Critical Factors to Technology Development in Indian Academia : An ISM-MICMAC Approach

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Abstract

The significance of research translation and technology transfer in academia is getting increasing attention for the greater public interest. Besides, the successful transfer of knowledge to augment a university's outreach mission is in a large measure driven by R&D outcomes, more particularly, in terms of developed technologies. It thus becomes worthwhile to analyze the factors that enable technology development in academia. This objective remains a gap in extant literature. Therefore, this study aimed to identify the enabling factors of technology development in the university ecosystem and to examine their interrelationships. An interpretive structural modelling (ISM) technique was applied to identify the interrelationship among factors. Further, MICMAC analysis was applied to identify the driving and dependent enabling factors. Our findings revealed that top management's leadership and visionary approach ; research mission ; strategy & culture ; adequate research infrastructure ; and intramural funding for research, development, and innovation-related activities are the key driving factors to technology development in academia. This study will be useful for the managers and decision-makers to comprehend the relationship between technology development enablers and framing the institutional policies and strategies.

Keywords : **academia, ISM, MICMAC, research translation, technology development, technology transfer, universities**

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In this era of a knowledge-based economy, the development of a nation is driven by innovation and technology. In this context, university research has emerged as an important source of innovative technologies that helps in industrial growth (Geiger & Sa, 2005; Reddy, 2011). Universities are the institutional entities that play a catalytic role in increasing local communities' innovation capacity, thereby making a significant contribution to regional economic growth (Etzkowitz & Leydesdorff, 2000; Saad et al., 2015). To this end, universities serve as developers and transferors of cutting-edge technologies while producing an educated and skilled workforce (Bagga et al., 2016; Bagga, 2017). It has been recognized earlier that both technological and commercial aspects influence scientific innovation. Thus, no matter how groundbreaking the technology is, enterprises and investors will invest only if it makes some economic sense (Nandagopal, 2013).

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In the context of the university system, the authors have explained the different phases of the research & development process and the level of business risk associated with each phase. They have highlighted the significance of undertaking pre-commercial technology development (TD) research to draw the enterprises' and investors' attention (Lee & Gaertner, 1994; Nandagopal, 2013).

Given the above, Indian higher education institutions are getting increased attention from policymakers. The Government of India (GOI) has taken several initiatives in the form of policy measures, funding schemes, and specialized technology-based programs to promote and support research, innovation, and TD in the university system (Arumugam & Jain, 2012; Kumar & Shekhar, 2017; Srivastava & Chandra, 2012). Despite all these initiatives, a significant gap persists in the case of TD in academia. This is seen in the low technology readiness level (TRL) of university technologies due to which Indian universities struggle with a low rate of technology commercialization compared to top tier universities in the west (Arumugam & Jain, 2012; Rath et al., 2014).

TD research is an important and complex process as it undertakes derisking of technology to improve its rate of successful transfer. Therefore, the need arises to identify and analyze the factors that enable the development of technology in an academic setting to avoid potential hindrances. These enabling factors not only influence the TD process, but also impact one another. Thus, it is essential to understand the characteristics of these enablers and their interrelationships so that the enablers which influence others, that is, driving enablers, and the enablers which get influenced by others, that is, dependent enablers can be identified.

A perusal of existing literature sees substantial reporting on enablers and barriers to knowledge creation (KC); knowledge transfer (KT); knowledge management (KM); and research, innovation, and technology transfer (TT) (Devi Ramachandran et al., 2013; Khan et al., 2017; Kumar et al., 2015; Ramjeawon & Rowley, 2017; Siadat et al., 2012; Supapawawisit et al., 2018; Van Ta & Zyngier, 2018). The common factors studied include organizational culture and structures, leadership, infrastructure, policy, researcher's quality, funding, communication, and industry-academia partnership. However, no previous research has studied TD and its enablers in the context of the Indian academic settings. Besides, there are few reporting on TD models and national level TD strategies (Ahmed & Newton, 2005; Aristodemou et al., 2019; Bagchi et al., 2011; Chakrabarti & Bhaumik, 2010). But these models are particularly for managing the industrial TD process, which enables rational decision-making while evaluating the technology projects. However, in the context of the university system, management of the TD process has not been adequately researched. Therefore, the present research aims to determine the enabling factors of TD within the Indian academic system, understand their complex relationship, and identify the most significant enablers. This study contributes toward the identification, prioritization, and classification of TD enablers and intends to propose a valuable roadmap for the decision-makers, technology developers, and R&D managers in addressing the issues related to TD in the university ecosystem.

