INDUSTRY ACADEMIA COLLABORATION IN THE CONTEXT OF OPEN INNOVATION: EMPIRICAL EVIDENCE FROM PAKISTAN

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Abstract. *Industry & academia are building pillars of a country's knowledge base economy. Industry focus is on practical significance while role of academia is to disseminate knowledge. Although they seem different in their focus; however, there are similarities for innovation-based partnerships. Once Industry & Academia are embedded in the notion of "open innovation", both parties can benefit from collaboration. This is a quantitative study in which drawing upon resource dependence theory, a framework is developed for collaborating factors between industry and academia in the context of Pakistan. Sample from industry and academia is studied using survey instrument and impact of collaboration is measured on magnitude and level of innovation. LISREL based modeling technique is used for quantitatively analyzing proposed framework. Two questions are addressed in this study; What are the antecedents of industry and academia to collaborate in the context of open innovation, and the impact of collaboration on magnitude and level of innovation? This study contains key implications for education sector, industry and policy makers for enhancement of knowledge base in Pakistan.*

Keywords: Collaboration; Open innovation; Industry; Academia

Introduction

Collaboration between Industry-Academia is beneficial for both parties to the collaboration. In research community, there is a growing emphasis on 'collaboration between industry and academia'. Although industry and academia have different cultures and work practices, their motives are not that different (Ankrah et.al, 2013). There is a continuum of capabilities each partner can offer to enhance collaboration. This study contributes to the literature on industry & academic partnership by examining key antecedents of each party to bridge gap of collaboration. Collaboration in this study is conceptualized in terms of 'open innovation' efforts and it is submitted that impact of open innovation on both magnitude and level of innovation is not considered before.

The implementation of innovation-based policies requires characteristics of current industry academia collaboration (Freitas et.al, 2013). The participation of industry & academia in knowledge transfer is discussed in literature (Rorwana, 2015) with a thematic diagnosis; however, less focus is provided to examine the antecedents of partners collaborating for open innovation.

In a study conducted in the context of United States university academia collaboration, the division of labor is emphasized for research & development (Ahmadpoor et al., 2017). Empirical results suggest that university has an active role to play in policy making for economic improvements, institutional reforms, technological advancement, commercialization and consultation with industry (Kaklauskas et al., 2018). Collaboration between Industry-Academia can be studied on academic end for managerial insights and on commercial end for technology transfer. Nonetheless, there are modes of interaction in between the continuum. For instance, commercialization of academic research, patenting of innovation and academic entrepreneurship is receiving research focus (Markman & Phan, 2006). The concept of open innovation is incorporated by leading industries in the field of electronics, software, biotech and telecom (Chesbrough, 2003). Moreover, industry academia relationship is beneficial at firm, organization and country level of engagement (Meath et al., 2016). However, research is lacking on identifying antecedents of industry and academia for collaborating in the context of open innovation. Open innovation is defined as "the use of purposive inflows and outflows of knowledge to accelerate innovation within an organization while expanding boundaries for external innovation (Chesbrough & Crowther, 2006). Interaction between Industry-Academia is explored in multiple contexts. For instance, in a study on technology and knowledge transfer between industry and academia, different motives of industry-university co-operation are identified (Galan Muros et al., 2017). Industrial knowledge enrichment, resource attainment, institutional motives, research propensity, cost reduction, process time optimization and specialized technology are some of the cooperation outcomes (Galan Muros et al., 2017). Academia provides stewardship in generating knowledge, linking with customers and fostering technological transfer (Gulbrandsen et al., 2007; Lilles et al; 2017). Also, commercialization is an important factor for estimating impact of academic collaborative efforts (Markman et.al., 2008).

