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Analysis of Factors Influencing Technology Transfer: A Structural Equation Modeling Based Approach

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Abstract: Technology transfer is one of the facets of academic entrepreneurship and acts as a vital element of the innovation system. It forms a sustainable link between research and business communities. A holistic model for successfully transferring technology in developing countries is an unmet need in the context of technology transfer from public-funded academic research institutions to small and medium enterprises. In this work, we developed a conceptual model and undertook an empirical study for the determinants of successful transfer. A questionnaire was prepared and administered to key stakeholders involved in technology transfer. Overall, 321 respondents participated in the survey with congener demography. The conceptualized input factors, viz. micro-level, meso-level, and macro-level factors, are significantly interrelated. The contribution of input factors towards the successful transfer of technology was extensively analyzed and tested using covariance-based structural equation modeling. The results show that the model is a good fit. The study revealed that communication, innovativeness, knowledge, quality of the product, and motivation were the five most important factors for successfully transferring technology.

Keywords: technology transfer; macro-level factors; meso-level factors; micro-level factors; structural equation modeling; public-funded academic research institutions

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1. Introduction

In recent decades, an increasing interest in technology transfer (TT) is seen among policymakers, practitioners, and scholars worldwide [1,2]. It is a long, complicated, and diverse process affected by several forces emanating from multiple stakeholders. The literature postulates the TT process as academic entrepreneurship [3], which is vital for achieving sustainability [4,5]. There is a pressing need to recognize enablers to effective TT so that stakeholders can better understand and support the process [6]. Further, many research and development (R&D) innovations are not exploited or commercialized despite many proactive policy interventions for various reasons [7].

The field of TT has garnered the attention of researchers from a variety of areas, including economics, marketing, history, anthropology, engineering, and political science. The researchers in these fields study the state-of-the-art TT operations, processes, and effectiveness factors [8]. In the previous studies, researchers have investigated the factors affecting TT and proposed several models. The majority of these models developed were international, from multi-national companies to local businesses [6]. Furthermore, there were relatively few models published in the literature that addressed TT from public-funded academic research institutions (ARIs) to industry, and the majority were executed in developed countries [1].

Moreover, the extant literature concentrates on TT from universities to existing businesses. TT from public-funded ARIs to small and medium-sized enterprises (SMEs) has earned little consideration [9]. Universities are not only different from ARIs in terms of

transfer origins [10], but existing companies are also different from SMEs in terms of transfer receivers [11]. Since TT is highly contextual and uncertain, it is vital to acknowledge the factors and develop models adapted to the local circumstances [12].

India aspires to be a $5 trillion economy by 2024–25, and its situation is at a crucial juncture concerning sustainability. The vast population density and rapid pace of growth are the two biggest challenges in the country's approach to sustainability. At the policy level, science, technology, and innovation are used increasingly as a tool to meet sustainable development goals (SDGs) through technology-based startups [13]. The policy changes focus on becoming sustainable technology providers [14]. In this context, TT from public-funded ARIs is crucial as they constitute a significant part of the supply ecosystem in a developing country [15].

The Council of Scientific & Industrial Research (CSIR) and associated Academy of Scientific & Innovative Research (AcSIR) are the largest public-funded ARIs with a pan-India presence [16] working primarily in the areas of green chemistry [17], waste management [18], electrostatic spraying for agricultural and healthcare applications [19], urban mining [20], and recycling [21]. Fu et al. has highlighted that the national environmental innovation systems are vital for sustaining TT [22]. In India, a poor connection between the innovation support system and the production system prevails [23]. SMEs are critical for the nation's economic and innovative progress, especially in new technology domains [24]. Strengthening TT from public-funded ARIs to SMEs is needed, and therefore, the study and conceptualization of factors that impact TT are vital in the Indian and global context [1].

The current literature has revealed several factors impacting TT. The objective of this study was to develop a conceptual model to understand the relationship between the factors affecting successful TT in an Indian public-funded ARIs–SMEs setting. The revelations will contribute to establishing successful TT as the driving force for SMEs. However, when synergized with institutional sustainability, this work will contribute towards the widespread proliferation of both TTs and SMEs.

The organization of the rest of this paper is as follows. First, we present a review of the literature with a specific focus on the factors influencing the success of TT from public-funded ARIs to SMEs. Next, we discuss the procedure adopted in the design of conceptual work and research methodology. Finally, we present the results of data analysis, findings, contributions, implications, and limitations of the work.