Literature Review

An extensive review of the literature was conducted through scientific repositories such as Google Search, Google Scholar, Scopus, World Scientific, and NISCAIR. Searches were performed using the keywords: technology management, TD, innovation and technology creation, impactful factors, and university being used alone or grouped from July – December 2020.

The literature review shows a scarcity of literature on TD models, though there is some reporting in the industry context. For instance, Cooper (2006) claimed that TD projects are scarce, unique, and fragile. Therefore, to properly manage TD projects, he proposed the technology stage-gate model. Cáñez et al. (2007) proposed the technology acquisition stage-gate model to acquire technology from an external source. Caetano et al. (2011) proposed the theoretical TD process (TTDP) model. This five-stage model initiates with an idea and finishes with the technology, which is all set to be incorporated into a new service or product development process.

Lercher (2016) proposed the big picture model to handle highly risky and uncertain TD projects. However, such kinds of studies have remained an unexplored area in the context of the university system.

Besides, few studies emphasized the factors that influence knowledge creation, knowledge sharing, knowledge management, knowledge transfer, and technology transfer. For instance, Siadat et al. (2012) explained the process of knowledge creation, examined the factors influencing it, and highlighted the impact of organizational culture and social capital on knowledge creation in an Iranian university. The empirical research by Devi Ramachandran et al. (2013) on the importance of knowledge management practices and its key enablers in public universities classified the enablers into organizational culture, leadership, information technology, and performance management. The empirical study by Razmerita et al. (2016) identified enablers and barriers to knowledge sharing. Later, Ramjeawon and Rowley (2017) presented enablers and barriers to knowledge management processes in Mauritius and South African-based universities.

Meanwhile, Supapawawisit et al. (2018) investigated the critical factors to research and innovation creation in universities of Thailand. Van Ta and Zyngier (2018) identified barriers to the effectiveness of knowledge sharing in Vietnamese higher education institutions. Anatan (2018) discussed and established the propositions involving variables influencing knowledge transfer within industry-academia alliances. Further, Yip and Ng (2019) examined the relationship between critical factors to success and perceived benefits around knowledge management. Moreover, significant research is available on impactful factors of technology evaluation, transfer, and commercialization (Biranvand et al., 2018; Govindaraju, 2010; Khan et al., 2017; Kumar et al., 2015; Luthra et al., 2015; Purushotham et al., 2013; Shouwu et al., 2016). However, the enablers of the TD process in the context of academia have not been adequately researched.

Given the above, it would be worth mentioning that there is a lack of studies on TD enablers and models in the context of Indian higher education institutions. Therefore, this study is a modest attempt to fill this gap.

Application of Interpretive Structural Equation Modelling (ISM)

ISM is a widely used technique to deal with complex issues in diversified sectors (Garg et al., 2015; Khan et al., 2017; Singh et al., 2019; Panackal & Venkataramani, 2021). It is a well-established prioritization method for accessing the complex relationship among factors defining a particular problem (Raj et al., 2008). For instance, Lee et al. (2011) applied ISM to select an appropriate technology to develop an innovative product. The application of ISM by Luthra et al. (2011) presented barriers to green supply chain management in the Indian automobile industry. Sohani and Sohani (2012) applied this methodology to develop a valuable framework for the Indian higher education system. A study by Bag and Anand (2014) presented an interrelationship between the soft dimension of a flexible manufacturing system for increasing enterprises' productivity and profitability. Taghizadeh and Shokri (2015) applied ISM to identify the interrelationship among knowledge management dimensions from the perspective of social capital. Shouwu et al. (2016) applied ISM to identify the underlying structure among factors influencing international technology transfer. Further, Biranvand et al. (2018) implemented ISM to develop a model of knowledge commercialization barriers in an Iranian University. Using the ISM approach, Suresh and Balajee (2021) presented the factors influencing informal learning among school teachers.

Research Methodology

The present study is exploratory as it aims to provide deep insights into the factors that enable TD in the university system. Due to the complexity of this research discipline, developing a framework based on experts' opinions is considered the most suitable. Using purposive sampling, semi-structured interviews with well-informed and experienced respondents were conducted between January – March 2021. Respondents were selected from the top 50 NIRF-listed universities. As a semi-structured interview provides a fairly open framework, therefore, it is considered to be a useful tool to gain deep insights into the research area (Newcomer et al.,2015), and to increase the probability of getting quality responses, the purposive sampling technique is used (Etikan et al., 2016).

