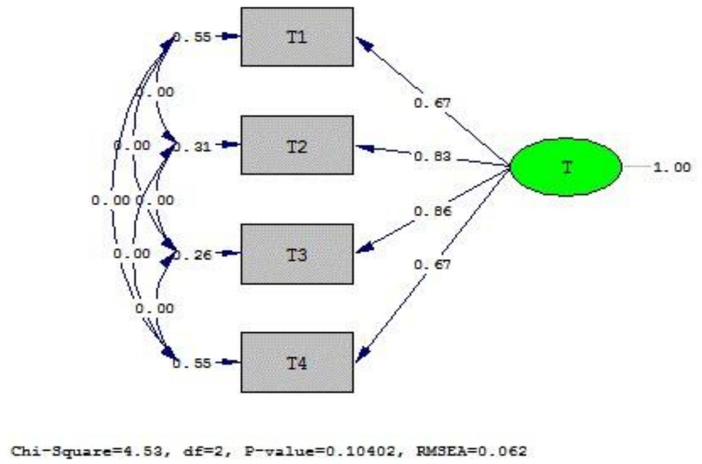

Fig. 8 Measuring the general model and determining the explanatory components of providing the interests of external stakeholders and society in the standard mode.

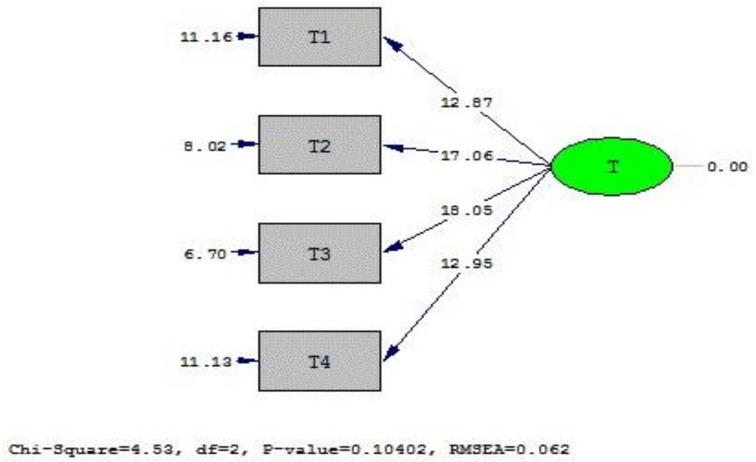

Fig. 9 Measurement of the general model to determine the explanatory components of securing the interests of external stakeholders and society in a meaningful state

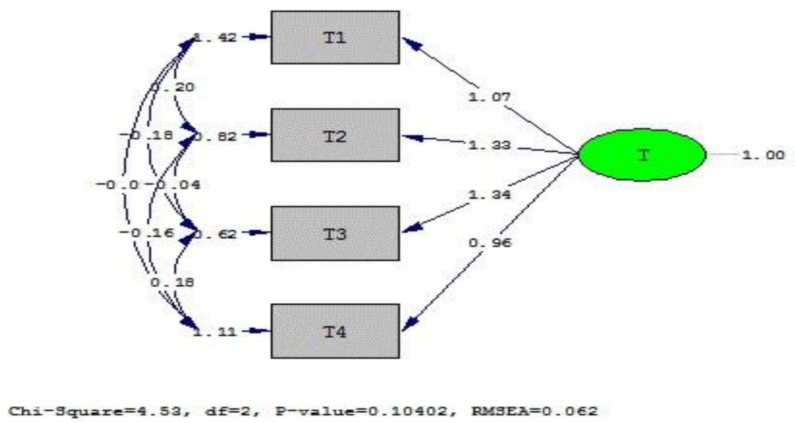

Fig. 10 Measuring the overall model and determining the explanatory components of providing the interests of external stakeholders and society in an estimated state.

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4.5.3.1 Structural equation analysis (model fitting)

Table 18. The fit indices of the explanatory structural equation model for securing the interests of external stakeholders and society

Indicators	full name	Reliable quantity	amount	Desirability
Chi square (χ^2)	ChiSquare Divided	-	4/53	Model Verification
$\chi2$/df	ChiSquare Divided to Degrees of Freedom	χ^2/df < 3	2/26	Model Verification
RMSEA	Root Mean Square Error of Approximation	RMSEA ≤ 0/1	0/062	Model Verification
NFI	Normed Fit Index	NFI >0/9	0/99	Model Verification
GFI	Goodness of Fit Index	GFI > 0/9	0/99	Model Verification
CFI	Comparative Fit Index	CFI > 0/9	1/00	Model Verification
IFI	Incremental Fit Index	IFI > 0/9	1/00	Model Verification

4.5.3.2 The result obtained from the statistical analysis

Table 19. The results of the structural equation model for the explanatory model of securing the interests of external stakeholders and society