Literature Review

The link between Industry-academia is explored in contexts such as "emergent and mature industries in new industrialized countries" (Freitas et al., 2013), "knowledge integration community" (Chen et al., 2017), "role of Pasteur scientists" (Baba, Shichijo, & Sedita, 2009), "engagement and commercialization" (Perkmann et al., 2013), "knowledge & technology transfer" (Gulan Muros et al., 2017), "Patentable research" (Jensen et al., 2004), "R&D alliances" (Cloodt & Roijakkers, 2010) and economic and social benefits. These benefits comprise but are not limited to knowledge pool of graduates, scientific techniques and development of infrastructure (Cohen, Richar, & John, 2002; Elder, 2018; Ramsden 2018). The extent of collaborative effort is also discussed in literature. For example, in a bibliometric study, collaboration between partners is explored by operationalizing "co-author ship" and publications. Partners seek stability in an environment with demand uncertainty, short product life cycles and threat of new entrants (Ankrah et al., 2013). Partnership, technological relatedness, informal interaction, commercialization and geographical proximity are key collaboration links for attaining stability (Perkmann et al., 2007; Petruzzelli, 2011; Ponds et al., 2007; 2010; Reuer, Lahiri, 2013). Also, variety of channels is provided through which knowledge and technology can be transferred between partners (Bekkers & Freitas, 2008). There is realization of external knowledge base as any organization does not inherit all strategic and competitive tools (Douglass, 2015)& growing emphasis is on acquisition of external resources instead of focusing on internal resources only (Chesbrough, 2003). Strong empirical support exists for partners collaborating with each other to build alliances for minimizing uncertainties and nature of cooperation is dependent on an organization's practicing field. For example, organizations working in different sectors with a similar focus tend to build symbiotic cooperation which is stable and long lasting (Stout et al., 2018). On other hand, organizations practicing in same sectors with a similar focus develops competitive cooperation. The nature of this study is of "symbiotic" type where collaboration is based on networking as opposed to transaction based "arm length" relationships (Pyka et al., 2018).

Resource Dependence Theory

Resource dependence theory draws a boundary between an organization and its environment by incorporating resources internal to an organization and resources external to it. The logic is to build relationships in order to share resources for gaining competitive advantage. Resource dependence theory (RDT) postulates that an organization does not inherit all resources and is dependent on other players for certain resources (Seippel, 2018). Resource dependence theory (RDT) provides insights on "venturing" and "collaboration". Collaboration among organizations can be for strategic alliancing, marketing agreements and for research & development (Albusaidi et al., 2017; Barringer et.al, 2000). Resource dependence theory considers the formation of alliances and partnerships between organizations for reducing uncertainty and complexity in the business environment (Robinson, 2017; Pfeffer, 1978; Xia et al., 2018)). The environment for innovation is different for mature and emergent industries in terms of parameters of knowledge, strategies for innovation, networking and technological orientation (Robertson, Tunzelmann, 2009). There is a cultural drift between industry and academia known as "two cultural problem" meaning that partners have different work environment, habits, reporting styles and incentives mechanism. Nevertheless, industry-academic collaboration is an important facet of innovation system of a country and policy makers are trying to bridge the gap for decades (Bonaccorsi et al., 2014). It is posited that industry and academia have unique value propositions to offer as a result of collaboration. Collaboration can provide both partners with competitive and sustainable advantages such as new technology concepts, knowledge sharing and patenting.

Antecedents of Academia

Academia is a major contributor to the innovation system of a country as it contributes manpower and knowledge areas, methodologies, and economic development (Kaklauskas et al., 2018). The academia's response to collaboration can be increased by making the collaborative effort a function of funding structure (Dodgson, 2018). The social and economic benefits of academia such as training personnel, scientific knowledge transfer, and creating an infrastructure contributes to industrial innovation (Cohen et al., 2002; Elder, 2018). Academia feels dependency on the industrial sector for its knowledge economy, research & development, scientific approach, patenting (Nelson, 2001), academic entrepreneurship, (Shane, 2007), technology transfer, and collaboration centers (Chau et al., 2017; Nelson, 2001; Shane, 2007) and accordingly, it is hypothesized that;

H1: ***There is a significant relationship between antecedents of academia and open innovation***