This study uses the ISM methodology to develop a framework for enabling factors to TD. John Warfield introduced the ISM methodology in 1973. Since then, the ISM approach has been vastly used for examining the interrelationships among impactful factors in both the service and manufacturing industries and has emerged as a valuable decision-making tool (Garg et al., 2015; Luthra et al., 2011; Sohani & Sohani, 2012). ISM is interactive learning and structure-based modeling technique. It is a methodology in which factors are displayed in hierarchical order, and the overall structure is portrayed in the form of a digraph model. ISM assists in interpreting the interrelationship among a large number of factors to develop a basic understanding and provide deeper insights to develop an appropriate action plan to resolve the critical matters (Attri et al., 2013). Using expert knowledge and experience, the relationship among various factors is identified, and an overall structure is obtained from an intricate set of factors (Suresh & Balajee, 2021).

Stepwise Implementation of the ISM Methodology

Step 1. Identification of the Factors

Initially, to identify the factors influencing the development of technology, an extensive review of the literature was performed. Further, an experience survey was performed to identify the enabling factors of TD in academia. The experience survey included semi-structured interviews of 30 academicians who were involved in or dealt with TD in Indian higher education institutions. Among the respondents, 40% were professors, 30% were scientists, and 30% were institutional heads. Table 1 shows the respondents' experience profile.

Factors identified from the literature review and validated with experts' inputs are shown in Table 2. Subsequently, utilizing Table 2, focus group interviews were conducted to identify the relationship among the enabling factors.

Table 1. ***Respondents' Experience Profile***

Respondents' Experience in R&D	Percentage
< 10 years	8%
10 – 20 years	24%
20 – 30 years	42%
> 30 years	26%

Table 2. ***Validated Enabling Factors of TD***

Factor No.	Factor	References
1	Top management's leadership and visionary approach	Mallari & Santiago (2016); Sung & Gibson (2005); Supapawawisit et al. (2018)
2	Clearly defined research mission and strategies	Hatakenaka (2008); Necoechea-Mondragón et al. (2013)
3	Adequate research infrastructure	Heinzl et al. (2013); Ramjeawon & Rowley (2017)
4	Well-documented research policy guidelines	Ramjeawon & Rowley (2017); Supapawawisit et al. (2018)

5	Internal funding for research and development activities	Heinzl et al. (2013); Supapawawisit et al. (2018)
6	Entrepreneurial, knowledge sharing, and innovation culture	Arumugam & Jain (2012); Choudhury (2016); Ramjeawon & Rowley (2017); Siadat et al. (2012)
7	Capable researchers	Rath et al. (2014); Van & Zyngier (2018)
8	Effective communication	Khan et al. (2017); Wu & Zhou (2012)
9	Government policy and funding support	Purushotham et al. (2013); Sheth et al. (2019)
10	R&D collaboration among universities and other research establishments	Marques et al. (2016); Tidd & Thuriaux-Alemán (2016)
11	Industry-Academia partnership for research & development and innovation engagement	Calcagnini & Favaretto (2016); Heinzl et al. (2013)
12	Promoting interdisciplinary research	Borrego & Newswander (2010); Van Noorden (2015)
13	Enterprise structures like TTOs, incubators, etc.	Boh et al. (2016); Nandgopal (2013)
14	Intellectual property management system	Govindaraju (2010); Gargate & Jain (2013)

Step 2. Development of SSIM

Fulfilling the criteria of adequate group size, a focus group of eight members comprising institutions' heads, professors, and distinguished scientists involved in TD or management was interviewed (Halcomb et al., 2007). This helped to identify the contextual relationship and related direction in a pairwise comparison of the enabling factors, as shown in Table 3. The symbols used to derive the contextual relationship between the pair of factors are as under :

Table 3. ***Structural Self-Interaction Matrix***

		b													
	Factors	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
a	1	V	V	V	V	V	V	V	V	V	V	V	V	V	–
	2	V	V	V	V	V	V	V	V	V	V	V	V	–	
	3	O	V	V	V	V	V	O	V	V	V	A	–		
	4	V	V	V	V	V	A	V	V	V	V	–			
	5	V	V	V	V	V	V	O	V	V	–				
	6	V	V	V	V	V	A	V	A	–					
	7	O	V	V	V	V	V	V	–						
	8	V	V	V	V	V	V	–							
	9	V	V	V	V	V	–								
	10	V	V	V	O	–									
	11	V	O	V	–										
	12	V	V	–											
	13	V	–												
	14	–													

"V" specifies factor *a* helps to achieve factor *b*,

"A" specifies factor *b* helps to achieve factor *a,*

"X" specifies factor *a* and factor *b* help to achieve one another,

"O" specifies factor *a* and factor *b* are unrelated.