2. Literature Review

2.1. Background

The United Nations SDGs have identified TT as a means to promote sustainability [25]. It is an essential pathway for achieving sustainability as new technology is more economically viable, environmentally positive, and has more significant social potential, focusing on developing countries [26]. In developing countries, the successful transfer of appropriate technologies is integral for economic and social development, and enhances sustainability [27]. However, the buzz has been around the international TT from developed to developing countries. The success of these practices depends on a host of issues in the receiving country, and it requires a balanced approach [28]. Possession of domestic technology capabilities can lead to broad-based sustainable development and innovation [29].

Wang developed a TT model from the technology receiver's perspective in China [30]. The focus of the model was on mechanisms involved in transfer between universities and enterprises. Heather et al. developed an innovative TT model in the Addiction Technology Transfer Center (ATTC) network [31], highlighting the need for creative innovation capabilities in developing countries.

Nazanin et al. developed a model for the commercialization of R&D outcomes [32] and identified 31 factors affecting the commercialization of research outcomes. The model has an excellent conceptual framework and considered the phases of TT. Albats et al. have analyzed the impact of key performance indicators (KPI) on the university–industry collaboration (UIC) lifecycle at the micro-level on collaborative projects in Finland and

Russia. The model identified several micro-level KPIs across the UIC lifecycle for the R&D laboratory [33].

Chehrehpak et al. determined the factors influencing TT using an empirical study in a large public petroleum company [34]. The study developed a model using SEM. The factors considered in the study were law and policy, capabilities, human resources, technology localization, technology traits, and cooperation among industries. The results of the empirical analysis showed that all the factors except cooperation among industries have a positive influence on the outcome of TT.

Cunningham and O'Reilly explored the conception of TT activities in the last few decades and deduced that macro perspectives study has significant prominence recently. The authors stressed the need and significance of micro and meso factors in TT [35]. Lee et al. proposed a prediction model for TT, which help to identify the research opportunities, and used it as a strategic tool for tapping the innovation opportunities by industry in line with societal needs [36].

2.2. Factors Affecting Technology Transfer

Communication and knowledge have been found essential for the success of technology transference [37]. The motivation of faculty for involvement in transfer activities is the determinant for an increase in licensing activity [38]. Investment of time in an informal interaction with the industry positively affects the research collaboration [39]. Thomas et al. highlighted the role and importance of individual actors in academic entrepreneurship as enablers for the lab to market journey [40]. Team competency and motivation have vital influences on the absorption of technology in an innovation alliance [41].

Research and market-oriented technology transfer office (TTO) have a positive impact on the licensing activity [42]. Incubators have significance for new product development and economic growth [43]. Knowledge of the licensor about the technology source within the transferor positively impacts the technology licensing [44]. Reis et al. identified management support as a vital factor [45], and lack of it can act as an inhibitor for researchers to engage in TT [46]. Appropriate training is essential for the adsorption of technology in the industry [47].

TT has a positive impact on the quality and quantity of the research [48] and society [49], and vice-versa [50]. The quality of work in public institutions influence entrepreneurship, innovativeness, and competitiveness [51]. Research and innovation are the critical drivers for the economic development of industry and nation [52]. Innovativeness is a prerequisite for academic entrepreneurship, which leads to research opportunities [53]. Proactive policies and acts result in improved transfer efficiency [54]. Return on investment from research and development has a long gestation period and requires consistent policy support [55]. Technology licensing modes are being explored on formal and informal lines, thinking beyond the traditional linear ways for a more significant impact on TT [56]. Financial support instruments help come up with investment-ready products, thereby leading to potent TT [57]. In the quintuple helix paradigm, Carayannis et al. identified societal impacts as drivers for technology generation and adoption [58].

Globally, the success of TT has been examined exhaustively on various parameters viz. diffusion, commercial, political, environmental benefits, replacement benefits, human resources, and economics, etc. [2]. However, special attention has been garnered by public value recently [1,59], thereby considering the entire realm of sustainability. As for the public impact, the literature highlights the need for studies assessing the overlap of levels of analysis from micro to macro and their effect on commercialization [60]. A successful TT requires collaborative efforts by several stakeholders to accomplish complicated and challenging tasks from a knowledge perspective. It involves implementing the whole process of imaging, incubating, representing, marketing, and sustaining a technology [7], which comes under institutional sustainability.

