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Analyzing Interrelationships of Critical Barriers to University Technology Transfer: Multi-Stakeholder Perspectives from Vietnam

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Universities have been tasked with generating and disseminating knowledge in an innovation system over the past few decades. However, university technology transfer (UTT) is regarded as a barrier to the commercialization and community application of innovative technologies. Consequently, identifying the obstacles and their complex interrelationships that impede the successful implementation of UTT provides a better understanding of the process, which may be considered as inputs for important decision-making initiatives. This study proposes an integration of Decision-Making Trial and Evaluation Laboratory (DEMATEL) method and Grey theory to identify the critical barriers by comparing the perspectives of key stakeholders, including university scholars, entrepreneurs, and technology transfer offices, and examines the interrelationships between proposed barriers. These findings aim to assist various stakeholders in comprehending the impact of barriers on formulating strategies and initiatives to carry out the UTT process in Vietnam effectively.

Keywords: *MCDM, university technology transfer, DEMATEL, Grey Theory*

INTRODUCTION

Universities are increasingly involved in technology transfer, in addition to education and research, to contribute to the socioeconomic development of their regions and countries. Technology transfer reflects transactions or long-term collaborations between technology acquirers and suppliers (Pagani et al., 2020). Technology transfer occurs in an academic setting between firms as acquirers and universities as suppliers of technologies. These collaborations, known as university-industry collaborations on technology transfer, are critical in fostering innovation (Hoc & Trong, 2019). Universities generate a large amount of knowledge, making university technology transfer (UTT) a critical process in unlocking the economic potential of innovative technologies (Pagani et al., 2020). The efficacy of UTT in innovation has been demonstrated in the domain literature (Munari et al., 2018; Shen, 2017; Singh et al., 2021; Stander & Broadhurst, 2021; Xia & Ruan, 2020).

As indicated by (Das, 2011), technology transfers are usually categorized into three types: (i) the host institution develops or innovates a technology with foreign institutions' collaboration. This type is advanced level and known as know-why. (ii) host parties import technology and/or equipment with some in-house technological efforts by the importer. This type is intermediate level and known as know-what. (iii) constitutes import technology and/or equipment, and also training on operation from another country, as the basic level of operational knowledge. This is the basic level and is known as know-how.

Universities and industry are both important components of any country's national innovation system (NIS) (Proksch et al., 2019). Not only does the university or industry contribute to knowledge production and transformation in the NIS as an individual actor, but collaboration between these two institutions is becoming an increasingly important component of the NIS (López-Rubio et al., 2022). Vietnam has experienced significant growth and moved from a centrally planned economy to a market economy, becoming a lower-middle-income country in 2010. Vietnam recognized the necessity to restructure its economy and become an industrialized country. Education and Science and Technology (S&T) policies must play critical roles in realizing industrialization. To that end, the National Assembly and the Government of Vietnam established a comprehensive legal framework for the development of S&T activities. The Law on Science and Technology, enacted in 2000, served as the foundation for the country's innovation (Thuvienphapluat, 2020). A variety of other regulations are in place, including the Law on Intellectual Property (Thuvienphapluat, 2005)and Amendments to and Additions to Some Articles of the Law on Intellectual Property (Thuvienphapluat, 2009); the Law on Technology Transfer (Thuvienphapluat, 2006) and the Law on High Technology (Vanbanphapluat, 2008). These laws and regulations established the necessary framework for the NIS. More recently, the Science and Technology Strategy 2011-2020 was approved, outlining specific targets for the future development of Vietnam NIS over the next ten years (MOST, 2011).

However, the government and various institutions have put in place the fundamentals of a comprehensive NIS. Vietnam's NIS is still in its early stages and faces numerous challenges and weaknesses (Anh et al., 2017). Among them are the isolation of research institutions, including universities, from the productive sectors of the economy, and the fact that the higher education sector is not yet fully operational as a source of knowledge creation and transfer. Furthermore, inherent in the complexity are the barriers of the technology transfer process that prevent industries and universities from achieving practical application of those developed technologies (R. S. Quiñones et al., 2020a). Recognizing the presence of numerous barriers aids in the discovery of salient potential issues and problems that may arise during the technology transfer process, guiding stakeholders in decision-making (Munari et al., 2018).