Antecedents of Industry

Industrial sector is facing challenges such as customer demands, market uncertainty, product innovation and new product development & it requires sustainable knowledge and scientific methodology (Bonaccorsi et al., 2014). Informal interaction with educational scholars and student body is suggested for knowledge transfer and problem solution (Furman et.al, 2009). Knowledge transfer is a determinant for industrial innovation as it determines extent of innovation required by the industry (Moodysson et.al, 2008). Also, role of funding is pertinent in the innovation process as it provides an incentive to break norms and innovate (Pavitt, 1984). One of the key advantages an industry can seek from collaboration is 'becoming innovative' in terms of R&D (Perkmann et.al, 2012). As discussed earlier, the ties between industry and academia are not of arm's length nature but are long termed with an assumption that collaboration repeats and increases over time leading to understanding of partner's needs and capabilities (Glaister, 2018) and similarly, it is hypothesized that:

H2: ***There is a significant relationship between antecedents of industry and open innovation.***

Collaboration and Magnitude of Innovation

There is growing reliance on partners to collaborate (Glaister, 2018; Khanna, 2018) as theoretical knowledge is comprehended in academic minds while technological and process part is offered by industry as there is a sense of complementarity by sharing resources. When resources are dispersed among partners and sharing them can offer a competitive advantage, the locus and emergence of innovation is found in the network of organizations (Strong et.al, 2018). Since there is an advantage in achieving innovatory milestones when both industry and academia collaborate, it can be asserted that magnitude and speed of innovation improves for the partners. We posit that share of innovation and revenues, investment of budget, number of newly identified areas, patents filed& utilized and percentage of funded ideas improves as a result of open innovation approach (Chesbrough, 2003).

H3: ***There is a significant relationship between open innovation and magnitude of innovation.***

Similarly, collaboration between industry and academia can result in either incremental level of innovation (improvement brought in current practices) or it can result in a radical innovation (new products and/or services) and we hypothesize that;

H4a: ***There is a significant relationship between open innovation and incremental level of innovation.***

H4b: ***There is a significant relationship between open innovation and radical level of innovation.***

Methodology

Organization is selected as a level of analysis and responses are collected based on a top down approach, starting with CEO followed by manager, R&D experts, production managers and academic scholars. LISREL based modeling is used for statistical analysis of the framework provided in Figure 1.

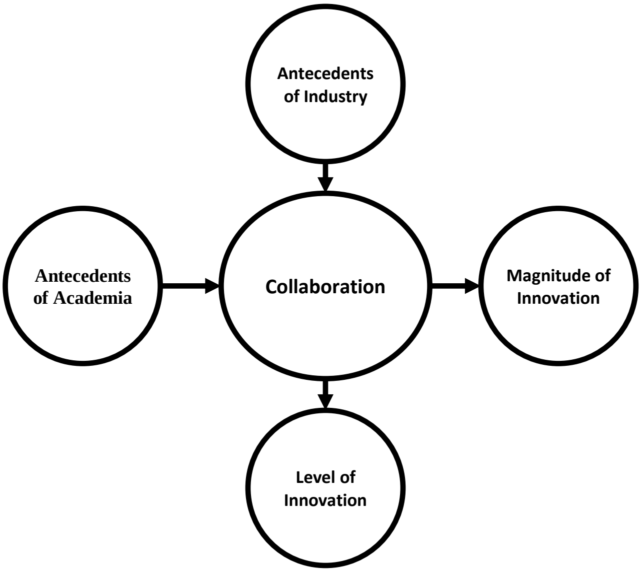

Figure 1 Research Framework for the Study

Sample of 200 participants was selected for this study. The dimensions for selection of respondents were based on age, experience, position and specialization. Sample characteristics and statistics are presented in Table 1.

Table1 *Respondents Characteristics*

Sample Characteristics	Respondents Academia	Respondents Industry	Percentage
Age			
25-35	60	58	59
35-60	40	42	41
Experience			
5-10years	55	48	51.5
10-25years	28	29	28.5
25-35years	17	23	20
Position			
Junior level	44	40	42
Senior level	56	60	58
Specialization			
Engineering	52	50	51
Business	48	50	49

Measures

Academic experts and research scholars inherit higher stakes in practical settings and they are urged to develop informal interaction with industry for new themes which can help on multiple fronts such as placement of graduates in industries. Similarly, Research & Development (R&D) intensity is a good resource for examining efforts towards collaboration and it is measured using expenditure on R&D. Knowledge transfer between partners, knowledge intensity, approach towards practical significance and scientific knowledge acquisition measures are adopted from literature (Autio et al., 2001; Boardman et al., 2009; David, 2001). Similarly, the measures for magnitude of innovation are borrowed from the study of Chesbrough (2003) that constitutes revenue from open innovation, number of new technology areas identified, number of patents filed and granted, patent utilization ratio, percentage of ideas funded and revenue from outwards licenses. The measures for Incremental and Radical innovation are adopted from the study of Ritala et.al, (2013) which is a single item scale for both incremental and radical innovation.