Step 3. Develop Initial Reachability Matrix (IRM)

At this step, IRM is created using SSIM. To create IRM, each entry in SSIM is replaced by 0 and 1 as per the following rules :

(i) In case entry in cell *(a, b)* in SSIM is *V*, then the cell *(a, b)* entry becomes 1, and the cell *(b, a)* entry becomes 0.

(ii) In case entry in the cell *(a, b)* in SSIM is *A*, then the cell *(a, b)* entry becomes 0, and the cell *(b, a)* entry becomes 1.

(iii) In case entry in cell *(a, b)* in SSIM is *X*, then entries in each of the two cells *(a, b)* and *(b, a)* become 1.

(iv) In case entry in cell *(a, b)* in SSIM is *O*, then the entries in each of the two cells *(a, b)* and *(b, a)* will become 0. Subsequently, an initial reachability matrix is obtained in Table 4.

Step 4. Developing the Final Reachability Matrix (RM)

The final RM is obtained by integrating transitivity in the initial RM, as explained in Step 3 of the ISM methodology. Table 5 represents the final RM, where rows represent driving power and columns represent

Table 4. ***Initial Reachability Matrix***

								b							
	Factors	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2	0	1	1	1	1	1	1	1	1	1	1	1	1	1
	3	0	0	1	0	1	1	1	0	1	1	1	1	1	0
	4	0	0	1	1	1	1	1	1	0	1	1	1	1	1
	5	0	0	0	0	1	1	1	0	1	1	1	1	1	1
a	6	0	0	0	0	0	1	1	1	0	1	1	1	1	1
	7	0	0	0	0	0	0	1	1	1	1	1	1	1	0
	8	0	0	0	0	0	0	0	1	1	1	1	1	1	1
	9	0	0	0	1	0	1	0	0	1	1	1	1	1	1
	10	0	0	0	0	0	0	0	0	0	1	0	1	1	1
	11	0	0	0	0	0	0	0	0	0	0	1	1	0	1
	12	0	0	0	0	0	0	0	0	0	0	0	1	1	1
	13	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Table 5. ***Final Reachability Matrix***

Factors	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Driving Power**
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	13
3	0	0	1	1*	1	1	1	1*	1	1	1	1	1	1*	12
4	0	0	1	1	1	1	1	1	1*	1	1	1	1	1	12
5	0	0	0	1*	1	1	1	1*	1	1	1	1	1	1	11
6	0	0	0	1*	0	1	1	1	1*	1	1	1	1	1	10
7	0	0	0	1*	0	1*	1	1	1	1	1	1	1	1*	10
8	0	0	0	1*	0	1*	1*	1	1	1	1	1	1	1	10
9	0	0	0	1	0	1	1*	1*	1	1	1	1	1	1	10
10	0	0	0	0	0	0	0	0	0	1	0	1	1	1	4
11	0	0	0	0	0	0	0	0	0	0	1	1	1*	1	4
12	0	0	0	0	0	0	0	0	0	0	0	1	1	1	3
13	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Dependence Power	1	2	4	9	5	9	9	9	9	10	10	12	13	14	

Note. 1* represents transitive relations.

dependence power. The driving power of each factor is calculated by adding all the 1s in a row, and dependence power is calculated by adding all the 1s in a column.

Step 5. Level Partitioning

At this step, the reachability set and antecedent set for each factor are derived from the final RM. The reachability set includes factors that influence other factors of the system and a factor itself. However, the antecedent set includes factors that are influenced by other factors of the system and a factor itself. Subsequently, the intersection set between the reachability set and antecedent set is obtained for all the factors. Factors having similar reachability set and intersection set are assigned as Level 1 in the ISM Model hierarchy. Factors at this level would be influenced by the factors above their level. After identifying a factor belonging to Level 1, it is removed from the remaining sets of factors. This procedure is repeated till levels to all the enabling factors are assigned. In this study, the intersection between reachability set and antecedent set along with different levels of 14 enabling factors are shown in Table 6. The process of level identification is accomplished in eight iterations. These levels help in the development of a digraph and final ISM model.