Despite significant efforts in understanding university-industry collaborations on technology transfer, little effort has been reported in the current literature in identifying and establishing the various barriers of UTT. While previous studies found that these barriers not only impede university technology transfer but also have an impact on one another, empirical research on their cause-and-effect interrelationships is still lacking. Determining and comprehending such relationships allows for a better understanding of how to address the complexities of the UTT process and devise strategies to overcome them. Furthermore, given the barriers that exist in university technology transfer, only a few studies focus on different stakeholders, i.e. university scientists, university technology transfer offices, and entrepreneurs, throughout the process to account for their various motives, behaviors, and cultural environments. Firstly, the primary goal of university scientists is to gain recognition in the scientific community through academic publications in prestigious journals, presentations at prestigious conferences, and government research grants. Faculty members may also be motivated by personal financial gain or an expectation to secure additional funding for their research groups and laboratory equipment. Secondly, the primary motive of university technology transfer offices is to safeguard the university's intellectual property but market the intellectual property to firms at the same time. University technology transfer offices' secondary goals include securing additional research funding for the university through royalties and licensing fees, sponsored research agreements, and an intrinsic desire to disseminate university innovations. Thirdly, entrepreneurs seek to profit financially from the commercialization of university-based technologies. As a result, to maintain control, they request exclusive rights to these technologies. They are also concerned about "time to market," because profits from innovations may be contingent on the rapid development of new products or processes.

Consequently, various stakeholders perceive corresponding barriers in the entire process of university technology transfer. The cause-and-effect interrelationships among barriers from various stakeholder perspectives must thus be clarified in order to identify the key barriers to future policy planning. Therefore, this study aims to bridge the research gap by comparing different stakeholders' perspectives on the interrelationship between the barriers. A picture of the interdependence of these barriers can help policymakers make better decisions, which can improve the effectiveness of technology transfer from universities to industries.

The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method is used in this study to visualize the interrelationship among the barriers to university technology transfer in Vietnam. This method aims to convert the relationships between the causes and effects of factors into a network relationship map of the system (Gabus and Fontela 1973; Fontela and Gabus 1976). However, the agenda of uncertainty and vagueness in the elicitation of decision-maker judgments within the DEMATEL process was not addressed. Besides, the Grey set theory is an important tool for supporting uncertain decisions. It can make the decision results closer to reality by constructing a flexible decision model using gray interval numbers. In reality, the evaluation given by experts or decision-makers on related fields is always expressed in linguistic expressions instead of crisp values. The Grey set theory can be implemented to measure the ambiguous concepts associated with human subjective judgments by combining linguistic variables. In particular, when experts make judgments using incomplete or conflicting information, or when they are aware of the lack of expertise in some situations, the contributions of the gray set theory will increase. To take advantage of the benefits of both the DEMATEL method and the Grey set theory, the Grey DEMATEL or fuzzy DEMATEL method was proposed by combining the DEMATEL method and the gray/fuzzy logic. The extended method has been widely used to address complicated and intertwined problems to assist researchers with better decision support in an environment of imperfect information characterized by linguistic expressions and incomplete/inaccurate expert personal judgments. As a result, in this study, the Grey DEMATEL method was used to obtain a more accurate analysis for identifying intertwined relationships of UTT barriers while addressing uncertainty in decision-making.

LITERATURE REVIEW

In Vietnam, Hanoi University of Science and Technology, also known as Vietnam France University, Post and Telecommunications Institute of Technology, Military Technical Institute, FPT university, University of Information Technology- Vietnam National University Ho Chi Minh City, University of Technology- Vietnam National University Ho Chi Minh City, and University of Natural Sciences - Vietnam National University Ho Chi Minh City are the leading multidisciplinary technical universities. In this study, a panel of various experts with over ten years of experience are involved in university-industry linking activities from these leading universities. The experts interviewed are asked to determine whether the barriers reflect UTT in the context of Vietnam. Table 1 presents the list of critical barriers (Hayter et al., 2020; Hoc & Trong, 2019; Pagani et al., 2020; R. Quiñones et al., 2019; R. S. Quiñones et al., 2020b; Ravi & Janodia, 2022; Shen, 2017; Stander & Broadhurst, 2021).

