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A SYSTEMATIC REVIEW OF COLLABORATION BETWEEN TERTIARY INSTITUTIONS AND INDUSTRY

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ABSTRACT
The partnership between higher education institutions and industry is increasingly regarded as a means to foster innovation through the exchange of information. This is demonstrated by a substantial rise in research examining the subject from many viewpoints. This collection of information remains scattered and lacks a cohesive overview. To rectify this deficiency, we implemented a systematic approach to examine the literature on Tertiary Institution-industry collaboration (TIIC). The review identified five fundamental features that supported the hypothesis of TIIC. We incorporate these essential elements into a comprehensive process framework, which, along with the review, significantly contributes by producing an integrated analysis of the literature regarding this phenomenon. Multiple research directions are identified as derived from the study.

1. INTRODUCTION
Tertiary institutions—industry collaboration (TIIC) denotes the interaction between components of the higher education system and industry, primarily aimed at fostering the interchange of knowledge and technology (Bekkers & Bodas Freitas, 2008; Siegel, Waldman, & Link, 2003). TIIC has a lengthy history (Bower, 1993; Oliver, 2004) as a method for enhancing organisations' knowledge repositories (Cricelli & Grimaldi, 2010). Recently, there has been a significant rise in these collaborations across various countries, including the United States (e.g., Lehrer, Nell, & Garber, 2009), Japan (e.g., Woolgar, 2007), Singapore (e.g., Lee & Win, 2004), and European Union nations (e.g., Barrett, Austin, & McCarthy, 2000; Gertner,

Roberts, & Charles, 2011; Powers, 2003). This rise has been ascribed to a confluence of forces affecting both the industrial sector and higher education institutions (Giuliani & Arza, 2009; Meyer-Krahmer & Schmoch, 1998). Industries have faced pressures such as rapid technical advancements, abbreviated product life cycles, and fierce worldwide competition, which have fundamentally altered the competitive landscape for most companies (Bettis & Hitt, 1995; Wright, Clarysse, Lockett, & Knockaert, 2008). Tertiary institutions face pressures from the expansion of new knowledge and the challenges of escalating costs and funding issues, which impose significant resource demands on them to establish partnerships with firms to maintain their competitive edge across all disciplines (Hagen, 2002). Furthermore, there is increasing societal pressure on higher education institutions to be perceived primarily as drivers of economic growth, rather than as entities performing their historical broader social responsibilities, such as education and knowledge generation (Blumenthal, 2003; Philbin, 2008). The demands on both parties have generated a growing impetus for the development of TIICs, which seek to bolster innovation and economic competitiveness at institutional levels (e.g., countries and sectors) through information exchange between academic and commercial sectors (Perkmann et al., 2013). Furthermore, TIIC is widely regarded as an effective mechanism for augmenting organisational capacity in open innovation, wherein an organisation utilises external networks to foster innovation and knowledge (Dess & Shaw, 2001), serving as a supplementary alternative to conventional internal R&D (Harvey & Tether, 2003).

Although there has been an increase in TIIC-related research, the existing literature remains fragmented and lacks a holistic perspective (Bovaird, 2007; Perkmann et al., 2013). The objective of this study is to enhance comprehension of TIIC for knowledge and technology transfer by systematically reviewing and critically integrating the key elements of this interorganizational interaction. Our assessment method was specifically directed by a principal research question: What are the predominant topics of TIIC? We integrate our findings by amalgamating several independently conducted investigations, perhaps with contradictory results, and synthesising their outcomes in particular domains. We contribute to the literature and practice in three distinct ways. Initially, we provide a thorough systematic assessment of the current understanding of TIIC. This enabled us to discern five major elements that prevail in the TIIC literature. This extensive coverage in a single study seems to be unprecedented in the literature, as the majority of prior research has focused on only one or two of these domains simultaneously, such as proposing a typology for TIIC (Dess & Shaw, 2001), identifying characteristics of firms and tertiary institutions involved in TIIC (Agrawal, 2001), and examining the antecedents and consequences of TIIC (Perkmann et al., 2013). Furthermore, our research, unlike other studies (e.g., Philbin, 2008), examines TIIC in its whole rather than solely concentrating on 'contract research' TIIC. The former presents a broader viewpoint for TIIC, suggesting a bi-directional exchange of knowledge, whereas the latter typically involves a unidirectional transfer of knowledge from higher education institutions, primarily concentrating on technological commercialisation (Meyer-Krahmer & Schmoch, 1998). This study is unique compared to prior research as it equally emphasises both higher education institutions and industry viewpoints. Dependence on information obtained from a singular perspective typically undermines the validity of results and constrains the opportunity to attain a holistic understanding of TIIC (Santoro & Chakrabarti, 2002). Secondly, we consolidate our findings into a conceptual process framework that connects the five predominant topics in the TIIC literature. The framework was utilised to identify potential deficiencies in our understanding of this occurrence and provide various directions for further research. The study is pertinent to practical applications. We offer additional insights into the diverse methods of