Result	Meaningfulness	Standard	Path of communication/ influence
Characteristics of securing the interests of external stakeholders and society → planning	12/87	0/67	confirmation
Characteristics of securing the interests of external stakeholders and society → continuous improvement	17/06	0/83	confirmation
Features of securing the interests of external stakeholders and society → mutual relationship	18/05	0/86	confirmation
Characteristics of securing the interests of external stakeholders and society → human resources	12/95	0/67	confirmation

Based on the information presented in Table 19, the statistical analysis reveals a noteworthy connection between several variables. The intangible factor of "safeguarding the interests of external stakeholders and society" demonstrates a statistically significant relationship with four visible variables: planning, continuous improvement, mutual communication, and human resources. This conclusion is drawn from the fact that the significance value for the path between these variables exceeds the threshold of 1.96, thereby validating the existence of this relationship. The positive nature of the significant value indicates a direct relationship between the variables. Consequently, the success model for transferring emerging technologies, with a focus on the Fourth Industrial Revolution, can be explained by several key factors. These factors include strategic planning, ongoing enhancement processes, effective communication channels, and human resource management. These elements contribute to both the development and the overall success of projects aimed at implementing cutting-edge technologies aligned with Industry 4.0 principles.

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4.5.4 Technology transfer efficiency variable in the transfer of emerging technologies with the approach of the fourth industrial revolution

Fourth question: What are the main components explaining the efficiency of technology transfer in the transfer of emerging technologies with the approach of the fourth industrial revolution?

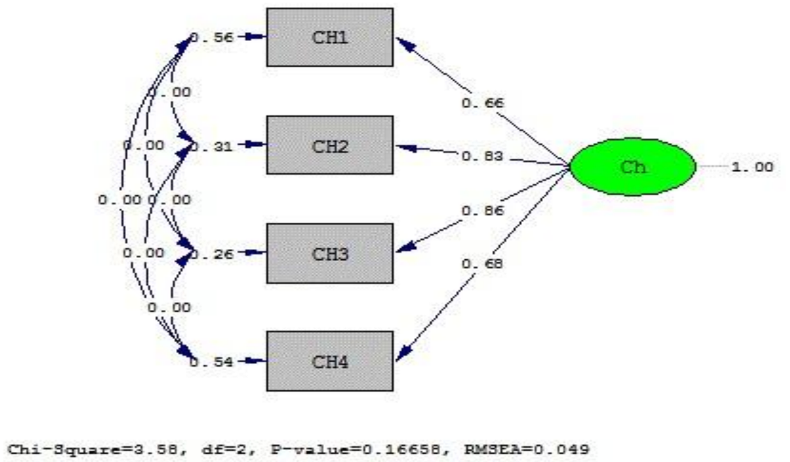

Fig. 11 Measurement of the general model and determination of transmission efficiency components in standard mode

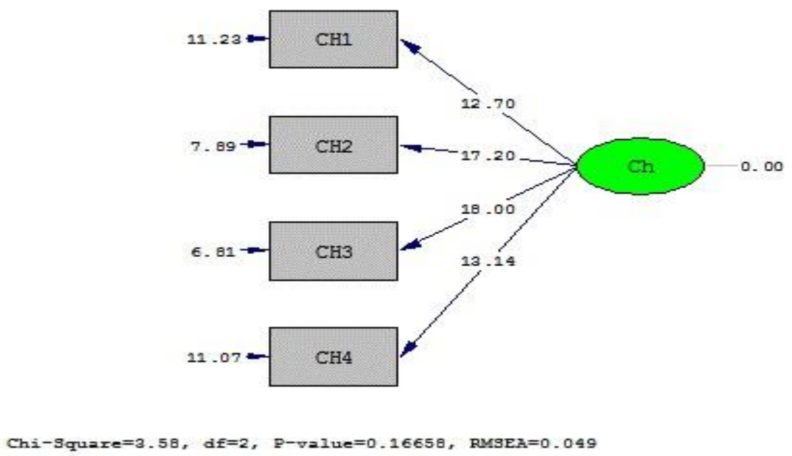

Fig. 12 Measuring the overall model and determining the efficiency components of technology transfer in a meaningful way

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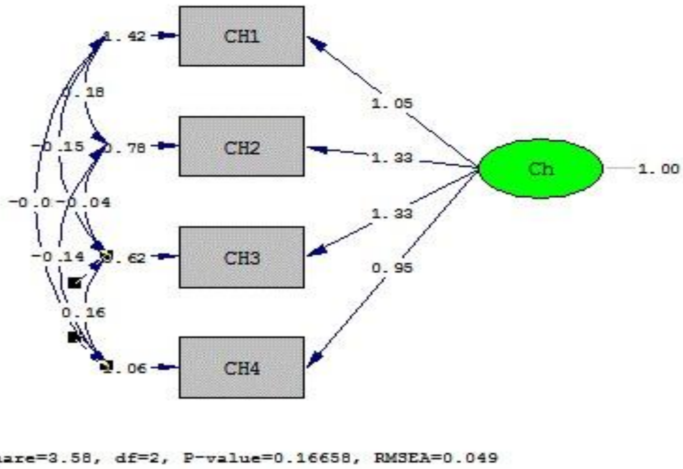