Table 1

List of critical barriers

Barriers	Definition
Lack of appropriate partners	University engagements to industry perceived difficulties with industrial network actors due to unwilling industrial organizations
Time constraints	Technology transfer for commercialization causes time pressures for research scholars, academic works (e.g., publications and research papers), and other
Lack of resources	Lack of financial resources to support the development of these industrial liaison activities, lack of R&D human resources that conduct research works
Risk of information leakage	Undesirable spill-over, to partners and/or competitors
Knowledge being too theoretical for practical purposes	The industry has a lower dependency on academic sources of knowledge because universities specialize in basic research than applied research
Insufficient Rewards for university researchers	Discrepancies in the incentive and reward systems for faculty involvement and the commercialization goals for university technology transfer
Poor marketing / technical / negotiation skills of Technology Transfer Office (TTO)	TTOs recruit more individuals with expertise in patenting, licensing, and technical areas than hiring individuals with marketing skills
University proponents have unrealistic expectations regarding the value of their technologies	Academics are sometimes too confident of the value of their product which, as a result, may discourage firms from adopting their IP assets
Lack of recognition for university–industry linkages	Professors have few connections from the other environments and lack of recognition for university–industry linkages is also a challenge to create suitable partners and contact people
Inconsistent rules and regulations	Rules and regulations imposed by universities, industries, and even government funding agencies also hinder university technology transfer due to its inconsistencies

Lack of venture capital	Universities could not get access to funding and guidance due to the lack of access to venture capital
High costs of managing joint research projects in terms of time and money	Time pressure that the two organizations will experience Technologies represent a unit character which means that production is costly
Cultural differences between academia and enterprises	Universities and industries have differences in motivation, timeframe, communication modes, and attitudes
Misalignment between research and commercialization objectives	The objective of enterprises is to gain economic benefits from technology transfer while universities prioritize on disseminating new knowledge
Complex organizational structure	The complex flow of communication due to the imperfection of the transmission of information evident between R&D organizations and the technology user
Institutional bureaucracy	Key decision-makers are in control of the decisions to be made in the university regarding the technology transfer
Lack of personal motivation	The University is unwilling to commit time and resources to technology transfer since it will hinder faculty members and students from their academic work
Process complexity	The collaboration and innovation network is a complex system that contains multiple types of network structure
Geographic distance	Technology cannot move freely when participants who must learn together are geographically separated from each other
Lack of national benchmark to evaluate successful collaboration	Lack of accurate evaluation to assess the success of technology transfer. Further, for every growing technology transfer program

Prototype technology is not compatible with the demands of mass production	Difficult or impossible to change to be suitable for the requesting production/market because technology is too sophisticated
Problems concerning intellectual property rights	Difficulties-other than delays-in dealing with universities over intellectual property
Procurement process	Technologies developed are highly technical which raises problems concerning the acquisition of its potential producer
Lack of sales distribution centers within university premises	Industrial partners responsible for commercialization and marketing aspects in the university technology transfer

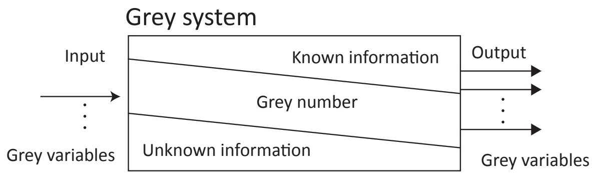
METHODOLOGY

Introduction to Grey Theory

Deng (1982) pioneered the concept of a gray system in response to insufficient knowledge, unquantifiable information, and partial ignorance. The gray theory is often used to resolve issues in an unpredictable world. This study establishes a foundation of gray numbers, gray sets, and gray theory. Figure 1 illustrates the definition of a gray scheme. In the following, this research briefly reviews some essential definitions of gray theory. The gray theory can be applied to any method that involves imprecise decision-making. Gray values can be quickly transformed to crisp numbers using the fuzzy value to crisp score conversion system.

Figure 1

The concept of the gray system



Definition 1: A gray system is a system containing uncertain information presented by a gray number and gray variables, as shown in Figure 1.

Definition 2: Let X be the universal set. Then a gray set G of X is defined by its two mappings L_G (x) and R_G (x)

$$\begin{cases} L_G(x): x \rightarrow [0,1] \\ R_G(x): x \rightarrow [0,1] \end{cases} \quad (1)$$

L_G (x)≥R_G (x),xϵX,X=R,L_G (x) and R_G (x) are the upper and lower membership functions in G, respectively.

When L_G (x)=R_G (x), the grey set G becomes a fuzzy set. It shows that grey theory considers the condition of the fuzziness and can deal flexibly with the fuzziness situation.

