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Academia-industry linkages: Theoretical and empirical review article

Sukhjinder Singh and Babita Kaundal *

Business Development & Marketing Unit, CSIR-Institute of Himalayan Bioresource Technology, Palampur (HP) India.

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Abstract

Academia-Industry collaboration is the key step towards the growth and development of economy. The academia is a store house of knowledge and innovation whereas the industry is a sector to convert the knowledge and technique into innovative product. The conversion of research and innovation through universities or research institutions to the marketplace for social benefit necessitates significant and ongoing efforts. As a result, the objective of this article's summary is to go through the mode and challenges of long-term partnership between academics and industry. A total of 40 publications were screened, with data retrieved and analyzed qualitatively using a grounded theory technique. The study focuses on the type of existing interactions and the barriers to collaboration amongst the two actors i.e., academia and industry and grouped into four major themes or core variables that encourage collaborative creation. The themes are form of collaboration, channels of collaboration, barriers and motivation for collaboration. Furthermore, the assessment discovered that developing nations continue to have a research coverage gap when compared to developed ones, indicating that educational partnership is underutilized. As a result, it is suggested that action research be used to improve research in developing countries, with special focus paid to A-I collaboration methods.

Keywords: Academia-Industry; Collaboration; Barriers; Motivation; Systematic Literature Review

1. Introduction

Academia-industry linkages are not new topic to discuss as it has been taken into consideration many times for more and more expansion of basic concept it holds that is growth and development of society through the mean of technology transfer [1]. The term "academia-industry" refers to the exchange of information and technology among any sector of higher education and industry with the objective of addressing technical difficulties, working on R&D, and acquiring scientific and technological knowledge. It entails collaboration between business and academia in a variety of fields in order to strengthen the country's research ecosystem and boost economic, industrial, and societal progress [2]. Academia including modern universities/research institutes that are becoming more widely recognized as key players in all countries' economic development processes. Their active interaction with industry has risen in recent years, and regulations have been created to encourage A-I collaboration [3]. Linkages between academia and industries are increasingly important for innovations in the country as these linkages is a win-win situation for both the industries as well as academia. To achieve a win–win–win scenario every stakeholder must engage with this initiative with new approach that leads to accomplish various goals of both parties [4]. Recently, the study has been taken into consideration of academia and industry collaboration in many countries such as the United States, Japan, Singapore, and European Union countries [5,6]. Academic-industry connections aid in obtaining and influencing additional funding for higher education, fostering innovation and ensuring the students with skilled and expertise qualities required for effective contribution to the workplace [7]. This increasing interaction leads to the pressure on academia as well as industry. Pressures on industry have included fast technological progress, shorter product life cycles, competitors, which have dramatically altered the competitive climate for most enterprises [8,9]. These demands on both parties have

* Corresponding author: Babita Kaundal
Business Development & Marketing Unit, CSIR-Institute of Himalayan Bioresource Technology, Palampur (HP) India.

resulted in an increased push for the development of A-I interaction with the goal of improving innovation and economic competitiveness at institutional levels also and facilitate the industries to access quality research and involve great minds of scholars as well as scientists in important projects that can help in new inventions to create history.

Collaboration between industry and academia is increasingly becoming a priority in science and technology policy development, planning, and administration. With ongoing economic reforms, the business and economic situation has changed industries, academia, and public laboratories environment dramatically. Safety is being exchanged by competitive attitude, controls are been taken over by liberalization, and imported goods are being replaced by globalized and export boosting [10]. Academia-industry (A-I) connections are interactions between businesses and academia (Universities/R&D Institutes) with the objective of addressing technical difficulties, working on R&D, launching new products, and obtaining scientific and technological information. It entails collaboration between industries and academia in a variety of fields in order to strengthen the country's research ecosystem and boost economic, industrial, and societal progress. A-I is a field of study that is extremely important for the world's economies in order to grow and become more competitive [11].

Innovation systems in regional economies and national competitiveness are both dependent on companies constantly adapting to change [12]. Research and development (R&D) investments are effective when they are interacted with scientific and technological institutions in the local area. When the interaction becomes increasingly active, R&D investment by companies, universities, and research institutes has a greater impact on the development of regional innovation systems [13,14]. Academia is a term used to describe institutions that play an important role in modern societies by teaching significant segments of the people and developing information with the objective of advancing the society's socioeconomic growth.