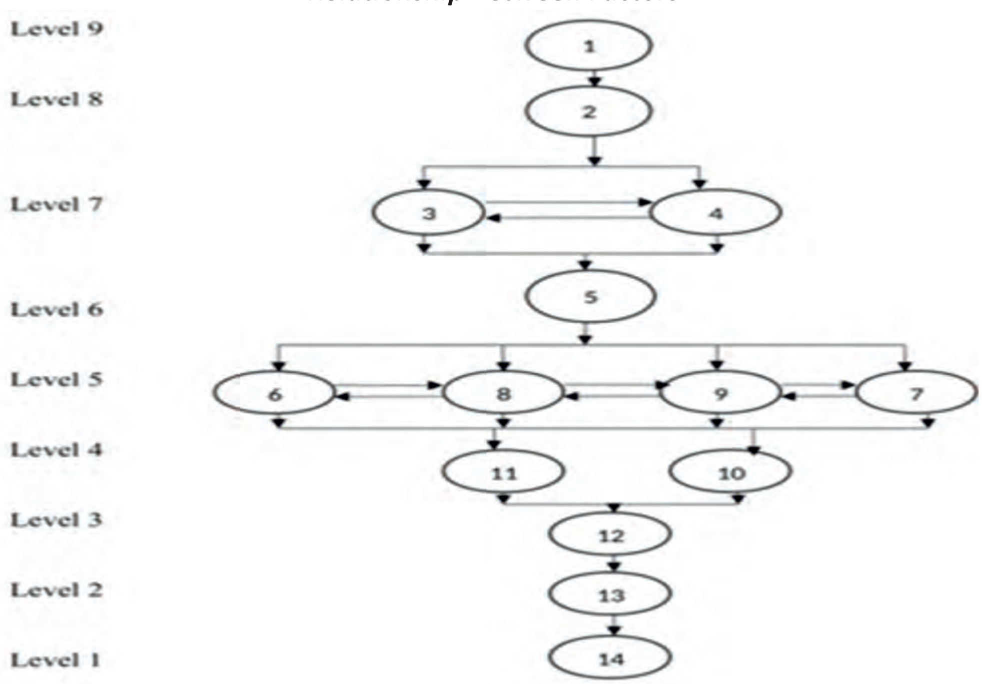
Step 6. Developing a Digraph

A digraph is developed using Table 5 and Table 6 to show the directional relationship among the factors. Level IX forms the starting point and is positioned at the peak of the hierarchy. Therefore, the factor: Top management leadership and visionary approach emerges as a key driving factor that influences other enabling factors of the system. Level 1 is positioned at the end, and thus, the intellectual management property system emerges as a factor influenced by all other enabling factors. Figure 1 illustrates the classification of enabling factors into nine different levels.

Table 6. ***Levels' Partitioning of Enabling Factors***

Factors	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,3,4,5,6,7,8,9,10,11,12,13,14	1	1	IX
2	2,3,4,5,6,7,8,9,10,11,12,13,14	1,2	2	VIII
3	3,4,5,6,7,8,9,10,11,12,13,14	1,2,3,4	3,4	VII
4	3,4,5,6,7,8,9,10,11,12,13,14	1,2,3,4,5,6,7,8,9	3,4,5,6,7,8,9	VII
5	4,5,6,7,8,9,10,11,12,13,14	1,2,3,4,5	4,5	VI
6	4,6,7,8,9,10,11,12,13,14	1,2,3,4,5,6,7,8,9	4,6,7,8,9	V
7	4,6,7,8,9,10,11,12,13,14	1,2,3,4,5,6,7,8,9	4,6,7,8,9	V
8	4,6,7,8,9,10,11,12,13,14	1,2,3,4,5,6,7,8,9	4,6,7,8,9	V
9	4,6,7,8,9,10,11,12,13,14	1,2,3,4,5,6,7,8,9	4,6,7,8,9	V
10	10,12,13,14	1,2,3,4,5,6,7,8,9,10	10	IV
11	11,12,13,14	1,2,3,4,5,6,7,8,9,11	11	IV
12	12,13,14	1,2,3,4,5,6,7,8,9,10,11,12	12	III
13	13,14	1,2,3,4,5,6,7,8,9,10,11,12,13	13	II
14	14	1,2,3,4,5,6,7,8,9,10,11,12,13,14	14	I

Figure 1. ***Diagraph Showing Hierarchy Levels and the Contextual Relationship Between Factors***



Step 7. Developing the ISM Model

At this step, the digraph achieved in Step 6 is converted into the ISM model by substituting the factors mentioned in the digraph nodes with statements, as shown in Figure 2.

Step 8. Checking the Conceptual Inconsistency

The model developed in the previous step was shared with focus group members and other experts to check the conceptual inconsistency. Their views accorded well with the obtained results, and the ISM model is finalized, as shown in Figure 2.