A five (5) points Likert scale questionnaire was developed for recording responses. Questionnaire was validated with the help of pilot study and reliability analysis was performed for measures. All of the construct measures had an adequate factor loading above 0.7 (Joreskog et al., 1993) except for two items of "existing knowledge base" (factor loading less than 0.7) and one item of "lack of resources" construct and they were removed. Factor loading, *t*-values and significance of all items is presented in Table 2. Except for the deleted items with lower values of factor loading, all retained items were significant at $p<0.001$ with adequate *t*-values. The questionnaire was administered to respondents online as well as through personal distribution for increasing the authenticity of data collection. For data collection purposes, recommendations were followed for timely feedback and tracking responses (Dilman, 2011). A total of 200 questionnaires were distributed and 126 questionnaires were returned out of which 10 questionnaires were discarded for missing values & partial responses and a survey response rate was 58%. Table 3 lists the internal consistency results and it can be observed that all constructs had internal consistency measure above 0.7 (Carrion et.al, 2017; Hair et al., 2011).

Table 2 *Factor Loading and Significance of Measurement Items*

Construct & Items	Standardized Factor Loading	t-value	P Value
Informal Interaction (II)			
II0	0.82	11.62	**
II1	0.77	10.96	**
II2	0.73	10.42	**
II3	0.79	9.68	**
II4	0.86	13.2	**
II5	0.81	12.45	**
II6	0.78	11.36	**
Research & Development Intensity (RD)			
EKI0	0.75	10.49	**
EKI1	0.82	14.62	**
EKI2	0.87	13.54	**
EKI3	0.56[b]	--------	-------
EKI4	0.62[b]	--------	-------
Practical Approach (PA)			
PA0	0.86	14.01	**
PA1	0.82	13.64	**
PA2	0.84	13.32	**
Lack of Resources (LR)			
LR0	0.92	16.55	**
LR1	0.88	14.98	**
LR2	0.76	14.21	**
LR3	0.64[c]	--------	-------
Collaboration & Open Innovation (CO)			
CO0	0.89	13.98	**
CO1	0.93	14.42	**
CO2	0.86	13.2	**
Magnitude of Open Innovation (MO)			
MO0	0.84	12.88	**
MO1	0.79	12.75	**
MO2	0.94	14.59	**
MO3	0.92	12.94	**
MO4	0.88	13.01	**
MO5	0.75	12.67	**

Incremental & Radical Innovation (IR)			
IR0	0.8	13.94	**
IR1	0.86	14.21	**

*b, c : deleted items; ** Significant at p <0.001*

Table 3 *Internal Consistency Tests of the Constructs*

Construct	Cronbach Alpha	Number of correlated items
Informal Interaction	0.87	7
Research & Development Intensity	0.76	3[b]
Practical Approach	0.92	3
Lack of resources	0.81	3[c]
Collaboration & Open innovation	0.83	3
Magnitude of Open innovation	0.85	6
Incremental and radical innovation	0.88	2

a: Overall Value of 0.89; b: two items were deleted and c: 1 item was deleted for factor loading < 0.7

Analysis

LISREL was used for modeling and study analysis was performed using a two-stage approach (Hair et al., 2011). In the first stage, confirmatory factor analysis was used for validity measurement while in the second stage; structural relationships of the hypotheses were analyzed (Sin et al., 2015). Statistical analysis and testing were performed on the acquired data for hypothesis testing. Missing values cases were removed for enhancing the credibility of the test results. A correlation matrix shown in Table 4 exhibits the Pearson r strength coefficient between variables. Test statistic of Pearson equal to 0.5 is considered as a good relationship and a value equals or more than 0.7 show strong relationship between variables (Hair et al., 2011). All of correlation indices were significant and relationship between magnitude of open innovation and Incremental/Radical innovation was greatest of all whereas the relationship between Lack of resources and practical approach seemed to be lowest of all with a Pearson r of 0.170. It can be interpreted that it is not advantageous for partners to adopt practical approach with no resources on hand. Resources can be identified in this context as technological equipment, human resources and monetary values for adopting practical approach. The correlation results are in-line with what was proposed in the framework for relationship among variables.