Definition 3: The gray number can be defined as a number with uncertain information. For example, the linguistic variables describe the ratings of attributes; there will be a numerical interval expressing it. This numerical interval will contain uncertain information. Generally, the gray number is written as ⊗G, (⊗G= ├ G┤ |_R^L)

Gray Operations:

(1) Additive operation

$$\otimes G_1 + \otimes G_2 = [G_1^L + G_2^L, G_1^R + G_2^R] \quad (2)$$

(2) Subtraction operation

$$\otimes G_1 - \otimes G_2 = [G_1^L - G_2^L, G_1^R - G_2^R] \quad (3)$$

(3) Multiplication operation

$$\otimes G_1 \times \otimes G_2 = [min(G_1^L G_2^L, G_1^L G_2^R, G_1^R G_2^L, G_1^R G_2^R), max(G_1^L G_2^L, G_1^L G_2^R, G_1^R G_2^L, G_1^R G_2^R)] \quad (4)$$

(4) Reciprocal operation

$$\otimes G^{-1} = \left[\frac{1}{G^R}, \frac{1}{G^L}\right] \quad (5)$$

(5) Division operation

$$\otimes G_1 / \otimes G_2 = \otimes G_1 \times \otimes G_2^{-1} = [G_1^L, G_1^R] \times \left[\frac{1}{G_2^R}, \frac{1}{G_2^L}\right] = \left[min\left(\frac{G_1^L}{G_2^L}, \frac{G_1^L}{G_2^R}, \frac{G_1^R}{G_2^L}, \frac{G_1^R}{G_2^R}\right), max\left(\frac{G_1^L}{G_2^L}, \frac{G_1^L}{G_2^R}, \frac{G_1^R}{G_2^L}, \frac{G_1^R}{G_2^R}\right)\right] \quad (6)$$

(6) Scalar multiplication

$$k.\otimes G = [k.G^L, k.G^R] \quad (7)$$

(7) Scalar power

$$\otimes G^k = \left[(G^L)^k, (G^R)^k\right] \quad (8)$$

DEMATEL-Based Grey Theory (Grey-DEMATEL)

In this study, the DEMATEL approach, known as a structural modeling approach, is applied to analyze the cause and effect relationships in numerous studies (Khan et al., 2020; NGUYEN et al., 2020; Singh et al., 2021; Xia & Ruan, 2020). Despite its advantages, it lacks significant implications in uncertain, insufficient information contexts. To overcome this drawback, the Grey DEMATEL approach is applied in this case. The process of the Grey DEMATEL approach is presented as follows:

Step 1: Considering and defining the relationships between the critical barriers based on experts' opinions. A matrix of direct relationships is constructed in Equation (9):

$$\otimes A = \begin{bmatrix} \otimes G_{11} & \cdots & \otimes G_{1n} \\ \vdots & \ddots & \vdots \\ \otimes G_{m1} & \cdots & \otimes G_{mn} \end{bmatrix} = \begin{bmatrix} [G_{11}^L, G_{11}^R] & \cdots & [G_{1n}^L, G_{1n}^R] \\ \vdots & \ddots & \vdots \\ [G_{m1}^L, G_{m1}^R] & \cdots & [[G_{mn}^L, G_{mn}^R]] \end{bmatrix} \quad (9)$$

Table 2

Linguistic Grey Assessment

Values	Linguistic assessment	Grey values $(G_{(x)}^L, G_{(x)}^R)$
0	No influence	(0.0,0.1)
1	Very low influence	(0.1,0.3)
2	Low influence	(0.2,0.5)
3	Medium influence	(0.4,0.7)
4	High influence	(0.6,0.9)
5	Very high influence	(0.9,1.0)

Step 2: Critical barriers are evaluated by using grey linguistic scales in Table 2.