technology exchange between higher education institutions and industry, namely through the established process framework, enabling partnering organisations to focus more on the associated activities.

The remainder of this work is structured as follows. The subsequent section delineates the methodological framework for the systematic review. We summarise the review outcomes in five principal areas, termed TIIC core themes: forms, motives, formation and activities, enablers and inhibitors, and outcomes. The fourth section critically examines the prevailing theories supporting TIIC and utilises the review findings to create a conceptual process framework for TIIC. The final portion presents the conclusion and fresh research directions.

2. METHODOLOGICAL FRAMEWORK FOR THE SYSTEMATIC LITERATURE REVIEW

Systematic literature reviews, initially developed in medical research (Black, 2001), are now being utilised in the social sciences (Burrows, 2000) and management (Pittaway & Cope, 2007; Shwom, 2014). A systematic review is an investigation designed to address a well-defined subject by locating, delineating, and assessing evidence from all published research pertinent to that question within specified parameters (Eriksson, 2013). Significantly, it diverges from conventional narrative reviews by employing a systematic and rigorous methodology that mitigates subjective bias and diminishes the likelihood of neglecting pertinent literature. A systematic review can be distinguished from conventional literature reviews in that traditional reviews frequently lack an effort to derive generalisations or cumulative knowledge from the material examined (Davies, 2000). The objective is to ascertain the scope and variety of existing literature, much of which may be inconclusive, and to identify a gap that new research could address (Tranfield, Denyer, & Smart, 2003). Davies (2000) characterises such evaluations as opportunistic, selective, and haphazard, lacking a systematic and comprehensive examination of all pertinent material.

The primary purpose of this study was to ascertain the key components of TIIC and to investigate their interrelations to facilitate conceptual advancement in TIIC literature. This objective was shaped by our observation of the substantial body of research on Tertiary institution-Industry Collaboration (TIIC), which has produced extensive literature highlighting the mechanisms, including initial conditions, established for the interaction between higher education institutions and industry, along with the outcomes of such partnerships. A systematic review of the existing literature in this domain was deemed essential to evaluate current knowledge and consolidate disparate findings, thereby presenting them in a manner that is more pertinent, reliable, and offers collective insights and guidance for academics, practitioners, and decision-makers.

In accordance with this purpose, we predominantly adhered to the methodology proposed by Tranfield et al. (2003) to conduct the review. We commenced by identifying all pertinent articles published between 1990 and 2014. Literature published before 1990 was excluded due to the perception that collaboration between higher education institutions and industry was deemed less significant during that age (Howells & Nedeva, 2003; Poyago-Theotoky, Beath, & Siegel, 2002). Furthermore, given that the phenomena of TIIC is dynamic (Blumenthal, 2003; Newberg & Dunn, 2002), the cumulative aspect of the discipline ensures that the risk of neglecting significant earlier contributions will be alleviated by contemporary studies that expand upon prior discoveries. The search approach exclusively encompassed peer-reviewed journal papers available in electronic databases, since they possess greater authenticity and are