The foregoing literature review details the factors influencing the successful TT from public-funded ARIs to SMEs. We undertook the study of models to establish the causal

relationship among factors. An analysis of the existing models in the literature shows that the majority were either conceptual or theoretical models, and most of them were not tested empirically and validated. Additionally, most of the existing models have focused on a single dimension or a few factors in TT. Further, the perspectives of technology receivers need to be studied empirically [61,62].

A prominent viewpoint emerging from the review is that Western countries have been at the forefront of technology development, research, and commercialization of new technologies. India has started embracing the process quickly and is evolving with its innovation capability [63]. The process of TT from public-funded ARIs has not been modeled adequately in the past studies except [6]. We propose to assess the relative influence of each of the identified factors on the successful transfer of technology in a proposed holistic model.

2.3. Conceptual Model

We developed a conceptual model for TT using the three input factors and one output factor from public-funded ARIs to the SMEs, as shown in Figure 1. The model pictorially depicts the relationships among factors affecting TT and success as the output factor. The basis of conceptualization are the insights and knowledge from the literature about the TT process from public-funded ARIs to SMEs.

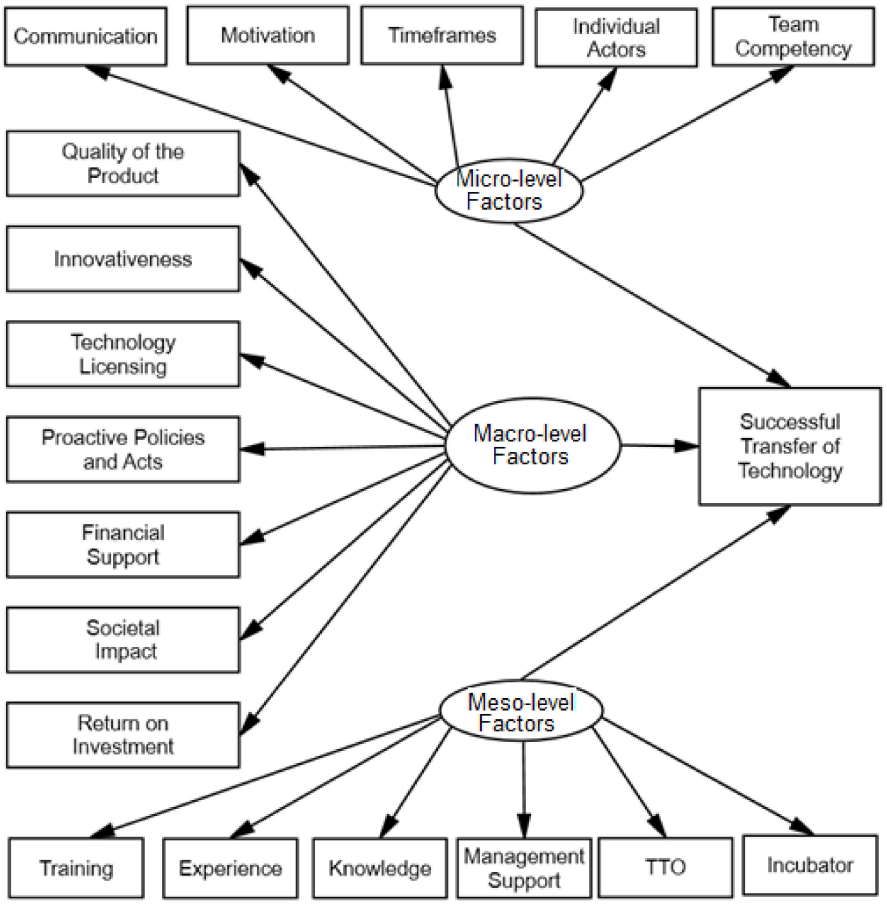


Figure 1. A conceptual model for successful TT from public-funded ARIs to SMEs.

We identified 43 items and used them to measure the 18 variables that are likely to impact the success of TT from public-funded ARIs to SMEs. These 18 variables were grouped hypothetically into three input factors: macro-level, meso-level, and micro-level factors. The model has one output factor: successful transfer of technology, measured using four variables. We tested the model using a set of hypotheses.