This study contributes to the literature by providing a more thorough and hence better view of how A-I links are implemented. As a consequence of the interactive requirement, also looking into the literature on the most frequently accepted way of linkage. Furthermore, the research makes it easier to comprehend of the similarities and differences between the two socioeconomic environments by comparing conclusions drawn from both developed and developing nations. This should lead to a better understanding of the A-I linkage phenomena [15].

Other than the introduction, the remainder of the article is divided into 4 parts: The method is introduced in part 2, the systematic review's findings are presented in part 3. Section 4 represents the conclusion.

2. Research Methodology

This review is drawn from the technique of various systematic literature reviews already studied for academia – Industry collaborations [16,17,18]. The procedure for this review is divided into four steps mentioned below.

2.1. Finds for related material

A list of relevant publications was obtained using three online databases namely the Web of Science (WoS) ELSEVIER, (Science Direct) and ERIC. The list of relevant publications was compiled using the key terms as operationalization, sustainability, practices, methods, effectiveness, determinants, antecedents, factors of success, patterns, problems, hurdles, issues, achievements, management, strategies, indicators, attitudes, and perceptions in Academia and Industry collaborations were among the terminology used in this study.

2.2. Selection of publications to be included

The step 2 involved screening of the articles collected in step 1 by going over their abstractions and, in certain cases, the entire text, in order to create a pool of papers that met the objective of the present study [19]. Only papers that included quantitative or qualitative data from field practices and reported on A-I implementation practices were examined.

2.3. Data extraction

To ease data extraction, a data gathering tool in Microsoft Excel was designed to enable for easy detection and reviewing of extracts during analysis process [20].

2.4. STEP 4 Data Analysis

In the fourth step, data were analysed using grounded theory through a two-abstraction level approach. The categorization of countries into developed and developing countries. From the coding process, 4 key topics were identified and they are presented in the next section on findings

3. Results and discussion

The available evidence on academic involvement in Industry was subjected to a thorough evaluation which helped in getting in-depth understanding of the subject [21]. For literature review, findings from 40 publications comprising different types of interactions amongst the academia and industries were studied. The most typically recognized routes of linkage include publication, contractual research, patents and licensing, R&D collaboration, spinoff, staff training, symposium and conferences, as well as consultation. The literature identified several barriers to collaboration in developing nations, including academic research that is not relevant to industry, conflict between requirements and expectations conflict, a limited knowledge about the industry, and a scarcity of enough state funding.

3.1. Mode of A-I interaction

Table 1 Organizational forms of A-I Interactions

Informal Relationships	• **Rotational(spin-off) • consulting • disclosure of knowledge • conferences and publications • talks • close connections**
Formal Relationships	• Student internships • Hiring of graduate students • Scholarships, Studentships, Fellowships • Exchange programmes • Employment of scientists by industry • Laboratory facilities • involvement in industrial projects
Third Party	• Technology Transfer Organizations • Industrial associations • Liaison offices • Institutional consultancy • Technological Brokerage Companies • Government Agencies
Formal Non-Targeted Agreements	• Advisory Boards • R&D funded by industry in academia (university/R&D institutes) • Broad agreements amongst academia & Industries collaborations • trusts donations, Research grant, gifts, endowment • Funding of university posts
Formal Targeted Agreements	• Joint curriculum development • Collaborative research initiatives • Investing in firms as a shareholder • Contract research • Training Programmes for employees • Patenting and Licensing Agreements
Focused Structures	• Innovation centres • science parks • Academia-Industry Partnerships • Association contracts

Source: Ankrah, S., & Omar, A. T. (2015). Universities–industry collaboration: A systematic review.

Available literature suggested that Joint Ventures, Networks, Consortia, and Partnerships are the most common kinds of A-I interaction used in practice [22], and the level to which the parties interact may vary among these specific forms of contact. Chen. (1994) defined the types of A-I connections for technology exchange based on the relationship's duration and the technology flow [23]. On the other hand, Santoro, M.D. and Gopalakrishnan, S., (2000) [24] propose four classifications for A-I connections: (1) cooperative research (2) transfer of technology (3) research support, knowledge transfer, personal relationships, institutional programmes, industrial education and (4) Agreements between organizations, plans for a team, facilities for universities/ R&D Institutes.

Various academics have sought to classify such channels based on a set of criteria. Some researchers have identified four types of channels depending on the style of connection with industry: Two-ways business, Assistance, and Traditional channels [25, 26].