Table 4 *Correlation Analysis of Variables*

#	Variable	1	2	3	4	5	6	7	8
1	Informal Interaction	1.00							
2	R&D Intensity	0.24	1.00						
3	Knowledge Intensity	0.34	0.55	1.00					
4	Practical Approach	0.53	0.62	0.69	1.00				
5	Lack of resources	0.20	0.22	0.19	0.17	1.00			
6	Collaboration & open Innovation	0.64	0.63	0.71	0.75	0.61	1.00		
7	Magnitude of Open Innovation	0.36	0.52	0.54	0.62	0.26	0.79	1.00	
8	Incremental & Radical Innovation	0.30	0.72	0.48	0.52	0.40	605.00	0.72	1.00

Composite reliability, average variance extracted and shared variance extracted are provided in Table 5 for reliability and validity of constructs, in addition to internal consistency tests. Composite Reliability (CR) is a more robust test compared to internal consistency checks (Hanim et al., 2012) and all CR values were greater than the suggested value of 0.60 (Hair et al., 2010). In addition to correlation analysis of the constructs that establishes the relationship among study variables, it is important to assess that variables are measuring different aspects in the relationship model (Ali et al., 2018). The Average Variance Extracted (AVE) indices are above the threshold of 0.50 (Hair et al., 2010) and also, correlation index of square root of variance extracted for a particular construct is greater than the correlation of AVE with any other construct. This illustrates that all constructs qualify for the composite reliability and discriminant validity tests.

Table 5 *Composite Reliability, Average Variance Extracted and Average Shared Variance of the Constructs*

Construct	CR	AVE	ASV	II	RD	PA	LR	CO	MO	IR
II	0.82	0.54	0.08	0.74						
RD	0.82	0.53	0.18	0.33	0.65					
PA	0.77	0.57	0.15	0.17	0.23	0.79				
LR	0.79	0.55	0.10	0.09	0.05	0.52	0.75			
CO	0.90	0.53	0.18	0.09	-0.07	-0.07	-0.13	0.73		
MO	0.88	0.55	0.19	0.42	0.35	0.02	-0.16	-0.05	0.74	
IR	0.82	0.52	0.19	-0.04	0.11	0.11	0.05	0.07	-0.04	0.72

II: Informal Interaction; RD: Research and Development; PA: Practical Approach; LR: Lack of Resources; CO: Collaboration & Open Innovation; MO: Magnitude of Open Innovation; IR: Incremental & Radical Innovation; CR: Composite Reliability; AVE: Averaged Variance Extracted; ASE: Average Shared Variance.

Chi-Square is a classical technique for overall model fit assessment &threshold for Chi-square ratio is ≤ 5.0 (Hu et al., 1999). As illustrated in Table 6, this ratio is less than 5.0 for all construct of the measurement model. Similarly, RMSEA is another fit index for evaluating fitness of model with a proposed value for good model <0.07 (Steiger, 2007); a criterion which is met by all constructs. GFI index is used for estimating proportion of variance accounted for by the population covariance (Tabachnick et al., 2007) and its recommended value is ≥ 0.90. The values of GFI in the measurement models ranges between 0.924-0.978 which is beyond suggested limit. Also, all SRMR values are in accordance with the suggested range of <0.08 (Wongparan et al., 2017). Normal Fit Index (NFI) acceptable values are >0.80 however; values above 0.95 are highly recommended for a robust model (Wongparan et al., 2017) and all result values of NFI are beyond the limit of 0.95. Similarly, Comparative Fit Index (CFI) is another reported fit index &it is least sensitive to change in the sample size with a recommended value ≥ 0.95 (Fan et al., 1999) & it is qualified by all constructs measure as shown in the table below.

