TRIANGULAR ECOLOGY OF ACADEMIA, ENTERPRISES AND PROS FOR IT & HIGH-TEC INNOVATIONS

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Abstract

This research article aspires to introduce a new way of collaborations to enhance partnership for rapid breakthroughs for information technology (IT) market. This pioneer research contribution has introduced Research and Development Triangulated Ecosystem (R&DTES) among three vertices called as University, Industry and Public Research Organizations (PROs). The two vertices namely the academia and industry are quite prevalent in literature but the third complimentary vertex called as the public research organization (PROs), has been brought in to the research domain to form an equilateral triangle of innovations and collaborations. PROs are state funded research organizations doing research and development for national defense projects. Due to their restricted nature of projects, most of research outcomes of PROs are not accessible. Inclusion of PROs with firms and faculty for joint R&D ventures has developed win-win ecosystem in the form of R&D-TES, where all the collaborators have been posited on the winning stand. This research contribution highlights the design, structure and significance of R&DTES. Theoretical and practical entailments of R&DTES have been evaluated by R&D professionals and project managers doing R&D projects in various domains from three sectors. A research instrument has been employed to know the perception of respondents from IT industry, academia and PROs, regarding R&D-TES. This Empirical study has been conducted in China and has come up with the verdict that R&D-TES provides an optimal R&D environment. Factors for R&D-TES have been listed down and evaluated by respondents. Empirical results of this research have proved R&D-TES as a house of rapid innovation due to optimized R&D cost and efforts for rapid innovations in IT market. This research article has also proved that R&D-TES provides best platform for selection of new partners due to same competitive advantages.

Keywords- R&D Triangulated Ecosystem; R&D collaborations; IT, High-tech Innovations; Partners' selection; Knowledge sharing

1 INTRODUCTION

This research foresees an idea of a triangulated ecosystem in which universities, industry and PROs collectively make efforts for collaborative R&D projects. After the Second World-War, R&D collaborations have gained many attentions due to fast developments and increased complexities in the field of aeronautics, astronautics and construction. During last few decades, policy makers have emphasized on R&D collaborations and more research has been conducted in this field. Different authors have given different reasons to make alliances. Partner's technological capabilities [1], exploiting opportunities by high technology firms [2] and capacities of small and medium firms [3] are factors which induced the business magnates to establish R&D alliances. More necessary conditions which force firms to establish R&D collaboration have been listed by Angel [4]. Diminishing marginal returns have been indorsed by the business tycoons. They are agreed to enhance the R&D budgets for promoting R&D culture [5, 6] which lead to R&D collaborations for joint R&D project executions. Similar argument also has been given by Guo on the basis of research consequences of her empirical studies [7]. Sharing of external knowledge [5, 8, 9, 10], sharing of technological competencies [11, 12], attaining innovative advantages [13] and overcoming technological complexities [6] are other stimulating factors to establish collaboration for articulated R&D projects. Above mentioned benefits triggered the business tycoons and academicians to posit in R&D clusters (R&D Ecology) which are more densely populated by other innovative firms with the same domains for innovative incentives [14].

Ever-growing technological innovations in the field of IT and high-tech industry have shortened the life span of new developments. These challenges can be met with fast exploitations for new discoveries to get competitive advantages. This scenario pushed the entrepreneurs and corporate moguls towards more complex environments where they need to find partners equipped with latest technology for IT and high-tech innovations. Considering the importance of R&D collaborations for high-tech innovations, author has proposed R&D triangulated ecosystem with its species as academia, private industry and PROs.

Ecosystems are dynamics, evolving, responding to natural disturbance and reacting to the competition among species. So survival of any ecosystem is necessary for the survival of its organisms and it may be attained by reacting to external changes [15] Different ecosystems; Industrial Ecosystem, Economy as an Ecosystem, Digital Business Ecosystem and Business Ecosystem have been described in the literature and all these concepts varies depending upon the nature of business to-business relationships. This study has proposed R&D triangulated ecosystem (R&D-TES) that is an analogy of business ecosystem where taxonomic group of this ecosystem are universities, industry and PROs. R&D-TES with combination of these three major research sectors, can enhance the pace of neo-discoveries by sharing technological knowledge, selecting appropriate partners and establishing trust due to with common goals. Proposed R&DTES with three vertices as universities, industry and PROs has been shown in figure 1.