Step 3: Normalize the lower and upper bounds using the grey values as given in Equation (10)-(12):

$$\Delta_{min}^{max} = \max G_{ij}^R - \min G_{ij}^L \quad (10)$$

$$X_{G_{ij}^L}^* = \frac{G_{ij}^L - \min G_{ij}^L}{\Delta_{min}^{max}} \quad (11)$$

$$X_{G_{ij}^R}^* = \frac{G_{ij}^R - \min G_{ij}^R}{\Delta_{min}^{max}} \quad (12)$$

Step 4: Computing the total normalized crisp value using Equation (13)-(14):

$$Y_{G_{ij}}^{Crisp} = \frac{\left(X_{G_{ij}^L}^* \, x \left(1 - X_{G_{ij}^L}^* \, x\right) + (X_{G_{ij}^R}^* x X_{G_{ij}^R}^*)\right)}{1 - X_{G_{ij}^L}^* \, x + X_{G_{ij}^R}^*} \quad (13)$$

$$Z_{G_{ij}}^* = \min X_{G_{ij}^L}^* + Y_{G_{ij}}^{Crisp} \, x \, \Delta_{min}^{max} \quad (14)$$

Step 5: Hence, kth direct-relation gray matrices (Z1, Z2,.., Zk) of kth expert are obtained. Then the average gray direct-relation matrix is taken by Equation (15):

$$Z = \frac{\sum_{i=1}^{k} Z^{*}_{G_{ij}}}{k} \quad (15)$$

Step 6: Normalize the initial direct-relation matrix. D is denoted as a normalized initial direct relation matrix, and S is denoted as the auxiliary parameter for normalizing the initial direct-relation matrix as given in Equation (16)-(17):

$$S = max\left[max_{1<i<n} \sum_{1<j<n}^{n} Z_{ij}\,;\, max_{1<j<n} \sum_{1<i<n}^{n} Z_{ij}\right] \quad (16)$$

$$D = Z/S \quad (17)$$

Step 7: Calculate the total relation matrix T. The powers of D represent the indirect effects between any two barriers. T is denoted as the total relation matrix, I is denoted as the identity matrix. Then the total relation matrix T can be calculated by Equation (18)-(22):

$$T = \left[T_{G_{ij}}\right]_{nxn} = \left[T^{L}_{G_{ij}};\, T^{R}_{G_{ij}}\right]_{nxn} = D + D^2 + D^3 + .. + D^{\infty} \quad (18)$$

$$T^{L}_{G} = \left[T^{L}_{G_{ij}}\right]_{nxn} = D^{L}x(I - D^{L})^{-1} \quad (19)$$

$$T^{R}_{G} = \left[T^{R}_{G_{ij}}\right]_{nxn} = D^{R}x(I - D^{R})^{-1} \quad (20)$$

$$D^{L} = \left[d^{L}_{G_{ij}}\right]_{nxn} \quad (21)$$

$$D^{R} = \left[d^{R}_{G_{ij}}\right]_{nxn} \quad (22)$$

Step 8: Determine the prior sequence of the proposed barriers from most to least important, and identify the cause-effect relations. The total effect that is directly and indirectly exerted by the ith factor, is denoted by R_i. The total effect, including direct and indirect effects received by the jth factor, is denoted by D_j. The value of (Ri+Dj), (Ri−Dj) is established using Equation (23)-(24):

$$R_i = \sum_{j=1}^{n} T_{G_{ij}} \quad (23)$$

$$D_j = \sum_{i=1}^{n} T_{G_{ij}} \quad (24)$$

The sum (Ri+Dj) represents the total effects given and received by the ith barriers. In other words, (Ri+Dj) is a measure of the degree of the importance of the ith barrier in the system. The prior sequence of the n barriers could be determined based on the value of (Ri+Dj). The bigger the value of (Ri+Dj) the more important the barrier is. The difference (Ri–Dj), is called relation. It shows the net effect that is contributed by the ith barrier to the system. When (Ri−Dj) > 0, the ith barrier is a net cause, which means the barrier belongs to the "cause group". On the contrary, when (Ri−Dj) < 0, the ith barrier is a net receiver/result, which means the barrier belongs to the "effect group". The gray numbers were converted to crisp values by taking the average. The results were validated through multi-stakeholders' perspectives, including university scientists, university technology transfer offices, and entrepreneurs. The causal relationship diagram will then be used to illustrate the influencing aspects.

EMPIRICAL ANALYSIS

The prominence and relation values of each barrier can then be calculated, as described in Step 8. The degrees of prominence and relation values of the three stakeholders are presented in Table 3-5. The barriers with high prominence values significantly affect other barriers or they are greatly affected by other barriers. These barriers should be addressed by managers or policy makers. The barriers with high and positive relation values, i.e. the dispatchers, indicate that they are the basic causal factors that need to be overcome.