Figure 2. ***ISM Model for Enabling Factors of TD***

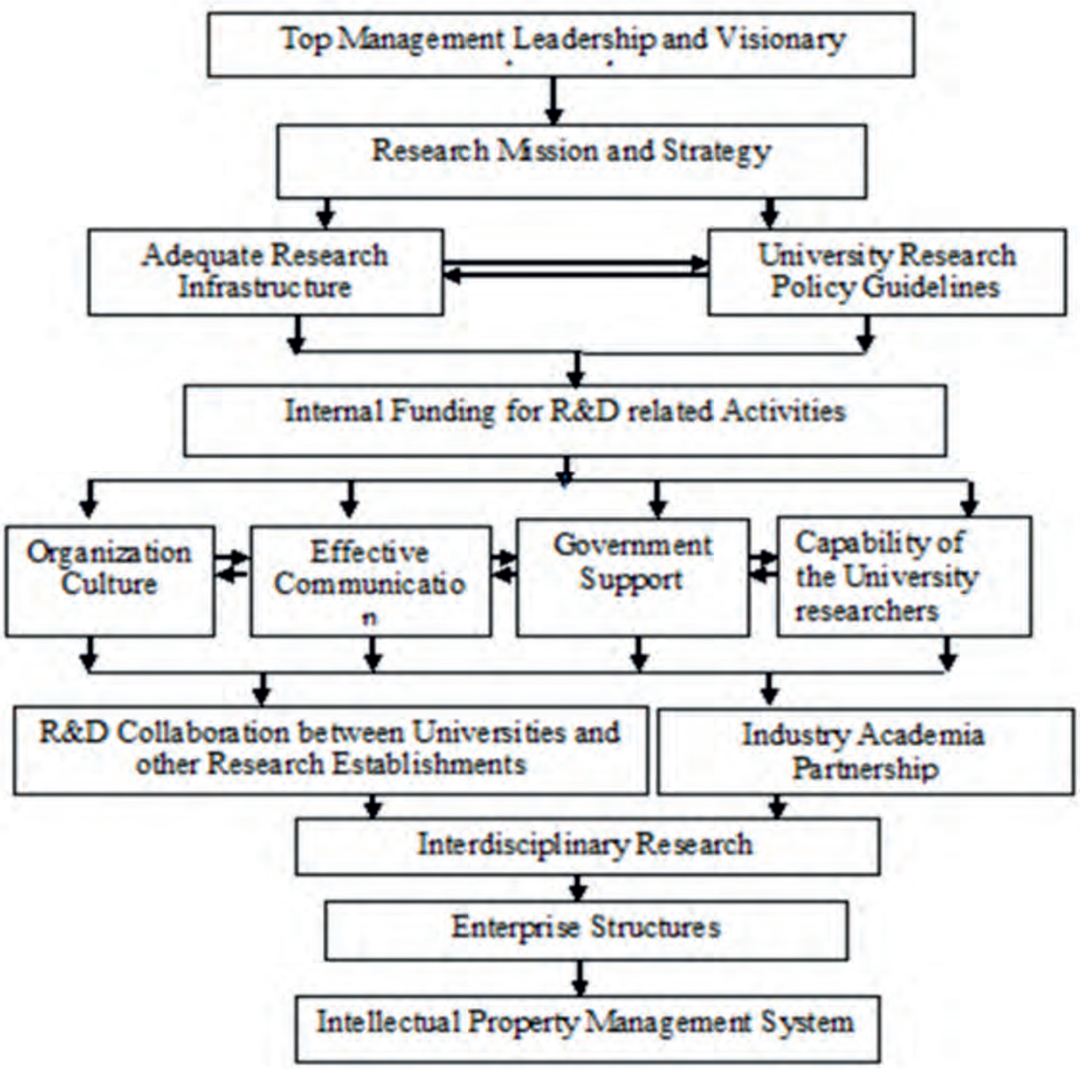
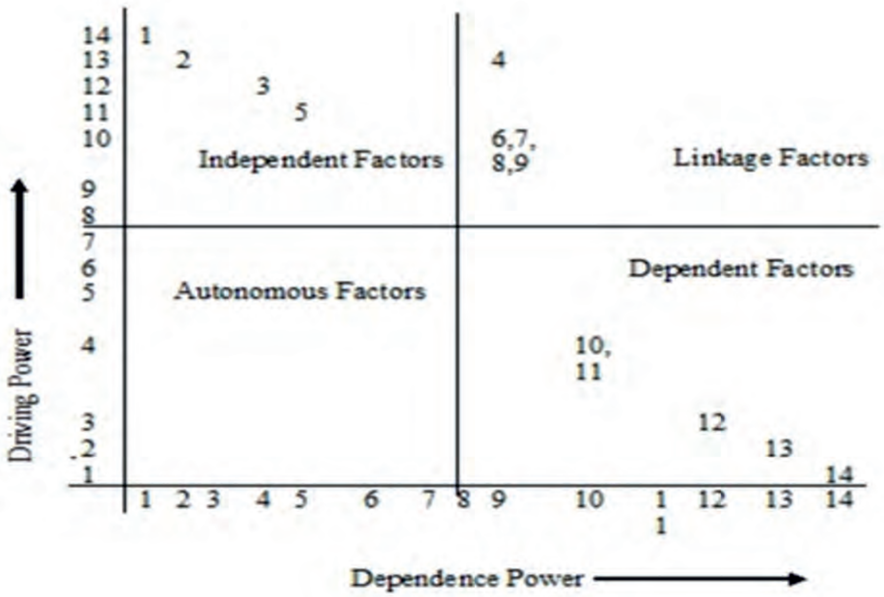