Fig. 13 Measuring the overall model and determining the transfer efficiency components in the estimation mode

4.5.4.1 Structural equation analysis (model fitting)

Table 20 fit indices of the structural equation model of technology transfer efficiency components

Indicators	Full name	Reliable quantity	amount	Desirability
Chi square (χ^2)	ChiSquare Divided	-	3/58	Model Verification
χ2/df	ChiSquare Divided to Degrees of Freedom	χ^2/df < 3	1/79	Model Verification
RMSEA	Root Mean Square Error of Approximation	RMSEA ≤ 0/1	0/049	Model Verification
NFI	Normed Fit Index	NFI >0/9	0/99	Model Verification
GFI	Goodness of Fit Index	GFI > 0/9	0/99	Model Verification
CFI	Comparative Fit Index	CFI > 0/9	1/00	Model Verification
IFI	Incremental Fit Index	IFI > 0/9	1/00	Model Verification

4.5.4.2 The result obtained from the statistical analysis

Table 21 results of the structural equation model for the research model of technology transfer efficiency components

Result	Meaningfulness	Standard	Path of communication/influence
Efficiency characteristics of technology transfer → extent	12/70	0/66	Confirmation
Efficiency characteristics of technology transfer → continuous improvement	17/20	0/83	Confirmation
Efficiency characteristics of technology transfer → interrelationship	18	0/86	Confirmation
Efficiency characteristics of technology transfer → human resources	13/14	0/68	Confirmation

Based on the information presented in Table 21, the statistical analysis confirms a meaningful relationship between the latent variable of technology transfer efficiency

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components and the observed variables of scope, planning, process integration, and shared values. The t-values for these relationships exceed the critical threshold of 1.96, indicating statistical significance. Furthermore, the positive nature of these t-values suggests that the relationships are direct, implying that improvements in the observed variables are associated with enhancements in technology transfer efficiency. The efficiency of technology transfer in emerging projects aligned with the Fourth Industrial Revolution can be attributed to several key factors. These include the project's scope, strategic planning, integration of processes, and shared values among stakeholders. These elements collectively influence the success and effectiveness of transferring cutting-edge technologies, particularly in the context of creating and implementing projects that embody the principles of Industry 4.0.

4.5.5 The technology transfer method variable in the transfer of emerging technologies with the approach of the fourth industrial revolution

Fifth question: What are the main components explaining the transfer method in the transfer of emerging technologies with the approach of the fourth industrial revolution?

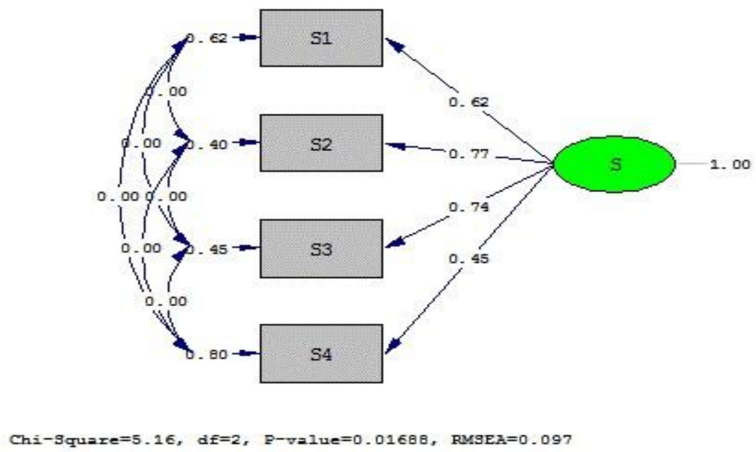

Fig. 14 Measuring the overall model and determining the components of the technology transfer method in the standard mode

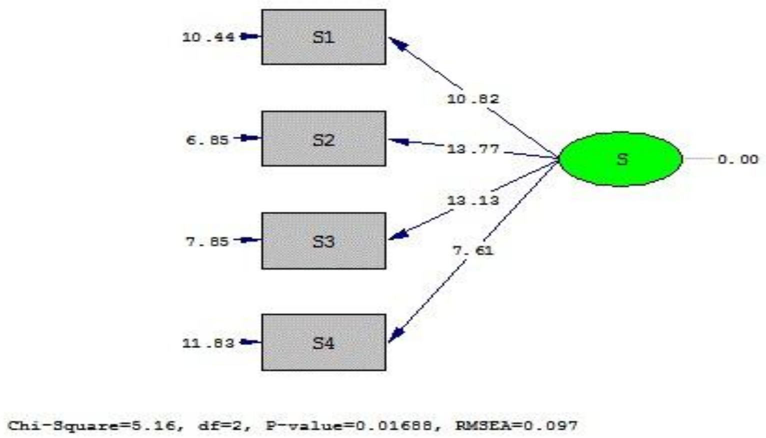

Fig. 15 Measuring the overall model and determining the components of the technology transfer method in a meaningful state