In the proposed model, micro-level factors focus on the mechanisms, actors and their role in TT, the role of TTO, cultural differences, motivations, communications, time allocations, and barriers to effective collaborations. Five variables have been considered to measure the micro-level factors: communication [64], motivation [38], timeframes [39], individual actors [65,66], and team competency [41]. We propose the following hypothesis:

H1: *Micro-level factors significantly influence the successful transfer of technology from public-funded ARIs to SMEs.*

The meso-level factors focus on supporting institution's roles, behaviors, and actions of supporting actors. Six variables have been identified to measure the meso-level factors, namely, TTO [67,68], incubators [69], management support [50,70,71], knowledge [44], experience [72], and training [47]. We propose the following hypothesis:

H2: *Meso-level factors significantly influence the successful transfer of technology from public-funded ARIs to SMEs.*

The macro-level factors focus on mechanisms of TT and methods, measurement, evaluation, and effectiveness of TT, and policy initiatives designed to support effective TT at various horizontal and vertical agglomeration levels. Seven variables considered to measure the macro-level factors are quality of the product [50], innovativeness [53], technology licensing [56], proactive policies and acts [54], financial support [57], societal impact [58], and return on investment [55]. We propose the following hypothesis:

H3: *Macro-level factors significantly influence the successful transfer of technology from public-funded ARIs to SMEs.*

Further, we analyzed the demographic variables, which reflect the respondent's profile and operating environment, viz. gender, age, educational qualification, experience in R&D projects, total experience, and designation.

3. Materials and Methods

The present study uses an explorative research design [73] wherein we collected the primary data using a questionnaire administered to the study participants. The questionnaire was designed based on the relevant hypotheses. The study adopted a cross-sectional survey design approach [74], an observational research method involving data collection from a population/sample at one specific point in time.

The focus of the sampling design was to identify those respondents who have experience and exposure to TT and related activities in the public-funded ARI–SMEs setting. Hence, we have used the purposive sampling design [75] as it was considered appropriate for such a study.

To ensure the validity of the survey instrument before the main study, the experts from public-funded ARI and academia vetted the questionnaire clarity, consistency, and redundancy. The target sample (approx. 1000) from the population (approx. 4500) consisted of scientists, industrial personnel, R&D engineers, and professionals involved in technology development and transfer activities in public-funded ARIs. The data collection was conducted from October 2020 to December 2020 through an online survey, distributed through emails, and followed up telephonically.

The survey instrument included five sections. The first section collected data related to the personal and organizational information of the respondents of the study. The data points in this section included gender, age, educational qualification, experience in R&D, total experience, and designation. The second section focused on the micro-level factors, measuring the influence of five elements in TT viz. communication, motivation, timeframes, individual actors, and team competency. The third section focused on the meso-level factors, measuring the influence of six elements in TT viz. roles of TTO, incubators and accelerators, management support, knowledge, experience, and training. The fourth section focused on the macro-level factors, measuring the influence of seven elements in TT viz. quality of the product, innovativeness, technology licensing, proactive policies and acts, financial

support, societal impact, and return on investment. The final section focuses on the items that measure the successful transfer of technology.

4. Data Analysis and Validation

SPSS 25.0 software package was used for statistical data analysis in this study to analyze the data collected from the respondents. Further, we used AMOS 26.0 software package for SEM and hypothesis testing.

4.1. Demographic Analysis

Overall, 321 respondents participated in the study, representing all the 38 laboratories of CSIR. Table 1 shows the demographic characteristics of the respondents of the survey.

Table 1. Demographic profile.

Variable	Category	Frequency	Percentage
Gender	Male	273	85.0
	Female	48	15.0
Age (years)	Up to 30	6	1.9
	31–40	112	34.9
	41–50	124	38.6
	Above 50	79	24.6
Educational qualification	Graduate	29	9.0
	Post-Graduate	111	34.6
	Doctorate	181	56.4
Experience in R&D projects	Up to 5 years	37	11.5
	5–10 years	79	24.6
	Above 10 years	205	63.9
Total experience	Up to 5 years	11	3.5
	5–10 years	65	20.2
	Above 10 years	245	76.3
Designation/ Position	Junior Practitioners	4	1.2
	Mid-Level Practitioners	258	80.4
	Top-Level Practitioners	59	18.4

The study primarily needed depth of information on the projects involving TT from public-funded ARIs to SMEs. The study involved respondents with vast experience in the field as they have a deeper understanding of the research problem.

To ensure the sample integrity, we performed an independent sample *t*-test and one-way ANOVA. It confirmed that respondents of different genders, ages, qualification, experience, and designation could be considered as a single sample [76]. At a 0.05 level of significance, the statistical analysis confirmed the validity of the demographic variables.