Figure 3. ***Diagram Showing Driving v/s Dependence Power of the Factors***



MICMAC Analysis

Duperrin and Godet introduced the MICMAC Analysis in 1973 for analyzing the direct and indirect relationship among factors achieved through the ISM technique (Garg et al., 2015). MICMAC analysis is important as it thoroughly represents the system under study and decreases complexities for clear understating. The derived simplicity enables the decision-makers to forecast and accomplishes the desired objectives (Saxena & Vrat, 1990). Based on the dependence and driving power, the MICMAC analysis classifies the factors into four categories shown in Figure 3 (Garg et al., 2015 ; Raj et al., 2008).

Discussion

This study is a modest attempt to investigate how the TD process can be efficiently managed to increase the prospects of technology transfer. The study aims to analyze the factors that enable TD in academia and their contextual relationship. In this regard, a model based on ISM has been developed. This study presents a hierarchy of measures to deal with various factors that enable the development of technology for their adoption by the enterprises for further development, bulk production, and commercialization.

The ISM model presents distinct levels of various enabling factors. Level identification is important to clearly understand the enabling factors' implications in the TD process. The ISM model presents a hierarchy of actions to be taken to manage these enablers. It indicates that the intellectual property management system is the lowest level enabler to TD. The third level enabler, that is, interdisciplinary research; the fourth level enablers, that is, industry-academia partnership, R&D collaboration between universities and other research establishments, and fifth-level enablers, that is, organization culture, the capability of the university researchers, government support, and effective communication are the operational level enabling factors which are vital to the development of technologies. A university's research policy may issue the guidelines to obtain internal funds for innovation-related activities and building adequate research infrastructure at the university premises. In this process, adequate research infrastructure at the university and institutional support for research, development, and innovation-related activities is critical. Enabling factor 1, that is, the top management's leadership and visionary approach possess the highest driving power and do not have any dependence, therefore, it appears at the highest level of the ISM hierarchy. This indicates that the top management's leadership and visionary approach toward research, development, and innovation-related activities play a critical role in the development of technology.

Our finding is consistent with the findings of Sohani and Sohani (2012), who identified the top management to be the most important enabler for managing the quality of the higher education system in India. However, Supapawawisit et al. (2018) identified the top management to be the least important factor for research and innovation in Thailand's public universities.

MICMAC analysis identifies the driving and dependence power of the factors. The findings of this study indicate that the factors namely, top management leadership and visionary approach, research mission and strategy, adequate research infrastructure, and internal funding for R&D-related activities are the independent enablers. Independent enablers have very high driving power and extremely weak dependence power (Raj et al., 2008). Therefore, these four enabling factors can be considered as the drivers of TD in academia. The findings indicate that industry-academia partnership, R&D collaboration between universities & other research establishments, interdisciplinary research, enterprise structures, and intellectual property management system are the dependent enabling factors. The dependent enablers have strong dependence power and weak driving power. As they are highly influenced by other enablers of the system, therefore, they must be handled with utmost care. In the present study, no enabler is found to be an autonomous factor. This indicates that the entire 14 enablers contribute significantly to the TD process. Therefore, the university management necessarily gives attention to all the enabling factors. It is further noticed from Figure 3 that organization culture, the capability of the university researchers, government support, effective communication, and the university's research policy guidelines are the linkage to successfully managing the TD process. These enablers require proactive consideration and special attention as they have high driving power as well as are dependent upon other enabling factors of the system. If the organizational culture promotes research, innovation, and TD, the university researchers are capable enough to conduct TD research; if government support in the form of timely funding and suitable policies is available, then a supportive environment, which is extremely essential to TD, can be created. In this, effective communication and university research policy guidelines play a critical role.

Managerial and Theoretical Implications

This study theoretically contributes to the existing literature on research, innovation, and TD practices by providing deep insights into the enabling factors, their interrelationships, and detailing their driving and dependent power. This is the first study that proposes a conceptual framework for enabling factors to efficiently manage the TD process in Indian academic settings using the ISM-MICMAC approach. The insights offered by this study will be valuable for the research and innovation-driven universities in India. From this study, the policymakers, technology developers, and R&D managers in academia can get insights into the relative importance and interdependency of these enabling factors. Accordingly, the policy interventions can be made in combination with other necessary actions.