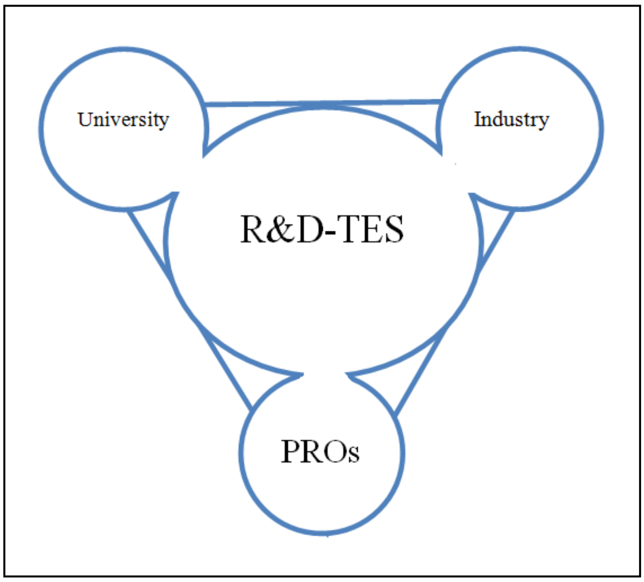

Fig-1: R&D Triangulated ecosystem

Such R&D ecologies provide chances for more interactions among the partners with diversified culture and research environment. R&D-TES is based on following taxonomic groups,

A. University:

The universities offering degrees in graduate and post graduate studies with research background have been included. Most of these universities are already engaged with R&D collaboration for mega projects

B. Industry:

The research covers information technology (IT), communication, aeronautics, mechanical, electronics and construction industries, doing R&D project for neo-ventures.

C. PROs:

Public Research Organizations are research institutes funded by state for National Defense Projects (NDP). Restricted nature of data has triggered these organizations away from public-loom. This research is an effort to motivate PROs to share research endeavors with academia and industry for capturing commercial incentives as well.

This research article has delved into the R&D collaboration insights and has explored its historical relation to existing research accomplishments. Significance of R&D-TES has been explained in second part of this paper. Research approach has constituted the third part and findings have been discussed in fourth section of this research article. Data analysis and interpretations have comprised fifth part. Article has been concluded with recommendations based on analysis and results.

2. R&D-TES SIGNIFICANCE

R&D-TES has been highly appreciated by research participants due to following connotations,

- Inclusion of public research institutes with university-Industry collaborations to enhance the band of R&D professionals and researchers. Triple helix model [16], R&D collaborations [17], R&D clusters [18] and digital business ecosystems [19] have already been discussed in literature to emphasize R&D collaborations, but none of the researcher had intentions to highlight the importance of PROs and their combination with academe and industry for new discoveries through establishing R&D ecologies.
- University-Industry collaboration is already in practice, but still there is gap for rapid innovation. PROs have been proved to be proactive partner for this ecosystem to fill this gap.
- R&D triangulated ecosystem is helpful for the researchers and practitioners for technological advantages and innovations by exchanging information.
- This study has listed down the important factors of R&D Collaboration and these factors have been quantified for evaluation of R&D-TES.

Figure 1.3 highlights the significances of this proposed system.