4.2. Descriptive Statistical Analysis

The descriptive statistical measures were computed for micro-level factors, meso-level factors, macro-level factors, and successful transfer of technology, as shown in Table 2.

From Table 2, it is clear that the top-rated factor impacting the successful transfer of technology is communication (M = 4.64, SD = 0.39) between transferor and receiver. The next highly-rated factor is innovativeness (M = 4.47, SD = 0.6). Knowledge (M = 4.34, SD = 0.52) and quality of the product (M = 4.31, SD = 0.58) are subsequent rated factors. Motivation was the fifth top-rated factor (M = 4.27, SD = 0.62). The least rated factors are experience (M = 3.69, SD = 0.86), and technology licensing (M = 3.82, SD = 0.69). The descriptive analysis also shows that micro-level factors are the predominant (M = 4.16, SD = 0.48) when compared with meso-level factors (M = 4.08, SD = 0.46) and macro-level factors (M = 4.05, SD = 0.44).

Table 2. Descriptive statistics (n = 321).

Variable	Mean	SD	Skewness	Kurtosis
Communication	4.64	0.39	−1.07	1.36
Motivation	4.27	0.62	−0.42	−0.64
Timeframes	3.84	0.82	−0.48	−0.19
Individual actors	3.88	0.52	−0.25	0.47
Team competency	4.21	0.58	−0.59	0.20
Micro-level factors	4.16	0.48	−0.48	0.56
Training	4.12	0.54	−0.43	0.37
Experience	3.69	0.86	−0.36	−0.56
Knowledge	4.34	0.52	−0.44	−0.66
Management support	3.88	0.90	−1.12	0.33
TTO	4.14	0.65	−0.45	0.18
Incubator	4.17	0.70	−0.64	0.59
Meso-level factors	4.08	0.46	−0.76	0.28
Quality of the product	4.31	0.58	−0.59	0.18
Innovativeness	4.47	0.60	−0.85	0.18
Technology licensing	3.82	0.69	−0.24	−0.55
Proactive policies and acts	4.03	0.69	−0.47	−0.61
Financial support	3.86	0.59	−0.41	0.48
Societal impact	3.93	0.61	−0.41	−0.17
Return on investment	3.96	0.61	−0.46	0.90
Macro-level factors	4.05	0.44	−0.14	−0.50
Successful transfer of technology	4.12	0.52	−0.92	3.78

4.3. Reliability Analysis

The Cronbach's alpha coefficient is the most common reliability analysis measure to assess the instrument's internal consistency [77]. If the Cronbach's alpha value of the items/factor is greater than 0.7, the tool is considered reliable in measuring the underlying construct [78]. The results of the reliability analysis of the elements of the study are as shown in Table 3. All these scales demonstrate acceptable reliability.

Table 3. Reliability analysis.

Variable	No. of Items	Cronbach's Alpha
Micro-level factors	13	0.852
Meso-level factors	12	0.812
Macro-level factors	18	0.840
Successful transfer of technology	4	0.740

4.4. Correlation Analysis

The relationship between variables of the study is analyzed using correlation analysis. The value of the correlation coefficient (R) can vary from 0 to 1, and the higher value of R is considered better in depicting the correlation between the variables. Table 4 shows the correlation between the input variables like micro-level factors, meso-level factors, macro-level factors, and output variable successful transfer of technology. The p-value represents the significance of the level of correlation.

From Table 4, we observed a significant correlation between input factors and the successful transfer of technology at a 0.01 level of significance. Additionally, we found that the micro-level, meso-level, and macro-level factors were significantly interrelated. The following section tested the SEM model to find the strength of the relationship between the input variables (micro-level factors, meso-level factors, and macro-level factors) and the outcome variable (successful transfer of technology).

Table 4. Pearson correlation analysis (n = 321).

Variable	Micro-Level Factors	Meso-Level Factors	Macro-Level Factors	Successful Transfer of Technology
Micro-level factors	1			
Meso-level factors	0.562 ** (0.000)	1		
Macro-level factors	0.482 ** (0.000)	0.604 ** 0.000	1	
Successful transfer of technology	0.561 ** (0.000)	0.615 ** 0.000	0.538 ** 0.000	1

** Correlation is significant at the 0.01 level (2-tailed).

4.5. Testing of Hypotheses

The SEM model of the hypothesized model (standardized estimates) is as shown in Figure 2 below.