more likely to address the primary contributions in the field (Payne, Moore, Griffis, & Autry, 2011; Perkmann, Neely, & Walsh, 2011). A search was performed in the following electronic databases for titles and abstracts of potentially pertinent studies: ABI Global, Applied Social Sciences Index and Abstracts, Elsevier (Science Direct), International Bibliography of the Social Sciences, Ingenta, NetEc, and Social Science Citation Index (Web of Science). These specific databases have been chosen due to their extensive coverage of the literature in the relevant field of study. No limitations were imposed regarding the nation of origin, source sector (such as academic, governmental, policy, etc.), or industrial type. Only published works in the English language were included. We examined these databases to identify pertinent studies by employing specific combinations of terms, including: 'tertiary institution' OR 'academia' OR 'higher educational institution' AND 'business' OR 'industry' OR 'firm' AND one of the following: 'alliance', 'bridge', 'collaboration', 'cooperation', 'exploitation', 'innovation', 'inter-organizational relationship', 'interaction', 'link', 'partnership', 'research and development', 'relationship', 'technology transfer', 'knowledge transfer', and 'scheme'. While the use of these terms was anticipated to initially produce a substantial volume of studies, it was essential to guarantee that all possibly pertinent studies were taken into account. This approach produced over 1500 results, deemed our preliminary sample.

Considering that the primary focus of the review is to thoroughly delineate the essential elements of TIIC, we examined the titles and abstracts (and, in some instances, the introductions) of each article to ascertain their principal objectives and contributions (Payne et al., 2011; Shwom, 2014). This stage was crucial for establishing the inclusion and exclusion criteria subsequently utilised to pick our final sample. Multiple preliminary coding themes have evolved inductively. Following extensive deliberations among the research team, five predominant facets of TIIC have been established: forms, motives, formation and operationalisation, facilitators and inhibitors, and outcomes. Based on these factors, we established six questions to serve as criteria for the inclusion and exclusion of research in the review to ascertain the final sample. The following questions are delineated below:

1. Does the study examine the collaboration between tertiary institutions and industry for technology transfer as a primary focus?
2. Does the study examine TIIC motivations?
3. Does the study analyse TIIC forms?
4. Does the study offer insights into the creation and operationalisation of TIIC?
5. Does the study encompass elements that promote or hinder TIIC?
6. Does the study address the results (advantages or disadvantages) of TIIC?

A study was incorporated in the final evaluation if the response to question 1 and at least one of the subsequent questions (2, 3, 4, 5, or 6) was affirmative (i.e., Yes). The screening process included, in addition to the aforementioned questions, a quality evaluation check. A quality evaluation was conducted to differentiate between higher and lower quality studies within the existing evidence base. Quality assessment was essential to evaluate a study's internal validity and the extent to which its design, execution, and analysis have mitigated biases or inaccuracies. The evaluation was based on the content of each study, adhering to a method proposed by Tranfield et al. (2003). The evaluation was facilitated using Farrington's methodological quality scale (Farrington, 2003). the fifth criterion, external validity (which pertains to the generalisability of the study findings beyond the specific context in which the research was conducted).

External validity for quantitative studies and representativeness/triangulation for qualitative analysis. Each study was evaluated and categorised as either "Quality Acceptable" or "Quality Unacceptable," with only those designated as "Quality Acceptable" included in the review. Through the application of inclusion and exclusion criteria, along with quality assessments, the final sample consisted of 109 studies, detailed in Appendix A.

Subsequent to this phase, we used methodologies from qualitative data analysis, specifically the matrix approach and tabulation methodology (Miles & Huberman, 2008), on the complete texts of the ultimately selected publications. This sought to gather facts and information specifically pertaining to the five highlighted critical features. We commenced the coding process by meticulously examining each article, word by word, to identify segments of text and associate them with pertinent major themes (i.e., the fundamental components). The subsequent process involved evaluating the content of each subject, which has been generated as an individual paper or a summary for each important theme. Subsequently, we progressed to the second and third levels of coding by aggregating pertinent information segments under designated titles, which subsequently form the sub-themes associated with each core topic. Furthermore, meticulous attention has been devoted at this stage to analysing and emphasising the divergence and convergence among the various papers, while seeking explanations for any discrepancies. This sought to enhance comprehension of the essence of these essential concepts and their significance to the TIIC subject.