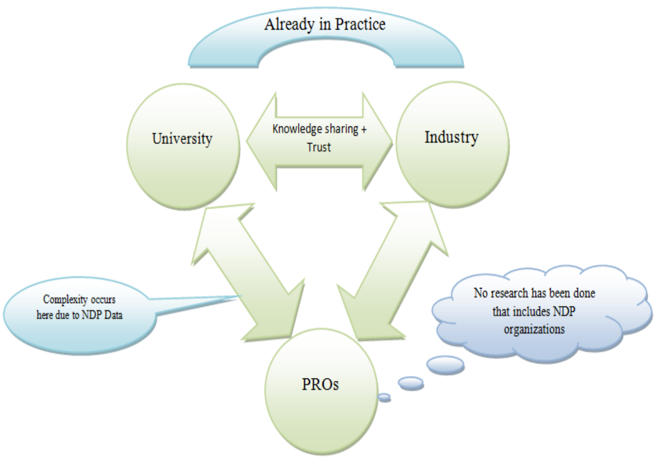

Figure 2 : Research significance

Conceptual layout for this research article and design of R&D-TES motivated the author to evaluate this R&D collaboration model with R&D professionals from IT and High-Tech industry. Main emphasis of this ecosystem is to hunt new partners for joint ventures in optimized articulated R&D environment where neo-innovations are the dire need of IT and high-tech market. Following hypotheses have been designed in this study,

Hypotheses

H1. R&D-TES provides an optimal articulated R&D culture

H2. R&D-TES leads to IT and high-tech innovations

H3. R&D-TES provides maximum chances to select best partner for neo-ventures

H4. Knowledge sharing is maximum among partners through R&D-TES to overcome technological complexities

3. RESEARCH METHODOLOGY

An empirical research has been performed to examine the perception of the researchers and practitioners doing R&D projects. Hypothetico-deductive approach is used for this purpose. In this approach, a hypothetical model is designed which is based on observations. This model is tested based on the consequences using deductive method. According to researchers [20, 21], the Hypothetico-deductive approach is used for a study where one or more hypothetical assumptions are to be tested for theory formulation and a phenomenon is to be explained. Research instrument was designed on the bases of various practices related with the R&D collaboration. A Research questionnaire with the same elements was constructed and filled by the researchers at Chinese universities, industries and PROs. Responses were scaled on 5-likert scale. Research questionnaire has two parts: initial part explored the demographic information of the respondents. Next datasets have been used to find the attributes of R&D-TES including different variables. These variables have been constructed on the base of literature review and interviews form interviewees from three sectors. 95 academic researchers, R&D practitioners and project managers have been selected from universities, industries and PROs, with the R&D project backgrounds. Details of respondent have been given in table 1. Hypotheses have been analyzed with 31 items and 5 variables. Snow-bowl sampling technique was used for this study which is non-probabilistic sampling method. Research sample is considered acceptable as this research sample is more than the number of variables.

Table 1: Summary of respondents' Frequency

	Online Sent	**Online Received**	**Online %**	**Face to Face**	**Face to Face Received**	**Face to Face %**	**Total Sent**	**Total Received**	**Response %age**	**Rejected**	**Total**
University	45	9	20	51	28	55	96	37	39	5	32
Industry	33	11	33	49	25	51	82	36	44	7	29
PROs	21	13	62	87	27	31	108	40	37	6	34
Total	99	33	33	187	80	43	286	113	40	18	95
Total	99	33	33	187	80	43	286	113	40	18	95

3.1. Data Characteristics

Participants have been targeted from public and privates universities, IT and high-tech industry and PROs from six disciplines as Information Technology, Aerospace, Mechanical, Communication, Construction and Electronics. Figure 3 has clearly depicted the sector-wise analysis of respondents. Public sector universities and PROs constituted major portion of the sample while on the contrary, industry has been prominent in private sector. Respondents' primary industry has been depicted in figure 4. Peak of the bar of university sector in aeronautics discipline has gained highest apex. Reason is the availability of researchers in this discipline, doing projects with firms and PROs at Northwestern Polytechnical University (NPU). Respondents were easy to solicit the responses.