Bonaccorsi, Piccaluga., (1994) [27] found the six main categories of A-I Interactions as presented in Table 1: and are categorised as Informal Relationships, formal Relationships, Third Party, Formal Targeted Agreements, Formal Non-Targeted Agreements and Focused Structures.

This systematic study for A-I collaboration was taken into consideration for developing countries (South Africa, Nigeria, Uganda, Egypt, China, Korea, Thailand, Taiwan, Malaysia, India, Brazil, Mexico, Costa Rica, Argentina, Bolivia, Kazakhstan, Mozambique, and South Korea) and for developed countries (The United States, the United Kingdom, Spain, Italy, Norway, Canada, Turkey, the Netherlands, France, Ireland, Finland, Denmark, Sweden, and Japan).

3.2. Interaction Channels

As per Nsanzumuhire, S.U. and Groot, W., (2020) the channels for collaboration between academia and industries have been categories in accordance to preference, and impact of channels on benefits. The table 2 presents the detailed description of aforesaid channels.

Table 2 Interaction channels from the perspectives of developed and developing nations

Topics	Studied observations of developed countries	Studied observation of developing countries
Channels of Interaction	• Publications, Patents • Recruitment of students • Industry connections • Joint research projects • Consultancy • Staff exchange between academia and industry. • University spin-offs, spin out, joint venture • Student training • Contract research • Laboratory in use • internships • technical training of firm's workers	• A channel that can be utilised both ways.: networking with industries, Joint projects, R&D contract) • Assistance channels: (such as, technical assistance, Consultation, staff exchange) • Intermediary organisations located at universities that work with state-level intermediaries (Finance cooperative initiatives Collaboration with these other actors Seminars and training Consultants Sharing of Equipment) • With the help of a market-driven intermediate entity (business group, resource exchange, exchange of information, product/process development through an association, consultancies service,
Preference of channels	• Channels rating: • Patent exploitation, renting the establishment of spin-offs or start-ups, and building or machinery are all negatively rated. • Consultation	• Channels rating: • Scholars place a higher priority on information exchange, especially knowledge transfer through collaborative research. • Firms place a higher emphasis on the traditional channel. With the exception of Chinese and Malaysian businesses, the commercial channel is

	• 'Academics and industry researchers alike consider the 'basic' transferring tools to be the most significant. • Informal connections exceed formal connections.	mostly irrelevant to both industry and academia, despite the numerous connections it represents. • Informal interactions • Project networks, Intellectual - property networks, and HR networks are the most efficient. • Preference for a certain channel is determined by the following factors: - Capacity for innovation, strategy for innovation, Centre for Public Research (PRO), Companies' origins • Type of technology transferred i.e., either new product, or new process. • The possibility for research discoveries to be put to use
Impact of channels on benefits	• Not applicable	• Advantages to the company's bottom line: • Operation Connection, IPR Network • HR channels are critical for bolstering R&D-based skills. • Developing capacities based on innovative activities besides R&D requires a strong HR channel and long-term relationships. • Impact on academic benefits: • In order to get economic advantages, the Knowledge Channel, Project Channel, and Personnel Channel all play a part. • The only channel that has a significant and favourable influence on intellectual benefits is the Knowledge Channel. • Intellectual gains are less affected by the Project Channel and the HR Channel.

Source: Nsanzumuhire, S.U. and Groot, W., (2020). Context perspective on University-Industry Collaboration processes: A systematic review of literature. *Journal of cleaner production*.

3.3. Barriers to A-I interactions

To investigate the barriers to AI interactions, many methodologies have been used. Both perceived and actual barriers were explored by Muscio, A. and Vallanti, G., (2014) and Muscio, A. and Pozzali, A., (2013) [28, 29]. Belkhodja, O. and Landry, R., (2007) [30] looked at perceived barriers from non-collaborating academics. Barriers were evaluated from the perspectives of academic researchers and industry in their research. Table 3 demonstrates the different forms of obstacles.

As per Bruneel et al, (2010) [31] two types of barriers do restrict the interaction amongst academia and industry. Problems among public and private information and incentives, Problems over intellectual property and academic bureaucracy, whereas Ankrah, S. and Omar, A.T., (2015) mentioned seven types of barriers hindering the activity of A-I interactions, i.e. (1) Capacity and Resources; (2) Institutional Policies, Lawful Concerns, and Contracts Processes; (3) Organizational and Management Issues; (4) Technology-related issues; (5) Political Concerns; (6) Social Concerns; and (7) Other Issues. These factors were discovered to have a positive impact on the perceived success of knowledge and technology transfer when managed correctly.