Although the systematic review process demonstrates superior transparency and receptiveness to critique compared to conventional narrative review approaches, it possesses several drawbacks (Hakala, 2011). The initial concern pertains to the parameters of the investigation. The present research analyses and discusses papers published in academic journals from 1990 to 2014. This suggests the possibility of omitting certain pertinent studies (e.g., book chapters) from the review. Nevertheless, this is a permissible technique in systematic reviews (Pittaway & Cope, 2007), as significant contributions in a certain study domain typically manifest consistently in subsequent journal publications. The second limitation pertains to the selection of keywords utilised to regulate the inclusion criterion of the articles. To alleviate the repercussions of this issue, a meticulous three-step review process has been implemented, encompassing the title, abstract, and complete content. This would guarantee that all pertinent studies have been reviewed.

3. RESULTS

This section presents the findings from the systematic review as a response to a specific question. Each question pertains to one of the five predominant themes identified in the investigation.

3.1 What are the organisational structures of TIIC?

The predominant types of TIIC examined in practice and literature include Joint Ventures, Networks, Consortia, and Alliances (Barringer & Harrison, 2000), with variations in the extent of participant interconnection. Nevertheless, authors disagree on the definitions and distinctions of the various kinds of TIIC (Bruneel, D'esteb, & Salter, 2010).

The aforementioned items aligned with the conclusions from the review. Although TIIC seems to include all types of relationships between higher institutions and industry, several additional forms were identified (see Table 1), suggesting that the potential for interaction within TIIC is quite extensive (Shenhar, 1993). Various researchers proposed distinct typologies or taxonomies of the relationships. Chen (1994) categorised the types of TIIC for technology

exchange based on the relationship duration and the technology transfer. Santoro and Gopalakrishnan (2000) propose four classifications for Tertiary institution-Industry Collaborations (TIICs): (1) research support (e.g., Endowment/Trust Fund), (2) cooperative research (e.g., institutional agreements, group arrangements, institutional facilities, informal intentions), (3) knowledge transfer (e.g., recruitment of recent graduates, personal interactions, institutional programs, cooperative education), and (4) technology transfer (e.g., product development and commercialisation activities via tertiary institution research centres).

The review thus validated Blackman and Seagal's (1991) assertion that developing a typology illustrating all potential connections between academic institutions and industry is exceedingly challenging. The framework developed by Bonarccorsi and Piccaluga (1994) was deemed sufficiently comprehensive and appropriate for this investigation. The framework had six primary elements as delineated in Table 1: Personal Informal Relationships, Personal Relationships, Third Party, Formal Targeted Agreements, Formal Non-targeted Agreements, and Creation of Focused Structures. The initial classification by Bonarccorsi and Piccaluga (1994) has been expanded to incorporate more information from the systematic review, as illustrated in Table 1. The six groups demonstrate a progressive level of organisational engagement, which can be succinctly examined across three dimensions: (a) involvement of organisational resources from the tertiary institution; (b) duration of the agreement; and (c) extent of formalisation. In the first dimension, the tertiary institution does not use organisational resources if the firm's interaction is solely with an academic individual, absent a formal agreement with the institution. The involvement of postsecondary institutions in resources escalates from Formal Personal Relationships to Focused Structures, wherein the entire institution engages in specialised frameworks for collaboration with industry. The duration of the agreement between tertiary institutions and enterprises, as the second dimension, may range from brief (yet renewable) in the context of Personal Formal Relationships, to extended in the case of specialised or Focused Structures. Exceptions arise in interactions between tertiary institutions and industries facilitated by a Third Party, which may result in prolonged agreements if the relationship becomes more stable. Upon formalising the agreement, the third dimension is either minimal or entirely lacking in Personal Informal Relationships. In Personal Formal Relationships and Third Parties, the agreement may or may not be formalised, but in other categories, the relationships are formalised (Bonarccorsi & Piccaluga, 1994). Ring and van de Ven (1994) emphasise that the matter of formalisation is crucial, as heightened formalisation and oversight of the relationship in a TIIC may incite conflict and distrust among the parties striving to preserve their organisational autonomy amidst growing interdependence.