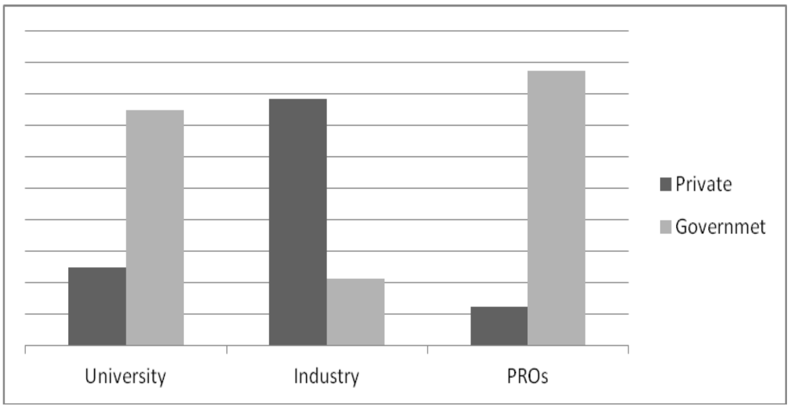

Fig 3: Sector-wise analysis of respondents

Most of the respondents from PROs have reported their primary sector as communication, aeronautics, electronics IT and mechanical where communication bar is highest and bar for mechanical is lowest. None of the respondents belonged to construction sector. Bowing industry is fast flourishing sector in China and NPU has collaboration with many private aircraft manufacturing companies. Due to this reason, most of respondents were targeted from the same sector to increase sample. Interviewees form air manufacturing industry was also easy to catch for soliciting their responses at the same university.

4. FINDINGS AND ANALYSIS

This research has used Hypothetico-deductive research approach where author tests the proposed hypotheses by finding relationships among variables. Statistical analysis software (SPSS 19) has been used for this research to analyze data validation and correlation. Regression analysis has been used as tool to find the relationships among variables. Before performing regression analysis, data is needed to meet some assumptions: reliability, sample size, linearity and normality. After data validation, reliability for the collected data has been checked through computing Cronbach's Alpha. Data with Cronbach's Alpha greater than 7 is considered as reliable.

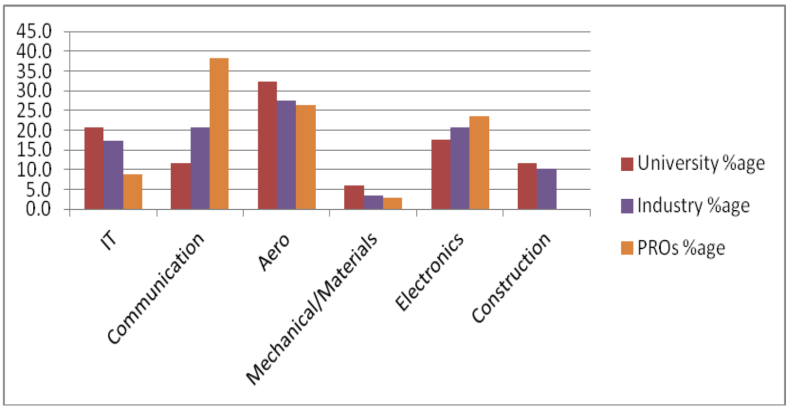

Fig 4: Respondents' primary industry

4.1. Data Validity

This test will assess that whether attributes in predicted model are adequately fitted to the attributes of theoretical model. Selected determinants from literature formed a variable list with 5-likert scale. Author has used advanced statistical tool, "Factor Analysis" to determine the data validity. A confirmatory factor analysis has been applied in this research. Maximum likelihood estimation is model-fitting procedure. Model-fitting procedure uses chi-square goodness-of-fit to determine the model adequateness. Sample size restricted author to bypass the internal data satisfaction by the use of Liketr scale. Nevertheless, numbers of cases in this research are greater than the number of factors applied. Garsos [22] also support this assumption that number of cases must be greater than the number of factors implemented in the model. Results of factor analysis have been given in table-2. Bartlett's Test of Sphericity should be significant at $p<0.05$ for social research [23]. Bartlett's Test of Sphericity for this study is 0.00<0.005. In the same way, Kaiser-Meyer-Olkin (KMO) measure ranges from 0 to 1 and 0.6 is considered to be the minimum value for an appropriate factor analysis (Pallant, 2011). Research measure of KMO for this research is 0.654. This means that data is valid and we can go for the next operation.

Table 2: KMO and Goodness-of-fit Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		*.654*
Bartlett's Test of Sphericity	*Approx. Chi-Square*	*60.374*
	df	*10*
	Sig.	*.000*

Goodness-of-fit Test		
Chi-Square	*df*	*Sig.*
5.184	*1*	*.023*

4.2. Data Normality

This research has assumed a null hypothesis, that collected data is normally distributed. Test of normality using Kolmogorov-Smirnov and Shapiro-Wilk technique have been used to measure normality at significance level of 0.5 and 0.05 respectively.