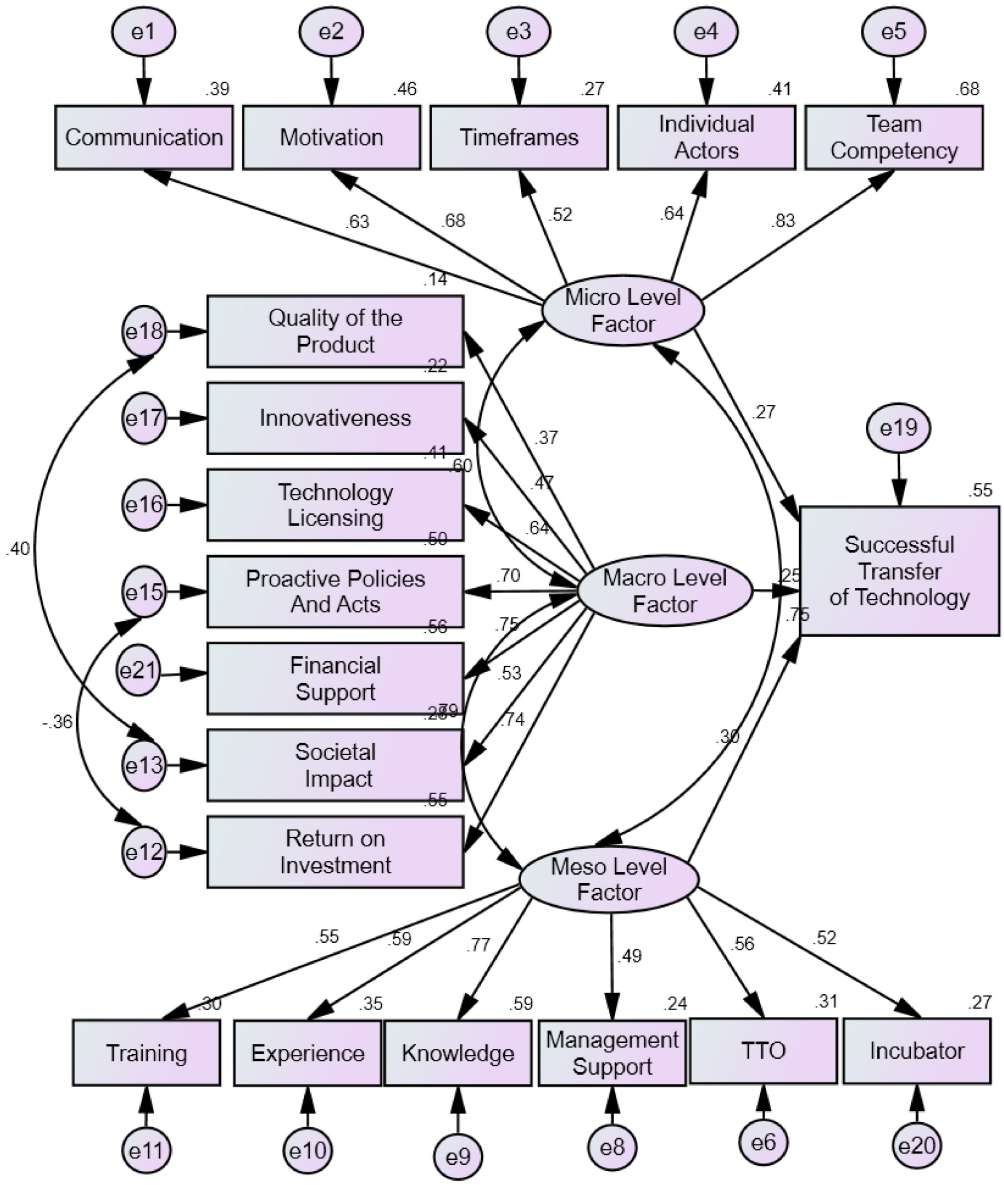


Figure 2. SEM model of the hypothesized model (standardized estimates).

The standardized regression estimates of the variables in the model are as shown in Table 5.

Table 5. Standardized regression estimates.