1994; Santoro and Gopalakrishnan, 2000.

3.2 What are the motivations behind TIIC?

To examine the motivations for TIIC, we reference Oliver's (1990) framework, which identified six essential conditions as universal determinants of inter-organizational relationships. These contingencies might be viewed as foundational to organisations' desire for interaction. Oliver observed that while each determinant independently suffices to initiate a relationship, these variables may also interact or coexist when organisations opt to establish an interorganizational relationship. According to Oliver, two fundamental assumptions underpin these determinants. Initially, organisations are presumed to intentionally decide to create an InterOrganizational Relationship (IOR) for well-defined objectives. Secondly, an organisational perspective from top management is presumed, however the determinants may also elucidate lower-level and sub-unit factors (Oliver, 1990). Conversely, the six scenarios appeared to align closely with strategic motivations for partnerships (Kyrgidou & Spyropoulou, 2013). Furthermore, the

systematic research revealed that the motivations of higher institutions and industry involved in TIICs strongly correspond with the six essential variables or factors outlined by Oliver (1990). Consequently, these contingencies were employed to classify the motivations for TIICs identified in the investigations. While several motivations may pertain to multiple determinants, they have been categorised under the determinant deemed most suitable. Furthermore, as the reasons for higher institutions to engage in Tertiary InstitutionsIndustry Collaborations (TIICs) differ in certain aspects from those of industry, the motives for both entities are examined independently.

Table 2. Motivations for Tertiary institutions and industry: a comparison.

Relationships and agreements	Results
Personal Informal Relationships	– Academic spin-offs – Individual consultancy (paid for or free) – Information exchange forums – Collegial interchange, conference, and publications – Joint or individual lectures – Personal contact with tertiary institution academic staff or industrial staff – Co-locational arrangement
Personal Formal Relationships	– Student internships and sandwich courses – Students' involvement in industrial projects – Scholarships, Studentships, Fellowships and postgraduate linkages – Joint supervision of PhDs and Masters theses – Exchange programmes (e.g. secondment) – Sabbaticals periods for professors – Hiring of graduate students – Employment of relevant scientists by industry – Use of tertiary institution or industrial facility (e.g., lab, database, etc.)
Third Party	– Institutional consultancy (tertiary institution companies including Faculty Consulting) – Liaison offices (in tertiary institutions or industry) – General Assistance Units (including technology transfer organizations) – Government Agencies (including regional technology transfer networks) – Industrial associations (functioning as brokers) – Technological Brokerage Companies
Formal Targeted Agreements	– Contract research (including technical services contract) – Patenting and Licensing Agreements (licensing of intellectual property rights) – Cooperative research projects – Equity holding in companies by tertiary institutions or faculty members – Exchange of research materials or Joint curriculum development: – Joint research programmes (including Joint venture research project with a tertiary institution as a research partner or Joint venture research project with a tertiary institution as a subcontractor) – Training Programmes for employees

Formal	Non-Targeted Agreements	– Broad agreements for U-I collaborations – Endowed Chairs and Advisory Boards – Funding of tertiary institution posts – Industrially sponsored R&D in tertiary institution departments – Research grant, gifts, endowment, trusts donations (financial or equipment), general or directed to specific departments or academics
	Focused Structures	– Association contracts – Innovation/incubation centers – Research, science and technology parks – Tertiary institution—Industry Consortia – Tertiary institution—Industry research cooperative research centers – Subsidiary ownerships – Mergers