Table 3 has borne witness that Kolmogorov-Smirnov for all variables is greater than significance level. Similarly, P-value of Shapiro-Wilk for all variables is lower than α which rejects alternate hypothesis in the favour of null hypothesis. Results for Kolmogorov-Smirnov and Shapiro-Wilk tests have been provided in table 3.

5. DATA ANALYSIS AND INTERPRETATIONS

Four hypotheses have been stated in this research. These hypotheses have been tested by using regression analysis.

1st hypothesis states that R&D-TES provides an optimal articulated R&D culture where joint R&D projects are executed smoothly.

Table 3: Tests of Normality by Kolmogorov-Smirnov and Shapiro-Wilk

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
RDColb	.272	93	.000	.831	93	.000
RDKnw	.346	93	.000	.748	93	.000
RDPS	.408	93	.000	.672	93	.000
RDInnov	.375	93	.000	.718	93	.000
RDOptd	.384	93	.000	.671	93	.000

a. Lilliefors Significance Correction

Optimal R&D environment has been characterized by various attributes collected from interviews with R&D professionals from Chinese high-tech and IT industry, universities and PROs. Following these attributes, R&D outcomes can be maximized with minimum R&D budget-heads. Results of regression analysis have been given in table 4.There exists a positive correlation between R&D-TES and optimal R&D environment at 0.05 significance level.

Table 4: Pearson correlation matrix for hypothesis 1

Correlations			
		RDTES	RDOptd
RDTES	Pearson Correlation	1	.278**
	Sig. (1-tailed)		.002
	N	93	93
RDOptd	Pearson Correlation	.278**	1
	Sig. (1-tailed)	.002	
	N	93	93

**. Correlation is significant at the 0.05 level (1-tailed)

Unstandardized Coefficients ***B*** also has positive sign with T-statistics of 1.562, which denotes positive correlation among variables. Detailed results with tolerance and VIF have been provided in table 5.

On the basis of these results, it is clear that R&D-TES provides optimal R&D environment for R&D professionals and project managers to execute joint R&D projects at lower R&D efforts and cost to maximize the profit which is ultimate goal to achieve.

Table 5: Unstandardized coefficients with tolerance and VIF for hypothesis 1

Model		Unstandardized Coefficients	t	Sig.	Collinearity Statistics	
		B			Tolerance	VIF
1	(Constant)	1.594	7.946	.000		
	RDTES	.142	1.562	.122	1.000	1.000

2nd hypothesis seeks the correlation between R&D-TES and rapid IT and high-tech inventions. Correlation has been computed at significance level of 0.05 using 1-tailed T-test. Results indicate positive correlation between these two variables. All participants from three sectors are agreed that the dream of rapid high-tech inventions can come true by establishing collaborations through such R&D ecologies. Pearson correlation matrix for hypothesis two has been shown in table 6.

Table 6: Pearson correlation matrix for hypothesis 2

Correlations			
		RDTES	RDInnov
RDTES	Pearson Correlation	1	.210*
	Sig. (1-tailed)		.004
	N	93	93
RDInnov	Pearson Correlation	.210*	1
	Sig. (1-tailed)	.004	
	N	93	93
*. Correlation is significant at the 0.05 level (1-tailed).			

B (Unstandardized Coefficient) also supporting above hypothesis which compel the business magnates, academic tycoons and R&D techno-personnel to enhance collaboration trough R&D-TES. Lion share of literature on R&D collaborations has emphasized on academia-industry R&D collaborations for rapid R&D innovations since many years. This research has enhanced the same research domain by including PROs as a part of this collaboration. Unstandardized coefficients also have been depicted in table 7 with tolerance and VIF. T statistics also supports the hypothesis where value of T is 1.935.

Table 7: Unstandardized coefficients with tolerance and VIF for hypothesis 2

Model	Unstandardized Coefficients	t	Sig.	Collinearity Statistics	
	B			Tolerance	VIF
Constan	1.864	11.132	.000		
RDTES	.146	1.935	.056	1.000	1.000

It has been proved by data analysis that R&D-TES provides maximum chances to select best partner for neo-ventures and R&D collaborations due to similarities in technological and innovative advantages. This statement constitutes 3rd hypothesis and correlation between R&D-TES and partners' selection has been analyzed significant at the 0.05 level using 1-tailed T test.