Outcome Variable	Predictor Variable	Estimate	SE	*p*
Communication	Micro-level factors	0.628		
Motivation	Micro-level factors	0.681	0.15	***
Timeframe	Micro-level factors	0.521	0.17	***
Individual actors	Micro-level factors	0.641	0.12	***
Team competency	Micro-level factors	0.827	0.16	***
Training	Meso-level factors	0.547	0.12	***
Experience	Meso-level factors	0.592	0.17	***
Knowledge	Meso-level factors	0.767	0.13	***
Management support	Meso-level factors	0.491	0.17	***
TTO	Meso-level factors	0.561	0.14	***
Incubators	Meso-level factors	0.517		
Quality of the product	Macro-level factors	0.371	0.08	***
Innovativeness	Macro-level factors	0.473	0.09	***
Technology licensing	Macro-level factors	0.641	0.09	***
Proactive policies and acts	Macro-level factors	0.704	0.11	***
Financial support	Macro-level factors	0.749	0.08	***
Societal impact	Macro-level factors	0.531	0.08	***
Return on investment	Macro-level factors	0.74		
Successful transfer of technology	Micro-level factors	0.272	0.14	0.00
Successful transfer of technology	Meso-level factors	0.305	0.19	0.02
Successful transfer of technology	Macro-level factors	0.246	0.11	0.01

*** $p < 0.01$.

The goodness of fit values shown in Table 6 specifies how well the models fit the observations. From the table, it is evident that the measured values conform to the recommended values. Overall values for model fit indices and measures obtained in the study are at an acceptable level. Therefore, we conclude that the SEM model is fit.

Table 6. The goodness of fit indices.

Indices	Suggested Value [Ref.]	Obtained Value
Chi-square value	-	484.234
DF	-	145
Chi-square value/DF (CMIN)	<5.00 [79]	3.340
GFI	>0.90 [80]	0.946
AGFI	>0.90 [79]	0.901
NFI	>0.90 [80]	0.922
CFI	>0.90 [81]	0.924
RMR	<0.08 [79]	0.030
RMSEA	<0.09 [79]	0.086

We tested the H1, H2, and H3 using the path analysis from the SEM model (Table 5). The relationship between the input variables and output variable in the SEM model was analyzed using path coefficients/standardized estimates and path significance. Path analysis brings out meaningful connections between the latent factors or constructs of the model.

H1: *Micro-level factors significantly influence the successful transfer of technology from public-funded ARIs to SMEs.*

The results of the analysis of regression coefficients of the SEM model (Table 5) clarify that micro-level factors have a significant impact (R = 0.272) on the successful transfer of

technology. The level of significance was 0.01 ($p < 0.01$). Thus, hypothesis H1 was accepted as the p-value is less than 0.05.

H2: *Meso-level factors significantly influence the successful transfer of technology from public-funded ARIs to SMEs.*

From the analysis of regression coefficients of the SEM model (Table 5), it is clear that meso-level factors have a significant impact (R = 0.305) on the successful transfer of technology. The level of significance was 0.05 ($p < 0.05$). Thus, hypothesis H2 was accepted as the p-value is less than 0.05.

H3: *Macro-level factors significantly influence the successful transfer of technology from public-funded ARIs to SMEs.*

From the analysis of regression coefficients of the SEM model (Table 5), it is clear that macro-level factors have a significant impact (R = 0.246) on the successful transfer of technology. The level of significance was 0.01 ($p < 0.05$). Thus, hypothesis H3 was accepted as the p-value is less than 0.05.

5. Discussion

5.1. Theoretical Implications

Bozeman et al. discussed the weak links between transferors with demand and channels [2], which continue to exist [1]. So, it is pertinent to identify and model the factors which impact the successful transfer of technology. In this context, the developed TT model is relevant for public-funded ARIs, those pursuing TT from these institutions, funding bodies, and government agencies aiming to utilize public R&D investments to achieve socio-economic growth.

The model has revealed some profound implications for the government and public-funded ARIs in achieving efficient technology transfer and increasing the pace of TT. If the factors identified and validated in the conceptual model are managed and handled appropriately in TT projects, they could lead to fruitful results.

The successful transfer and adoption of technology [82] have multifold implications for SMEs [83] and the innovation ecosystem [84]. It not only leads to new product development (NPD), improving the business performance of the SMEs [85] but also inculcates innovation culture leading to social gain [86] and corporate sustainability [87]. The absorption capacity of the SMEs, which is critical to the success of NPD [88], is improved, which enables them to attract further investment [89]. Further, with the endowment funding [90] available for sustainable technology development, proximity can lead to further collaboration, technology development, and even reverse TT [91]. Thus, as postulated, successful transfer of technology from ARIs seems to be a key enabler for sustainable technologies and can be further explored empirically in other structural settings.