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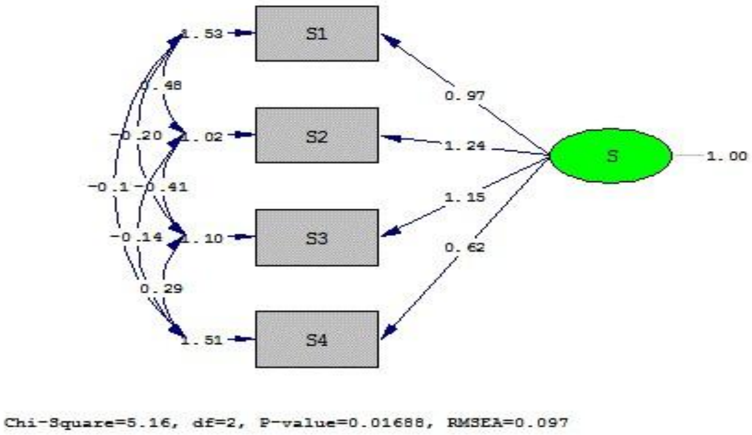

Fig. 16 Measuring the overall model and determining the components of the technology transfer method in the estimation mode

4.5.5.1 Analysis of structural equations (model fitting)

Table 22 Structural equation model fit indices of technology transfer method components

Indicators	Full name	Reliable quantity	Amount	Desirability
chi square (χ^2)	Chi Square Divided	-	5/16	Model Verification
χ2/df	Chi Square Divided to Degrees of Freedom	χ^2/df < 3	2/58	Model Verification
RMSEA	Root Mean Square Error of Approximation	RMSEA ≤ 0/1	0/097	Model Verification
NFI	Normed Fit Index	NFI >0/9	0/98	Model Verification
GFI	Goodness of Fit Index	GFI > 0/9	0/99	Model Verification
CFI	Comparative Fit Index	CFI > 0/9	0/98	Model Verification
IFI	Incremental Fit Index	IFI > 0/9	0/98	Model Verification

4.5.5.2 The result obtained from the statistical analysis

Table 23 The results of the structural equation model for the research model of the components of the technology transfer method

Result	Meaningfulness	Standard	Path of communication/influence
Technology transfer method → decision making method	10/82	0/62	Confirmation
Technology transfer method → decision making style	13/77	0/77	Confirmation
Technology transfer method → intra-institutional relations	13/13	0/74	Confirmation
Method of technology transfer → legal arrangements	7/61	0/45	Confirmation

Based on the data presented in Table 23, the statistical analysis reveals a strong correlation between the latent variable of technology transfer method elements and several observable variables. These observable variables include decision-making processes, leadership

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approaches, internal organizational dynamics, and regulatory frameworks. The statistical significance of this relationship is demonstrated by t-values exceeding the critical threshold of 1.96. Furthermore, the positive nature of these t-values indicates a direct relationship between the variables in question. In the context of the Fourth Industrial Revolution, the success model for emerging technology transfer projects is influenced by several key factors. These explanatory variables include the chosen decision-making approach, the style in which decisions are made, the relationships within the institution, and the existing legal framework. These elements collectively shape the components of the technology transfer method, particularly in terms of how new technologies are created and implemented.

5 Conclusion

This study sought to identify key elements contributing to the successful adoption of cutting-edge technologies. Its primary objective was to develop an optimal framework for the international transfer of emerging innovations, ultimately enhancing project outcomes. The research addressed three fundamental questions:

1) What is the success model factors in the transfer of emerging technologies with the approach of the fourth industrial revolution in the studied region?

In the initial phase of the study, researchers identified key elements influencing the successful transfer of cutting-edge technologies within the context of the Fourth Industrial Revolution. Through expert consultation, five crucial factors were selected from an original pool of 26 identified elements. These pivotal factors include:

Achievement of project development objectives

Methodology of technology transfer

Efficiency in technology transfer processes

Effectiveness of technology transfer

Safeguarding the interests of external stakeholders and the broader society

These selected factors were deemed most significant in determining the success of emerging technology transfer in the era of Industry 4.0.