Table 3

The degrees of prominence and relation values of barriers – university scientists

R_i		D_j		R_i+D_j		R_i-D_j		Crisp R_i+D_j	Crisp R_i-D_j
2.118	3.301	2.165	3.348	4.283	6.648	-1.230	1.136	5.466	-0.047
2.139	3.330	1.914	3.112	4.054	6.442	-0.973	1.415	5.248	0.221
2.264	3.463	1.703	2.905	3.967	6.367	-0.640	1.759	5.167	0.560
1.930	3.132	1.619	2.815	3.549	5.948	-0.885	1.513	4.749	0.314
1.621	2.817	2.482	3.674	4.103	6.491	-2.053	0.336	5.297	-0.859
1.924	3.119	1.685	2.876	3.609	5.995	-0.952	1.434	4.802	0.241
1.895	3.084	1.7373	2.9434	3.633	6.027	-1.048	1.347	4.830	0.149
1.824	3.020	2.142	3.346	3.966	6.366	-1.522	0.878	5.166	-0.322
1.529	2.739	2.060	3.244	3.588	5.983	-1.715	0.679	4.786	-0.518
1.472	2.669	1.743	2.947	3.215	5.616	-1.475	0.925	4.416	-0.275
1.458	2.658	1.419	2.617	2.878	5.274	-1.158	1.238	4.076	0.040
1.974	3.153	1.743	2.932	3.717	6.085	-0.958	1.410	4.901	0.226
1.549	2.752	2.071	3.267	3.619	6.019	-1.719	0.681	4.819	-0.519

1.785	3.006	1.831	3.025	3.615	6.031	-1.240	1.176	4.823	-0.032
1.410	2.610	1.762	2.954	3.171	5.564	-1.545	0.848	4.368	-0.348
1.771	2.967	2.228	3.422	3.999	6.389	-1.650	0.739	5.194	-0.455
2.048	3.251	1.511	2.710	3.559	5.961	-0.662	1.740	4.760	0.539
2.610	3.795	1.604	2.805	4.214	6.600	-0.195	2.191	5.407	0.998
1.970	3.152	2.470	3.666	4.440	6.818	-1.695	0.682	5.629	-0.507
1.939	3.144	1.828	3.022	3.767	6.167	-1.083	1.316	4.967	0.116
1.952	3.154	2.135	3.341	4.087	6.495	-1.389	1.019	5.291	-0.185
1.706	2.892	1.921	3.133	3.628	6.024	-1.426	0.970	4.826	-0.228
2.071	3.266	1.955	3.142	4.026	6.408	-1.071	1.311	5.217	0.120
2.881	4.072	2.115	3.298	4.996	7.370	-0.417	1.957	6.183	0.770

According to the university scientists, rules and regulations imposed by universities or government funding agencies and the lack of mutual understanding about expectations and working practices are regarded as significant barriers with the highest and second highest prominence values, as shown in Table 3. For example, the MOST's University-Industry Collaborative Research Programme requires researchers to find industrial partners before conducting collaborative research. If the researchers lack such connections, it will be difficult for them to contribute to the university-industry collaboration. Furthermore, the disparity in working practices between universities and industries is reflected in the lack of mutual understanding. University researchers, for example, seek publication in peer-reviewed journals, present at discipline-related conferences, and receive government research grants, whereas practitioners seek patents only.

The important barriers with the highest and second highest relation values are time constraints and rules and regulations imposed by universities or government funding agencies. A university's primary mission is fundamental research and education. Furthermore, the academic output is emphasized in Taiwan's promotion and tenure criteria for university scientists. However, because university researchers must publish their scientific research while also participating in coursework, their time for university-industry collaborations can be extremely limited.