Table 1. Organizational forms of TIIC

Relationships and agreements		– Results
Personal Relationships	Informal	– Academic spin-offs – Individual consultancy (paid for or free) – Information exchange forums – Collegial interchange, conference, and publications – *Joint or individual lectures* – *Personal contact with tertiary institution academic staff or industrial staff – Co-locational arrangement*
Personal Relationships	Formal	– Student internships and sandwich courses – *Students' involvement in industrial projects* – Scholarships, Studentships, Fellowships and postgraduate linkages – *Joint supervision of PhDs and Masters theses* – Exchange programmes (e.g. secondment) – Sabbaticals periods for professors – *Hiring of graduate students* – *Employment of relevant scientists by industry* – *Use of tertiary institution or industrial facility* (e.g., *lab*, *database*, etc.)
Third Party		– Institutional consultancy (tertiary institution companies including Faculty Consulting) – Liaison offices (in tertiary institutions or industry) – *General Assistance Units (including technology transfer organizations)* – Government Agencies (including regional technology transfer networks) – Industrial associations (functioning as brokers) – *Technological Brokerage Companies*

Formal Targeted Agreements	– Contract research (including technical services contract) – *Patenting and Licensing Agreements (licensing of intellectual property rights)* – Cooperative research projects – *Equity holding in companies by tertiary institutions or faculty members* – Exchange of research materials or Joint curriculum development: – *Joint research programmes* (*including Joint venture research project with a tertiary institution as a research partner or Joint venture research project with a tertiary institution as a subcontractor*) – Training Programmes for employees
Formal Non-Targeted Agreements	– Broad agreements for U-I collaborations – *Endowed Chairs and Advisory Boards* – *Funding of tertiary institution posts* – *Industrially sponsored R&D in tertiary institution departments* – Research grant, gifts, endowment, trusts donations (financial or equipment), general or directed to specific departments or academics
Focused Structures	– Association contracts – Innovation/incubation centers – Research, science and technology parks – Tertiary institution—Industry Consortia – Tertiary institution—Industry research cooperative research centers – *Subsidiary ownerships* – Mergers

The *italic* indicates new organizational forms as identified from the review.

Table 2. Motivations for Tertiary Institutions and industry: a comparison

	Tertiary Institutions	Industry
Necessity	– Responsiveness to government policy – Strategic institutional policy	– Responsiveness to government initiatives/policy – Strategic Institutional policy
Reciprocity		– Access to students for summer internship or hiring – Hiring of faculty members

Efficiency	– Access complementary expertise, state-of-the-art equipment and facilities – Employment opportunities for tertiary institution graduates – Access funding for research (Government grant for research & Industrial funding for research assistance, lab equipment, etc.) – Business opportunity, e.g. exploitation of research capabilities and results or deployment of IPR to obtain patents – Personal financial gain for academics	– Commercialize tertiary institution-based technologies for financial gain – Benefit financially from serendipitous research results – Cost savings (easier and cheaper than to obtain a license to exploit foreign technology) – National incentives for developing such relations such as tax exemptions and grants – Enhance the technological capacity and economic competitiveness of firms – Shortening product life cycle – Human capital development
Stability	– Responsiveness to government policy – Strategic institutional policy – Access complementary expertise, state-of-the-art equipment and facilities – Employment opportunities for tertiary institution graduates – Access funding for research (Government grant for research & Industrial funding for research assistance, lab equipment, etc.) – Business opportunity, e.g. exploitation of research capabilities and results or deployment of IPR to obtain patents – –	– Shift in knowledge-based economy (growth in new knowledge) – Business growth – Access new knowledge, cuttingedge technology, state-of-the art expertise/research facilities and complementary know-how – Multidisciplinary character of leading-edge technologies – Access to research networks or pre-cursor to other collaborations – Solutions to specific problems – Subcontract R&D (for example due to lack of in- house R&D) – Risk reduction or sharing –
Legitimacy	– Personal financial gain for academics – Shift in knowledge-based economy (growth in new knowledge) – Discover new knowledge/test application of theory – Obtain better insights into curricula development – Expose students and faculty to practical problems/ applied technologies – Publication of papers – Shift in knowledge-based economy (growth in new knowledge) – Discover new knowledge/test application of theory – Obtain better insights into curricula development	– Enhancement of corporate image Maintain control over proprietary technology