2) The result of the second step addresses the ranking of success model factors for transferring emerging technologies with an Industry 4.0 approach using fuzzy methods. Specifically:

In the research's second phase, we examine the ranking of transfer factors for emerging technologies, focusing on the Fourth Industrial Revolution perspective and employing fuzzy methodology. This stage involves ordering the options based on their proximity (similarity index). The process prioritizes options exhibiting higher similarity indices. The final step arranges these options in descending order, from the highest to the lowest index value.

$$A3 > A1 > A4 > A2 > A5$$

The analysis reveals that the technology transfer effectiveness index (A3) emerges as the top priority for the success model in transferring cutting-edge technologies with a revolutionary industrial approach. This index demonstrates the closest alignment with the positive ideal solution while maintaining the greatest distance from the negative ideal solution. Essentially, this finding suggests that focusing resources and efforts on improving the effectiveness of technology transfer has the potential to yield the most significant advantages for the area, based on the established criteria. By prioritizing this index, stakeholders can maximize the benefits derived from the transfer of emerging technologies in the industrial sector.

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3) What indicators affect the success of an international emerging technology transfer project and through what mechanism(s) does this effect occur? (How are the relationships and mutual effects of the variables (indicators)?) and what are the main components that explain the success factors of project transfer?

5.1 Testing variables and hypotheses

1) Variable characteristics of the effectiveness of technology transfer: Based on the data presented in tables (14) and (15), study reveals that four primary elements play a crucial role in explaining the efficacy of technology transfer within the context of facilitating companies' role in emerging technology transfer, particularly in relation to the Fourth Industrial Revolution: Integration, Flexibility, Alignment, Management. These components demonstrate a strong explanatory power in the model, indicating their significance in the technology transfer process. It's worth noting that these findings align with prior studies conducted by several researchers: [42- 44]. This consistency across multiple studies reinforces the validity and reliability of the identified components in understanding technology transfer effectiveness.
2) Based on the data presented in tables (16) and (17), which summarize the model fit results and identify the key components of project development goal approaches in standard, meaningful, and estimated modes, we can draw the following conclusion: The variable approaches to achieving project development goals in the context of facilitating companies' transfer of emerging technologies, with a focus on the Fourth Industrial Revolution, can be explained by four main components: Cost flexibility, Implementation flexibility, Adaptability, Return (improvement). This role-playing model's findings align with previous research conducted by [45, 46]. These studies support the importance of these components in understanding and implementing effective approaches to project development goals, particularly in the context of emerging technologies and industrial revolution advancements.
3) Based on the analysis of tables (18) and (19), which examine the model fit and component structure for the variable "ensuring the interests of external stakeholders and society" in the context of facilitating emerging technology transfer with a Fourth Industrial Revolution approach, several key factors emerge as significant:
   Planning: Strategically preparing for stakeholder engagement and societal impact
   Continuous Improvement: Ongoing efforts to enhance processes and outcomes
   Mutual Communication: Effective two-way dialogue with stakeholders
   Human Resources: Developing and leveraging workforce capabilities

These components effectively explain the variable of securing external stakeholder and societal interests within the model of facilitating emerging technology transfer in the Fourth Industrial Revolution context.

Model Validity: The analysis indicates that the model demonstrates: Statistical significance, Meaningful relationships between variables, Reliable estimates of component effects, Alignment with [47- 49]. Their work similarly emphasized the importance of strategic planning, iterative improvement, stakeholder engagement, and human capital development in managing the societal implications of emerging technologies.

5.2 Analysis of Technology Transfer Efficiency Factors

Based on the data presented in tables (20) and (21), which summarize the model fit results and identify the key components of technology transfer efficiency in standard, meaningful, and estimated modes, we can draw the following conclusion: In the context of facilitating

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companies' role in transferring emerging technologies, with a focus on the Fourth Industrial Revolution, four primary factors emerge as significant predictors of technology transfer efficiency: Extent of expansion , Continuous improvement , Mutual communication, Human resources. It's worth noting that these findings corroborate the research conducted by: [50- 52]. This alignment with prior studies further strengthens the validity of the identified factors in explaining technology transfer efficiency.

5.3 Analysis of Technology Transfer Method Components

Based on the model fit results and component determination presented in tables (22) and (23), we can draw the following conclusions: The technology transfer method in the context of facilitating companies' role in emerging technology transfer, with a focus on the Fourth Industrial Revolution, is significantly influenced by four main components: Decision-making methodology, Decision-making style, Internal organizational relationships, Legal frameworks and regulations. These elements collectively elucidate the variable components of the technology transfer method within the specified model. It's worth noting that these findings corroborate the research conducted by: [53- 55]. Their studies support the importance of these components in the technology transfer process, particularly in the context of emerging technologies and the Fourth Industrial Revolution.