Table 4

The degrees of prominence and relation values of barriers – UTT offices

Ri		Dj		Ri+Dj		Ri-Dj		Crisp Ri+Dj	Crisp Ri-Dj
1.142	5.893	1.452	6.875	2.594	12.767	-5.732	4.441	7.681	-0.645
1.142	5.892	1.149	5.916	2.292	11.808	-4.773	4.743	7.050	-0.015
1.198	6.070	0.878	5.055	2.077	11.126	-3.857	5.192	6.601	0.668
0.943	5.259	1.067	5.654	2.010	10.913	-4.711	4.192	6.462	-0.260
0.823	4.878	1.283	6.338	2.105	11.216	-5.515	3.595	6.661	-0.960
1.069	5.659	0.975	5.362	2.044	11.020	-4.293	4.684	6.532	0.195
0.998	5.435	0.9335	5.2301	1.932	10.665	-4.232	4.501	6.298	0.135
1.177	6.002	1.042	5.574	2.219	11.577	-4.397	4.961	6.898	0.282
1.098	5.753	1.156	5.937	2.255	11.690	-4.839	4.596	6.972	-0.121
1.106	5.776	0.990	5.411	2.096	11.186	-4.305	4.786	6.641	0.240
0.895	5.109	0.818	4.862	1.713	9.971	-3.967	4.291	5.842	0.162
1.098	5.752	0.998	5.434	2.096	11.185	-4.336	4.754	6.641	0.209
1.347	6.544	1.174	5.993	2.521	12.536	-4.645	5.370	7.529	0.362
1.292	6.367	1.058	5.624	2.350	11.991	-4.332	5.309	7.171	0.488
0.986	5.395	1.153	5.925	2.138	11.320	-4.940	4.242	6.729	-0.349
1.060	5.631	1.268	6.291	2.328	11.922	-5.231	4.363	7.125	-0.434
1.131	5.857	0.977	5.366	2.107	11.223	-4.236	4.880	6.665	0.322
1.347	6.541	1.228	6.166	2.575	12.707	-4.819	5.313	7.641	0.247
1.030	5.536	1.379	6.642	2.408	12.178	-5.612	4.157	7.293	-0.728
1.068	5.656	1.096	5.744	2.163	11.400	-4.677	4.560	6.782	-0.058
1.137	5.875	1.285	6.346	2.422	12.221	-5.210	4.590	7.322	-0.310
1.127	5.844	1.201	6.080	2.329	11.925	-4.953	4.643	7.127	-0.155
1.141	5.888	1.128	5.847	2.269	11.735	-4.706	4.760	7.002	0.027
1.422	6.782	1.088	5.720	2.510	12.501	-4.297	5.694	7.506	0.698

Regarding university TTO perspectives, two significant barriers to university technology transfer are a lack of mutual understanding about expectations and working practices and a lack of recognition of university industry linkages (Table 4). As previously stated, each stakeholder group has its own primary motivation. For example, the concept of time in terms of goals, deadlines, and results is frequently different and a source of contention with universities and researchers having longer time horizons than businesses. Furthermore, because entrepreneurs and university scientists have few connections to the other environment, it is more difficult to identify suitable contact people to begin initial discussions. Accordingly, establishing university-industry links is difficult. TTOs play the role of an intermediary between university scientists and those who want to commercialize university innovations. As a result, TTO personnel can easily detect differences in working practices between university scientists and industrial practitioners, as well as a lack of awareness between academics and entrepreneurs. Rules and regulations imposed by universities or government funding agencies, as well as bureaucracy and inflexibility of university administrators, have the highest relation values for university technology transfer dispatchers. TTOs experience the operation of university technology transfer regulated by universities or the government, as well as bureaucracy and inflexibility embedded in organizations, because they are responsible for the operations of university technology transfer.