The findings of this study have brought out some implications for the involved stakeholders whose joint efforts will lead to an efficient TD process in the university system. The results indicate that it is the top management's leadership and visionary approach ; the university's research mission and strategy ; availability of adequate research infrastructure ; and intramural funding to perform research, development, and innovation-related activities that play a key role in the development of technology. Approaches adopted by the top management lead to : (a) a culture of research and innovation, (b) capability building of the university researchers, (c) effective communication for information dissemination, and (d) obtaining government support for R&D and innovation-related activities. It is proposed that systems' top management promote interdisciplinarity and prioritize some of the research areas where the institute can build upon its expertise, establish technological infrastructure, and emerge as a champion by developing industrially and socially relevant technologies.

From this study, the policymakers can draw on several insights. As industry people are driven by timely and quality deliverables, therefore, it is proposed that policymakers need to consider balancing the teaching and administrative workload of the faculty members, particularly those who are involved in industry-oriented research and development activities. This will promote focused research work, which is a prerequisite to TD. The role of institutional policy in enabling TD takes the framework beyond just the experience, skillset, and passion of a researcher who would need an appropriate network and undertake crucial additional work. For the motivation of faculty researchers who enhance the university's research, development, and innovation base by putting extra efforts into TD research, the policy intervention may involve the reward and incentive system.

Another scope for policy intervention is to foster working in a collaborative mode with other research establishments and industry for the development of industry-oriented cutting-edge technologies. This will support evolving research, development, and innovation culture at the university. By working collaboratively, partners can leverage each other's knowledge and resources for developing technology.

The merits of industry-academia collaboration can be seen in this context wherein the university researchers get familiar with the applied and commercial aspects of knowledge, while the industry personnel get opportunities to strengthen linkages with basic research, get accessibility to the university experts, and thus enrich the pathway to joint and speedy technological development. This is in agreement with Wang et al. (2021) who have emphasized the benefits of industry-academia collaboration for improving the firms' innovation performance.

Conclusion

The present study is an attempt to identify the enablers of TD in the Indian university system and to understand their complex relationship. This study provides several key results relevant to research and innovation-driven universities in India. It is interesting to note that no autonomous enabling factor has been found in this study. The analysis result concludes that all the identified enablers are well-linked with the system, therefore, the entire 14 enablers are highly significant and essential to TD in academia. Out of these 14 enabling factors, four are classified under driving factors, that is, key enablers ; five are classified under linkage factors ; and the remaining five are classified under dependent factors. This implies that all the identified enablers affect the TD process to a definite degree. This study also advocates that these enablers should not be treated in isolation as some of them have a feedback effect on themselves.

The findings of this study contribute significantly to the literature on research, innovation, and TD by providing deep insights into the enablers and their complex interrelationship. The study has identified the top management's leadership and visionary approach to be the most significant enablers to TD. This is in agreement with Sohani and Sohani (2012), who identified top managements' critical role to be a key driving enabler and proposed a framework for a quality higher education system in India. However, it is interesting to find that the top management was identified as the least important enabler of research and innovation creation in public universities in Thailand (Supapawawisit et al., 2018).

Moreover, the findings of this study would benefit various stakeholders, primarily university policymakers in decision-making around resource allocation, development initiatives, and the design of a reward system. Generally, most of the technologies in Indian universities remain at the laboratory scale or publication stage. In the absence of effective institutional mechanisms and support systems, they fail to mature further. This negatively influences the rate of technology transfer from academia. Therefore, for the universities that are aiming to accomplish their third mission of outreach responsibility, it is important to focus on the proper development of technologies for enhancing the prospects of their transfer. Academia thus needs to analyze the gaps in their enabling environment and take suitable remedial measures.

Limitations of the Study and Scope for Future Research

The present study involves the application of the ISM - MICMAC approach, which is based on an expert's opinion. Any prejudice by the experts while judging the factors may impact the results. This study will serve as a base for future research. Therefore, empirical studies may be applied to extend the present research work. Besides, the findings of the present study are in the Indian context, therefore, parallel studies may be carried out in the context of other countries.

Authors' Contribution

Under the valuable guidance of Prof. Balvinder Shukla and Dr. Anil Wali, Meenakshi Kanojia conceived the idea and developed a qualitative design to undertake this study. She collected and analyzed the data and wrote this research paper. Prof. Balvinder Shukla and Dr. Anil Wali reviewed the research paper and guided her to upgrade its quality.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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