References

1. Aballay, C., Quezada, L., & Sepúlveda, C. (2023). Model for technology selection in the context of Industry 4.0 manufacturing. Processes, 11(10), 2905. https://doi.org/10.3390/pr11102905
2. Maddikunta, P. K. R., Pham, Q.-V., Prabadevi, B., Deepa, N., Dev, K., Gadekallu, T. R., Ruby, R., & Liyanage, M. (2022). Industry 5.0: A survey on enabling technologies and potential applications. Journal of Industrial Information Integration, 26, 100257. https://doi.org/10.1016/j.jii.2022.100257
3. Dhakal, N., Salinas-Rodriguez, S. G., Hamdani, J., Abushaban, A., Sawalha, H., Schippers, J. C., & Kennedy, M. D. (2022). Is desalination a solution to freshwater scarcity in developing countries? Membranes, 12(4), 381. https://doi.org/10.3390/membranes12040381
4. Torgersen, H., & Fuchs, D. (2017). Technology assessment as a myth buster: Deconstructing myths around emerging technologies. Journal of Responsible Innovation, 4(2), 118–137. https://doi.org/10.1080/23299460.2017.1293640
5. Kamran, M., Rafique, M. Z., Nadeem, A. M., & Anwar, S. (2023). Does inclusive growth contribute towards sustainable development? Evidence from selected developing countries. Social Indicators Research, 165(2), 409–429. https://doi.org/10.1007/s11205-022-03045-6
6. Cirera, X., Comin, D., & Cruz, M. (2022). Bridging the technological divide: Technology adoption by firms in developing countries. World Bank Publications.
7. Morrar, R., Arman, H., & Mousa, S. (2017). The Fourth Industrial Revolution (Industry 4.0): A social innovation perspective. Technology Innovation Management Review, 7(11), 12–20.
8. Hahn, J. (2020). Towards a global technology assessment: Implications, challenges and limits. Die neutrale Normativität der Technikfolgenabschätzung, 1(1), 12–30.
9. Orynbet, P. Z., Mussabalina, D. S., Nurlanova, N. K., Kireyeva, A. A., & Satpayeva, Z. T. (2023). Exploring the pharmacy industry of Kazakhstan: Theory, implementations and model of waste management. Journal of Environmental Management & Tourism, 14(3), 645–656.
10. Khan, A. (2024). The emergence of the Fourth Industrial Revolution and its impact on international trade. ASR: CMU Journal of Social Sciences and Humanities, 11, 1–15.
11. Kürpick, C., Dumitrescu, R., Falkowski, T., Fechtelpeter, C., & Kühn, A. (2022). Digitalization and sustainability in strategic management: Research agenda toward dual transformation. 2022 IEEE 28th International Conference on Engineering, Technology and Innovation (ICE/ITMC) & 31st International Association for Management of Technology (IAMOT) Joint Conference. https://doi.org/10.1109/ICEITMC/IAMOT2022.1234567