Table 5

The degrees of prominence and relation values of barriers – entrepreneurs

Ri		Dj		Ri+Dj		Ri-Dj		Crisp Ri+Dj	Crisp Ri-Dj
1.956	3.712	2.476	4.324	4.432	8.036	-2.369	1.236	6.234	-0.566
1.962	3.661	2.031	3.781	3.994	7.442	-1.818	1.630	5.718	-0.094
2.032	3.832	1.509	3.126	3.541	6.957	-1.094	2.323	5.249	0.615
1.585	3.188	1.511	3.086	3.095	6.274	-1.501	1.677	4.685	0.088
1.357	2.931	2.330	4.089	3.688	7.020	-2.732	0.601	5.354	-1.066
1.939	3.672	1.620	3.184	3.559	6.857	-1.246	2.052	5.208	0.403
1.937	3.649	1.6614	3.3840	3.599	7.034	-1.447	1.988	5.316	0.271
1.876	3.554	1.939	3.675	3.815	7.229	-1.799	1.615	5.522	-0.092
1.686	3.303	1.976	3.752	3.662	7.055	-2.066	1.327	5.358	-0.369
1.686	3.276	1.649	3.312	3.334	6.588	-1.626	1.628	4.961	0.001
1.349	2.913	1.362	2.967	2.711	5.880	-1.618	1.551	4.295	-0.034
1.862	3.508	1.675	3.350	3.536	6.858	-1.488	1.833	5.197	0.172
2.098	3.774	1.946	3.726	4.044	7.501	-1.629	1.828	5.772	0.100
2.129	3.845	1.774	3.467	3.903	7.312	-1.338	2.071	5.607	0.367
1.577	3.120	1.890	3.567	3.466	6.687	-1.990	1.230	5.077	-0.380
1.583	3.207	2.078	3.801	3.661	7.008	-2.218	1.129	5.334	-0.545
1.928	3.645	1.625	3.212	3.554	6.857	-1.284	2.020	5.206	0.368
2.510	4.446	1.761	3.383	4.271	7.830	-0.873	2.685	6.050	0.906
1.889	3.575	2.445	4.256	4.334	7.831	-2.366	1.130	6.082	-0.618
1.875	3.581	1.815	3.494	3.690	7.074	-1.618	1.766	5.382	0.074
1.893	3.581	2.107	3.884	4.000	7.466	-1.991	1.475	5.733	-0.258
1.649	3.263	2.057	3.775	3.707	7.039	-2.126	1.206	5.373	-0.460
1.981	3.720	1.957	3.638	3.939	7.358	-1.657	1.763	5.648	0.053
2.704	4.751	1.850	3.476	4.554	8.227	-0.772	2.902	6.391	1.065

According to the entrepreneurs, two significant barriers with the highest and second highest prominence values are a lack of mutual understanding about expectations and working practices and a lack of recognition for university-industry linkages. This outcome is consistent with the viewpoint of university TTOs. According to Table 5, the rules and regulations imposed by universities or government funding agencies and cultural differences between academia and businesses are regarded as the two most important dispatchers, with the highest and second highest relation values that affect other barriers such as i10 and i13. In other words, the findings show that entrepreneurs who have worked with universities face the same challenges that the researchers did.

Furthermore, the cultural differences between academia and enterprises identified as the most critical barrier with the second highest correlation value reveal the different cultural factors inherent in universities and firms. Universities focus on creating and disseminating new fundamental knowledge, whereas businesses frequently seek directly applicable knowledge to provide immediate economic value. Communication is essential for the development and success of university-industry links because differences in terminology, language, and communication styles are likely to stymie cooperation.

CONCLUSION

Despite its complexity, many organizations and stakeholders regard technology transfer as an essential process. The various barriers that prevent universities from completing a successful UTT process are inherent in its complexity. As a result, a plethora of studies in the literature have attempted to comprehend the existence of these barriers. However, the current literature on UTT barriers is fragmented, and little effort has been made to compile a comprehensive list of UTT barriers and their possible interrelationships. Creating a list of UTT challenges is critical for streamlining the major impediments to UTT, which will aid in planning, resource allocation decisions, policy-making, and decision-making. Furthermore, understanding the interrelationships of these barriers provides critical insights into the complexity of the situation.

First, during the interviewing process, 24 barriers (such as a lack of resources and geographic distance, among others) were identified. Then, the highly influential barrier was identified as the high costs of managing joint research projects in terms of both time and money, which impacts the barrier on the technology transfer office's poor marketing/technical/negotiation skills, the challenges on the misalignment of research and commercialization objectives, and the geographic distance barrier. As a result, the institutional bureaucracy barrier was determined to influence the barriers of information leakage risk, knowledge challenges of being too theoretical for practical purposes, and cultural differences between academia and enterprises. Furthermore, the barrier to misalignment between research and commercialization appears to be the most powerful of all. While UTT challenges are unavoidable, identifying these obstacles and their interrelationships is critical for the strategic development of achieving successful UTT. As a result, higher education institutions must prioritize UTT in terms of financial resource allocation. The allocation must be carefully designed to address primarily the improvement of marketing and technical skills for university technology transfer, as well as significant involvement of relevant industries and other stakeholders to facilitate face-to-face interactions and socialization, which should result in better alignment of research activities encompassing both university priorities and enterprises. Furthermore, because the work was conducted in only one situation, the results would be influenced by a few contextual factors (e.g., cultural, social, and bureaucratic factors). Several modeling approaches can be used in future works to analyze the interrelationships between concepts. Formal concept analysis, for example, can be used to group concepts that have similar attributes and characteristics before developing a cognitive map to reduce redundant concepts.

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