Table 6 *Fit Indices of the Measurement Model*

Fit indices	Defined levels	II	RD	PA	LR	CO	MO	IR
λ^2/df	≤ 5.0	1.05	1.35	1.10	2.32	1.68	1.93	2.07
P value of λ^2	> 0.05	0.48	0.09	0.08	0.38	0.33	0.62	0.58
RMSEA	≤ 0.06	0.01	0.02	0.01	0.06	0.04	0.03	0.03
GFI	≥ 0.90	0.95	0.92	0.92	0.98	0.93	0.97	0.97
RMR	≤ 0.05	0.01	0.02	0.01	0.02	0.01	0.04	0.03
SRMR	≤ 0.08	0.00	0.02	0.04	0.04	0.06	0.06	0.07
TLI	≥ 0.90	0.91	0.91	0.93	0.93	0.90	0.94	0.93
NFI	≥ 0.90	0.91	0.93	0.91	0.94	0.94	0.90	0.93
CFI	≥ 0.95	0.97	0.97	0.99	1.00	0.95	0.96	0.98

II: Informal Interaction; RD: Research and Development; PA: Practical Approach; LR: Lack of Resources; CO: Collaboration & Open Innovation; MO: Magnitude of Open Innovation; IR: Incremental & Radical Innovation; RMSEA: Root Mean Square Error of Approximation; GFI: Goodness of Fit Index; RMR: Root Mean Square Residual; SRMR: Standard Root Mean Residual; TLI: Tucker- Lewis Index; NFI: Normal Fit Index; CFI Comparative Fit Index.

Next, coefficients of determination value are presented in Table 7. All of the hypothesized relationships were significant at $p<0.001$ and the strength of relationship between antecedents of relationship and collaboration were 0.189 which means that a rise in overall antecedents by 1 unit would elevate the collaboration by 0.189 units. Rest of the coefficient estimates can be interpreted in the similar way.

Table 7 *Estimated Coefficients for Hypothesized Relationships*

Hypothesis	Description	Estimate	Standard Error	Sig.
H_1	Positive impact of Academia antecedents on Collaboration	0.189	0.085	**
H_2	Positive impact of Industry antecedents on Collaboration	0.105	0.097	**
H_3	Positive impact of Collaboration on magnitude of Open Innovation	0.116	0.142	**
H_{4a}	Positive impact of Collaboration on Incremental level of Innovation	0.156	0.106	**
H_{4b}	Positive impact of Collaboration on Radical level of Innovation	0.191	0.118	**

***Significant at p<0.001*

Conclusion

In the wake of the industry 4.0 phenomena and dense competition in the marketplace where customers' perceptions are volatile, it is a high time to collaborate with partners for gaining a competitive edge & minimizing uncertainty. For innovation, Academia and Industry fosters open innovation where partners can benefit from unique capabilities of each player. Industry provides practical sense by offering technology & practices whereas academia has a sustainable advantage of theoretical insights for managerial implication. We provide an important implication for open innovation which impacts magnitude as well as level of innovation. Variation in collaboration is accounted for12.6% by academic antecedents while Industry antecedents cause 15.2% variation in collaboration. Similarly, Collaboration explains 16.6%, 19.8% and 17.4% variations caused in the magnitude of innovation, incremental level of innovation and radical level of innovation, respectably.

This is a first study that explores antecedents of industry and academia in the context of open innovation using a theoretical framework. Future research can focus on extending this relationship framework by including more independent variables as the adjusted R^2 values for hypothesis suggests room for including meaningful variables. Among all of the correlation indices, Pearson coefficient was higher for magnitude and level of innovation and we suggest that future research can establish a causal mechanism between these dependent variables to obtain more research findings. Similarly, time-based regression and forecasting can help in analyzing the trend towards future in specific country contexts. Lastly, future investigation can focus on considering some control variables in the analysis for comparing across size of the enterprise, country context and especially the fostering role of government in the context of open innovation.

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