Vega et al., (2008) and Gümüsay, A.A. and Bohné, T.M., (2018) [32, 33] emphasized the position of obstacles in respect to Institutional boundaries and are divided into two types: Internal and External obstacles. whereas Attia, A.M., (2015) [34] and Zaharia and Kaburakis (2016) [35] looked at Barriers were identified as orientational and transactional barriers from the standpoint of institutional operations.

Table 3 Barriers to A-I interactions

Main categories	The factors
Capacity and Resource	• Resources that are adequate (fund, human and facilities) • Academic researchers should be compensated. • Technology transfer staff must be effectively trained • Capacity constraints for SMEs
Institutional Policies, Lawful Concerns, and Contracts Processes	• Examples of inflexible university policies includes IPR, licencing, patents and contractual processes • Information that is sensitive or proprietary is handled with care. Legal constraints vs. moral responsibility (research on humans)
Organizational and Management Issues	• Commitment and support from top management • Pioneer of cooperation • Collaborative effort and adaptability • Connectivity • Mutual commitment and loyalty (as well as personal ties)) • Business stability • Management of a venture • Cultural environment of academia and of industry • Organizational structure of industry and academia • Boundary spanners' abilities and roles in both academia and industry • Personnel exchange/mobility of human capital
Technology-related issues	• Nature of the to-be-transferred technology/knowledge
Political Concerns	• Regulation to guide, promote, and encourage AIC (including tax relief, communication systems, and direct industry advice).
Social Concerns	• Improved reputation and prestige
Other Issues	• Lack of knowledge of academic research • third party • Innovation risk • Merge parallels and discrepancies • closeness to each other

Source: Ankrah, S. and Omar, A.T., (2015) Universities–industry collaboration: A systematic review. *Scandinavian Journal of Management.*

The study reviewed the barriers showed that S.U. Nsanzumuhire, W. Groot, (2020) classified it into five categories given below: -

Table 4 Classification of Barriers as per Nsanzumuhire, S.U. and Groot, W., (2020)

Misalignment barriers	• Academia (University/R&D Institutes) not centred on industrial significance. • Divergent demands and expectations, Lack of mutual knowledge of expectations and working procedures. • Disagreement on patents • Concerns about confidentiality and the absence of safe facilities, as well as the thought of losing knowledge • The focus of university research is mostly on pure science.
Motivation related barrier	• Lack of faith in the educational system in the area • Incentives for students and instructors to create partnerships with businesses are lacking. • Poor working and wage circumstances for lecturers • A lack of interest on the part of businesses • A scarcity of incentive programmes • There is no additional financing for collaboration. • Disappointing results • No impact on academic standing • Prohibited due to research freedom
Barrier due to capability	• Inadequate knowledge of the industry • Research of poor quality • lack of institutional support • Lack of a sufficient connection structure (no TTO, no method for exposing students to the sector) • Limited time • There is a paucity of partnership management training. Legal contracts aren't always easy to come by. • insufficient governmental and private financing • Infrastructure issues, such as ICT, provide a challenge
Barriers relating to governance	• The problems faced during the research processes. • Governments imposed regulations.
Barriers related to context	• The government-funding schemes or university rules. • Unfavourable environment, culture of university for collaboration • Regional difference • Businesses' profiles don't allow you to seek for academics as a helpful companion. • Lacking of a national policy • There is no explicit regulation requiring firms, particularly multinational corporations, to finance higher education institutions. • Only a few academics and scientists are involved in the work at businesses.

3.4. Motivation for collaboration

Motivation is essential for success, and adjustments are made in accordance with new regulations that reflect both the work and personal lives of employees and employers. The motivation to academia-industry interaction depends upon the three elements i.e., structural elements, institutional element and individual elements [36]. The motivations for

academia (universities/research institutes) and industries to enter into relationships are categorized into Necessity, Reciprocity, Efficiency, Stability, Legitimacy [37]. Furthermore, the reasons for academia and industry to participate in A-I interaction were discovered to be closely aligned with six important conditions or determinants [38]. In several ways, the motives for academia to participate in A-I interaction differ from those for industry. The two organizations' motivations are examined separately.