5.2. Managerial Implications

It is crucial for any successful transfer of technology to open the dialog between the scientists and the receiver. The business development groups in public-funded ARIs need to facilitate this. The motivation level of the individual actors is vital as the technology commercialization process has bottlenecks and overcoming them to lead to success depends on these actors. The communication process creates an environment for friendly technical and business discussions, leading to lesser conflicts and goal achievement. Meeting the timelines is vital as the opportunity created in the market for the technology may vanish with delay. Moreover, the team should be competent to implement the commercialization successfully. These aspects are complementary and support innovation.

The meso-level factors that reflect the individual actor's ecosystem play an equally important role in successfully transferring technology. The training [92] given via webinars or workshops, the funding of the projects to build the capability and the knowledge base, and the management support is vital to boost the confidence of the scientists. Moreover,

the TTO's role is essential to deal with the financial negotiations, match-making with the firm, and deal with the write-offs.

Finally, the macro factors are also crucial. The quality of the product decides its fate in the market. The certifications, proper testing, and customer acceptance are the key to enhancing the quality. The innovativeness of the product leads to increased market share for the firm and thus overcomes competition leading to business growth. The national policies and acts in different sectors create an environment for commercialization. They can also lead to an increase in demand. In addition, regulatory support is critical for achieving economies of scale in green technologies. The financial support given to the firms, especially for startups, can go a long way in deciding the product's success from lab to the market, considering the societal and environmental impacts of the technology is vital for the countries to meet the SDGs as part of international commitments. The societal implications of the technologies help in prioritizing the activities around its commercialization process by the government. The gestation period for return from technology can be very long, especially in environmentally friendly technologies, and can also be considered holistically [1,93].

6. Limitations

Although we have put in our best effort to structure the research to be comprehensive, it is not without limitations. One of the limitations of this method of analysis is related to self-selection bias. People who are already interested in the topic of the study are more likely to respond to this sort of survey, resulting in bias.

Since the present study is exploratory and transversal, it is challenging to define causal relationships among the variables in the model. As a result, we recommend that future studies perform longitudinal analysis to validate these causal relationships.

Similarly, this study used data collected from the respondents, which are perceptual. Perceptual data may have skewed appeal to specific stakeholders in the absence of objective data to equate. Finally, since a geographical framework constrains the population, deviations may be observed while extrapolating the findings to other settings.

7. Conclusions

The demographic variables of the study are congeners, and the descriptive statistical analysis highlighted the importance of micro-level factors. We observed communication, innovativeness, knowledge, quality of the product, and motivation to be the five most important factors. On the other hand, experience and technology licensing are the least important factors. The motivation for engagement of researchers with the industry [49] and shortened technology lifecycle [94] typically support such findings.

The results of SEM analysis show a significant relationship between the three model factors and the outcome factor. We used standardized estimates of the SEM model to test the hypotheses. We infer that the three input factors significantly impact the successful transfer of technology with a 0.05 level of significance. The outcomes validated the conceptual model and identified variables for considering the successful transfer of technology from public-funded ARIs to SMEs.

TT is a multi-faceted phenomenon that depends on a host of equally critical interrelated mechanisms. The interrelationships between conceptualized micro-level, meso-level, and macro-level factors are positive using correlation analysis at the 0.01 level of significance.

A contribution of this work is in the timing of this empirical study. We observe the strengthening of communication between the transferor and receiver with the addition of frequent virtual channels. The current pandemic seems to have ignited the prevalence of virtual communication, not observed in [95]. Ivarsson et al. identify regional proximity as positive for technology absorption and innovation [96]. Whether virtual channels lead to intellectual proximity, and if this acts as a substitute to regional proximity for tacit knowledge, needs to be explored in future studies.

In the context of SMEs, literature depicts the linkage of economic performance with the sustainability of the enterprises [87,97]. An interesting perspective for future studies could be to downstream these findings and contextualize the sustainability of ARIs with the economic performance of SMEs being moderated by various control variables and determine the causality. This linkage would enrich the literature by extending the sustainability of technologies and ARIs and their impact on SMEs. A potential productive area for investigation could be the design of an experimental study to evaluate the performance of a transferred technology in terms of its socio-economic impacts on the key stakeholders.

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