Table 8 indicates that R&D-TES has a positive significant impact for selecting collaboration partners. However, significance level for this test is a bit higher than defined level due to misalignment of working culture, research environment and organizational culture of participants from three sectors. Unstandardized coefficients with tolerance and VIF have been depicted in table 9.

Table 8: Pearson correlation matrix for hypothesis 3

Correlations			
		RDTES	RDPS
RDTES	Pearson Correlation	1	.199*
	Sig. (1-tailed)		.008
	N	93	93
RDPS	Pearson Correlation	.199*	1
	Sig. (1-tailed)	.008	
	N	93	93

*. Correlation is significant at the 0.05 level (1-tailed)

Table 9: Unstandardized coefficients with tolerance and VIF for hypothesis 3

Model	Unstandardized Coefficients	t	Sig.	Collinearity Statistics	
	B			Tolerance	VIF
1 (Constant)	1.639	8.372	.000		
RDTES	.181	2.051	.043	1.000	1.000

Last hypothesis has been narrated as knowledge sharing is maximum among partners through R&D-TES to overcome technological complexities. Knowledge sharing has gained much attention by previous literature. This study has expanded this concept through R&D-TES. This scientific research has proved that R&D-TES has positive significant relationship with knowledge sharing. Participants are strongly agreed that R&D ecologies provide best plate form to share technological knowledge for its re-usability to achieve new discoveries. Trust among the partner is root cause to enhance knowledge sharing. Results have been computed and provided in table 10 at significance level of 0.05. Similarly, Unstandardized coefficients with tolerance and VIF also have depicted strong positive ***B*** that supports the hypothesis. Detailed analysis has been shown in table 11.

Table 10: Pearson correlation matrix for hypothesis 4

Correlations			
		RDTES	RDKnw
RDTES	Pearson Correlation	1	.162
	Sig. (1-tailed)		.041
	N	93	93
RDKnw	Pearson Correlation	.162	1
	Sig. (1-tailed)	.041	
	N	93	93

Table 11: Unstandardized coefficients with tolerance and VIF for hypothesis 4

Model		Unstandardized Coefficients	t	Sig.	Collinearity Statistics	
		B			Tolerance	VIF
	(Constant)	1.758	7.504	.000		
	RDKnw	.185	1.562	.122	1.000	1.00

6. ACKNOWLEDGEMENT

This research has been conducted for project of National Natural Science Foundation of China for project of Empirical Study on R&D Project Complexity Measurement and its Relationship with Project Risks (Project Number = 70972126). Author is thankful to NPU and National Natural Science Foundation of China for support of this research.

7. CONCLUSION

This research endeavor has introduced a novel concept of R&D-TES with three vertices as university, industry and PROs to attain rapid inventions in high-tech industry. Inclusion of PROs can make this ecology complex due to restricted nature of projects, but proper agreements, patenting techniques and trust among the partners can minimize collaboration complexity. Detailed R&D-TES design has been explained to highlight its significance. To validate the theoretical and practical implications of this proposed model, author has conducted a research survey with R&D professionals and project managers doing R&D projects in Chinese universities, industries and PROs. Detailed analysis of results have shown that R&D-TES can be proved as a new and fast track for neo-discoveries. Participants from three sectors have supported R&D-TES as it provides optimal R&D environment for attaining innovations at rapid rate with lowest budgets. Regression model has depicted positive impact of R&D-TES on IT and high-tech innovations. Most of Chinese universities have started joint ventures with PROs for mega projects as aircraft manufacturing, satellite projects and IT related projects. But still it is dire need of time to make clusters among these three sectors. This research is helpful for the researchers and practitioners for attaining technological advantages and innovations by exchanging information to overcome technological complexities. Practitioner's approach is different to deal with complexity in R&D collaborations than researchers. This research has explored this gap by getting views of practitioners / researchers by conducting their interviews and surveys.

Future Research:

This research needs further research achievements to enhance the scope of R&D-TES through exploring collaboration complexity among three partners,

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