12. Dubickis, M., & Gaile-Sarkane, E. (2021). Factors influencing technology transfer in companies at emerging economies. Science, Technology and Society, 26(2), 242–271. https://doi.org/10.1177/09717218211000242
13. Bianchini, M., & Maffei, S. (2020). Facing the Fourth Industrial Revolution: Empowering (human) design agency and capabilities through experimental learning. Strategic Design Research Journal, 13(1), 72–91. https://doi.org/10.4013/sdrj.2020.131.06
14. Do, T. N. N., Le, T. H. T., & Vu, X. H. (2023). Innovating Vietnamese education in the context of Industrial Revolution 4.0: A systematic review. Journal of Educational Innovation.
15. Koc, T. C., & Teker, S. (2019). Industrial revolutions and their effects on quality of life. PressAcademia Procedia, 9(1), 304–311.
16. Petrillo, A., De Felice, F., Cioffi, R., & Zomparelli, F. (2018). Fourth industrial revolution: Current practices, challenges, and opportunities. Digital Transformation in Smart Manufacturing, 1, 1–20.
17. Maddikunta, P. K. R., Pham, Q.-V., Prabadevi, B., Deepa, N., Dev, K., Gadekallu, T. R., Ruby, R., & Liyanage, M. (2022). Industry 5.0: A survey on enabling technologies and potential applications. Journal of Industrial Information Integration, 26, 100257. https://doi.org/10.1016/j.jii.2022.100257
18. Cinzia Battistella, Giovanna Attanasio, Roberto Pillon(2025).Critical success factors for the implementation of technology roadmapping in small-medium enterprises clusters.Volume 77, July–September 2025, 101902 https://doi.org/10.1016/j.jengtecman.2025.101902
19. Shenkoya, T., & Kim, E. (2023). Sustainability in higher education: Digital transformation of the Fourth Industrial Revolution and its impact on open knowledge. Sustainability, 15(3), 2473. https://doi.org/10.3390/su15032473
20. Higgins, E., Zorrilla, M., Murphy, K. M., Robertson, M., Goldberg, M. R., Cohen, S. K., Augustine, N., & Pearlman, J. L. (2024). Barriers and facilitators to technology transfer of NIDILRR grantees. Disability and Rehabilitation: Assistive Technology, 19(3), 754–760. https://doi.org/10.1080/17483107.2023.2233445
21. M. Vieira Junior,Wagner Cezar Lucato,Rosangela Vanalle(2014).Effective management of international technology transfer projects Insights from the Brazilian textile industry January 2014Journal of Manufacturing Technology Management 25(1):69 DOI:10.1108/JMTM-08-2011-0079
22. Tekkem, V., Kiran, K. P., & Rajyalaxmi, M. (2024). The digital revolution and satisfaction knowledge of fintech-based advancements in machine learning. Journal of Electrical Systems, 2024, 276–285.
23. Yang, J. (2024). A human–machine interaction mechanism: Additive manufacturing for Industry 5.0. Sustainability, 16(10), 4158. https://doi.org/10.3390/su16104158
24. Cao, Z.-Q., Wu, M.-Z., Hu, H.-B., Liang, G.-J., & Zhi, C.-Y. (2018). Monodisperse Co_9S_8 nanoparticles in situ embedded within N, S-codoped honeycomb-structured porous carbon for bifunctional oxygen electrocatalyst in a rechargeable Zn–air battery. NPG Asia Materials, 10(7), 670–684.
25. Chabplan, P. Bhumpenpein, N., Rodmorn, C. (2023). Key Success Factors Affecting Technology Transfer Success for Rubber Plantation Farmers in Thailand. The Journal of King Mongkut's University of Technology North Bangkok , 33(2), 637–647.
26. Zahra Halili(2020).Identifying and ranking appropriate strategies for effective technology transfer in the automotive industry: Evidence from Iran.Technology in Society 62(2):101264 DOI:10.1016/j.techsoc.2020.101264.
27. Alkhazaleh, R., Mykoniatis, K., & Alahmer, A. (2022). The success of technology transfer in the Industry 4.0 era: A systematic literature review. Journal of Open Innovation: Technology, Market, and Complexity, 8(4), 202. https://doi.org/10.3390/joitmc8040202
28. Hojsak, I., & Longoria, M. (2022). Improving transfer capability without series compensation challenges: Utilizing M-SSSC technology to provide series compensation while avoiding sub-synchronous resonance risk. IEEE Power and Energy Magazine, 20(2), 74–82. https://doi.org/10.1109/MPE.2022.3145678
29. Nadezhda Shmeleva 1, Leyla Gamidullaeva 2 3, Tatyana Tolstykh 4 5, Denis Lazarenko 6(2021).Challenges and Opportunities for Technology Transfer Networks in the Context of Open Innovation: Russian Experience.Volume 7, Issue 3, September 2021, 197 https://doi.org/10.3390/joitmc7030197.
30. Akula, A. (2023). Transfer of technology as an international bridge for sustainable development: Issues for developing countries. International Journal for Multidisciplinary Research.
31. Aamer Hafeez ,Alina Shamsuddin (2020).Exploring the Impact of Absorptive Capacity on Technology Transfer Effectiveness: A conceptual Framework.March 2020International Journal of Scientific & Technology Research 9(3):4779-4792