Table 5 University and industrial motivations

Elements	**academia**	**Industry**
Necessity	• Government-policy receptivity • Institutional strategic policy	• Government initiatives/policy responsiveness • Institutional policies that are strategic in nature
Reciprocity	• Get access to complementary knowledge, cutting-edge equipment, and cutting-edge facilities. Opportunities for university graduates to find work	• Access to students for summer internship or hiring • Professorial appointments
Efficiency	• Grant for research from government and industries • Opportunity for business, • Individual financial benefits for academics	• Profit from university-based technologies by commercialising them. • Profit money from coincidental research findings • Cost-cutting (simple and less expensive than obtaining a licence to use advance technologies) • Government rewards for building relations such as tax break and grants • Firms' technological competence and economic competitiveness should be improved. • Product lifecycles are being shortened. • Development of human capital
Stability	• Transformation into knowledge-based society • Shift in knowledge-based economy • New inventions and put theory for testing • Gain a deeper understanding of how curricula are developed • Disclose students and faculty to practical situation/ technology in practise • Article Publication	• Knowledge-based economy shift • Business expansion • Availability of new information, cutting-edge technology, cutting-edge expertise/research facilities, and complementing know-how • multiple facets of foremost technologies • Connectivity to research networks or a stepping stone to additional partnerships • Problem-solving techniques • Outsourcing R&D • Sharing or reducing risks
Legitimacy	• Pressure from society • Assistance to the industrial/social community • Encourage new ideas • Contribution to the local or national economy • Academics' ambition for greatness and recognition	• Improving the company's image
Asymmetry	• NA	• Keep control of exclusive technologies.

Source: Oliver, C. (1990). Determinants of inter organisational relationships: Integration and future directions. Academy of Management Review

3.5. Academia perspective

3.5.1. Prerequisite

Faced with increased worldwide competition and fast technological development, government has been actively encouraging academia-industry cooperation as a method of Increasing the effectiveness of invention and, as a result, wealth generation [39].It is very critical for the government and in charge of research expenditure to examine how effectively the collaboration amongst academia and industries work to guarantee the transfer of innovative research to the industries efficiently and productively to benefit the economy's growth and development [40].

3.5.2. Reciprocity

In academia, it has been noticed, that comprehensive access is offered to a wide range of research and infrastructure for research, whereas industry provides substantial access to competence in market understanding, product development and research infrastructure [41]. As a result, academia may be encouraged to form partnerships with industry in order to capitalize on these assets for mutual benefit.

3.5.3. Productivity

Faculty members may be driven to enter into partnerships with business by personal financial gain, according to academics [42]. While public funds support AIC initiatives, academic institutions are progressively seeking for new sources of income for basic research and materials, such as commercial production of academic staff research and the manipulation of intellectual property rights or patent licensing, in order to minimize their dependence on government funding [43].

4. Conclusion

The findings of a systematic review on AIC are presented in this paper. These studies were assessed using qualitative data analysis methodologies against five inductively determined features. The review and framework not only made a significant contribution by providing a clear comprehensive appraisal of the status of the literature, but they also identified areas that need additional exploration.

First, the review revealed that the advantages and effectiveness of a technology translation alliance are often assessed based on the judgement of business or academic actors, who may have decided the results by comparing past demands and expectations with a tested prediction, actual or potential satisfaction. One of the issues with this sort of evaluation is that the individuals from business and academics may have various conceptions of the success of the interaction and its results.

Second, it was clear from the study that there is a need to investigate the extent to which the AIC may shift from a resource complementing strategy to utilizing the competitive advantages of the participating enterprises.

Third, additional study is required to investigate the role of government in AIC. According to the studies, government is a significant participant in enabling the formation and growth of such collaboration in developed economies. However, we don't know if governments in emerging and developing countries, having higher education institutions (classified as either pure or semi-public) will adopt the same approach.

There are three sorts of institutional links between universities, industry, and government. (1) The government directs the AIC by defining goals and placing restrictions on the academic partnership. (2) With universities/R&D Institutes and government taking minor roles, industry becomes the driving force behind the AIC. The job of academia is to offer intellectual talent, whereas the duty of government is to control social and economic forces. (3) Although the three parties work together to convey knowledge to society, the academia may take the lead in this framework.

In addition, research in this topic can look on how inter-country AIC might help the hosting country's national innovation capabilities. However, we believe that research in this area should be undertaken not to evaluate current interpretations regarding AIC, but rather to establish conceptual and practical understanding of the complexities that endorse and/or restrict the emergence of global AICs (e.g., cultural differences, policy contradictions, and divergences in national priorities).

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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