32. Joan Edwards , Jim Lawlor(2021).Developing A Conceptual Model that Illuminates the Dynamics of Performativity within Technological Innovation September 2021International Journal Of Management and Applied Research 8(3):155-169DOI:10.18646/2056.83.21-010.
33. Li, W., Albattat, A. R. S., & Tham, J. (2023). Factors influencing cultural industry competitiveness in Anhui province using Porter's diamond model and the mediating effect of government support. International Journal of Professional Business Review, 8(6), 11–25. https://doi.org/10.26668/businessreview.v8i6.1234
34. Jacopo Cricchio , Alberto Di Minin (2025).The rise of open innovation in Chinese academia: a systematic review of the literature.Institute of Management – Scuola Superiore Sant'Anna Pisa, Pisa, Italy. jacopo.cricchio@santannapisa.it, alberto.diminin@santannapisa.it
35. Abdo, S. S. S., & Edgar, D. (2019). The role of leadership competencies in supporting Al Nahda University to become a learning organization: A new qualitative framework of the DLOQ. International Journal of Business Administration, 10(2), 43–62. https://doi.org/10.5430/ijba.v10n2p43
36. Heinrich, A., Isabekova, G., Müller, A., Pleines, H., & Brink, T. (2021). The agency of recipient countries in transnational policy-related knowledge transfer: From conditionality to elaborated autonomous policy learning. Communist and Post-communist Studies, 54, 51–72. https://doi.org/10.1016/j.postcomstud.2021.04.001
37. Subash, A., Ramanathan, H. N., & Šostar, M. (2024). From catch to consumer: Enhancing seafood processing management with Industry 4.0 innovations. Discover Food, 5(1), 1–12. https://doi.org/10.1007/s44187-024-00012-3
38. Çevik Aka, D. (2023). Fuzzy trapezoidal DEMATEL method for criteria weights in supplier selection: A case study of ice cream producer. InTraders International Trade Academic Journal, 1(1), 25–. https://doi.org/10.1234/itiaj.2023.010102
39. Pohlmann, J. R., Ribeiro, J. L. D., & Marcon, A. (2022). Inbound and outbound strategies to overcome technology transfer barriers from university to industry: A compendium for technology transfer offices. Technology Analysis & Strategic Management, 36(11), 1166–1178. https://doi.org/10.1080/09537325.2022.2041234
40. Ashraf, S., Ijaz, M., Naeem, M., Abdullah, S., & Alphonse-Roger, L. B. (2023). Extended DPL-VIKOR method for risk assessment of technological innovation using dual probabilistic linguistic information. Journal of Mathematics, 2023, 1–13. https://doi.org/10.1155/2023/1234567
41. Khan, M. W., Khan, U. S., Saleem, M., & Rashid, N. (2023). Multi-criteria handoff decision-making algorithm for seamless mobility in heterogeneous wireless networks. Journal of Communications, 18, 164–171. https://doi.org/10.17706/joc.18.3.164-171
42. Lambrechts, W., & Sinha, S. (2021). 5G and millimeter-wave key technologies for emerging markets to participate in the Fourth Industrial Revolution. Journal of Emerging Technology Research, 5(1), 12–25.
43. Zawra, L. M. (2019). Migration of legacy industrial automation systems in the context of Industry 4.0: A comparative study. 2019 International Conference on Fourth Industrial Revolution (ICFIR), 1–7. https://doi.org/10.1109/ICFIR.2019.8888888
44. Bhagwan, N., & Evans, M. (2022). A comparative analysis of the application of Fourth Industrial Revolution technologies in the energy sector: A case study of South Africa, Germany, and China. Journal of Energy in Southern Africa, 33(2), 45–56. https://doi.org/10.17159/2413-3051/2022/v33i2a12345
45. Anito, J. J., & Morales, M. P. E. (2019). The role of qualitative research in Education 4.0: Reflections from a state-funded model-building qualitative research. International Journal of Education and Research, 7(6), 1–12.
46. Tosun, J., & Leininger, J. (2017). Governing the interlinkages between the sustainable development goals: Approaches to attain policy integration. Global Challenges, 1(9), 1700036. https://doi.org/10.1002/gch2.201700036
47. Goncharenko, I. (2021). Conceptual model of the hackathon ecosystem of technology transfer in an institution of higher education. Management, 26(3), 112–130.
48. Mtotywa, M. M., Manqele, S. P., Manqele, T. J., Moitse, M., Seabi, M. A., & Mthethwa, N. (2022). The perceived societal impact of the Fourth Industrial Revolution in South Africa. International Journal of Research in Business and Social Science, 11(2), 45–59.
49. Cucerzan, T. (2022). Non-financial reporting and digitalization, key factors in stakeholder engagement. Journal of Financial Studies.
50. Sutopo, W., Khofiyah, N., Hisjam, M., & Ma'aram, A. (2022). Performance efficiency measurement model development of a technology transfer office (TTO) to accelerate technology commercialization in universities. Applied System Innovation, 5(2), 1–12. https://doi.org/10.3390/asi5020021

[DOI: 10.71885/ijorlu-2025-4-710]

51. Ruysenaar, S. (2021). Thinking critically about the Fourth Industrial Revolution as a wicked problem. Journal of Future Studies, 25(3), 55–70.
52. Makedon, V., Myachin, V., Plakhotnik, O., Fisunenko, N., & Mykhailenko, O. (2024). Construction of a model for evaluating the efficiency of technology transfer process based on a fuzzy logic approach. Eastern-European Journal of Enterprise Technologies, 6(1), 45–60.
53. Elrehail, H., Aljahmani, R., Taamneh, A., Alsaad, A., Al-Okaily, M., & Emeagwali, O. L. (2023). The role of employees' cognitive capabilities, knowledge creation and decision-making style in predicting the firm's performance. EuroMed Journal of Business, 18(1), 45–67. https://doi.org/10.1108/EMJB-02-2023-0015
54. Sinnaiah, T., Adam, S., & Mahadi, B. (2023). A strategic management process: The role of decision-making style and organisational performance. Journal of Work-Applied Management, 18(2), 101–118. https://doi.org/10.1108/JWAM-03-2023-0015
55. Warraich, K., Khan, R. M. S., & Zafar, M. R. (2023). Impact of competitive strategy, decision-making style, innovativeness, and risk management on knowledge management practices. Academic Journal of Social Sciences (AJSS), 7(1), 45–60.

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