	– Expose students and faculty to practical problems/ applied technologies – Publication of papers	
	– Societal pressure – Service to the industrial community/society – Promote innovation (through technology exchange) – Contribute to regional or national economy – Academics' quest for recognition or achieve eminence	
Asymmetry	– NA	— Maintain control over proprietary technology

3.3 Perspective of tertiary institutions

The investigation indicates that the motives for tertiary institutions to engage with industry are summarised in Table 2. Nevertheless, none of the reasons discovered for higher education institutions could be classified under the determinant. The asymmetry indicates that tertiary institutions are not motivated to engage in partnerships with industry to exert power or control over its resources.

Essentiality. In the context of escalating global competition and swift technological advancements, governments are promoting partnerships between higher education institutions and industry to enhance innovation efficiency and subsequently increase wealth creation (Barnes, Pashby, & Gibbons, 2002). Hall, Link, and Scott (2001) and López-Martínez, Medellín, Scanlon, and Solleiro (1994) assert that a critical concern for policymakers and research budget stakeholders, such as Research Councils, is the efficacy of the interface between higher education institutions and industry. This interface is essential for the prompt and effective transfer of applicable research to industry, thereby fostering economic growth and well-being. Consequently, tertiary institutions are progressively focussing on promoting Tertiary institution-Industry Collaboration (TIIC) in alignment with government policy and as part of their institutional strategic initiatives (Howells, Nevada, & Georghiou, 1998; Perkmann, King, & Pavelin, 2011a).

Mutual exchange. Sherwood, Butts, and Kacar (2004) contend that higher education institutions provide substantial access to diverse research expertise and infrastructure, while industry grants significant access to expertise in product development and commercialisation, market knowledge (Sherwood et al., 2004), and employment opportunities for graduates of tertiary institutions (Lee & Win, 2004; Santoro & Betts, 2002). Consequently, postsecondary institutions may be incentivised to establish partnerships with industry to leverage these assets for reciprocal benefit.

Effectiveness. Government grants facilitate new TIIC initiatives (Harman & Sherwell, 2002); however, the mounting pressures on public funding for tertiary institutions have strongly incentivised these institutions to pursue alternative revenue sources for fundamental research and equipment. This includes the commercialisation of faculty research and the exploitation of

intellectual property rights or patent licensing, aimed at diminishing their reliance on public funding (Logar, Ponzurick, Spears, & France, 2001). Blumenthal (2003) and Santoro and Gopalakrishnan (2001) indicate that connections with industry are attractive to tertiary institutions due to the reduced bureaucratic constraints associated with sector funding compared to public support. Other scholars, like Siegel, Waldman, Atwater, and Link (2004), have asserted that faculty members may be incentivised by personal financial benefit to engage in connections with industry.

Equilibrium. Collaboration theory posits that inter-organizational relationships serve as a technique to be employed when the environment becomes significantly unstable and unpredictable (Boddy, Macbeth, & Wagner, 2000; Grey & Wood, 1991). Oliver (1990) posits that organisations are driven by the stability contingency to engage in collaboration, thereby addressing environmental uncertainty to attain predictability and reliability. The review identified motivations connected to this contingency, including the transition to the contemporary knowledge-based economy, which has transformed TIIC from sponsorship to partnership, emphasising continuous engagement, as stated by Jacob, Hellstrom, Adler, and Norrgren (2000). The expansion of new knowledge has imposed significant resource demands on individual tertiary institutions, prompting them to form alliances with industry to maintain a competitive advantage across all disciplines. Cyert and Goodman (1997) assert that scientists in tertiary institutions generally perceive these connections as conducive to the development and testing of hypotheses, refinement of their skills, and the training and placement of their students. Meyer-Krahmer and Schmoch (1998) and Santoro and Chakrabarti (2001) have asserted that higher education institutions partner with industry to immerse academics and students in industrial settings, providing access to the latest findings from industrial research, instructional case studies, and practical challenges via projects. All of these factors contribute to curriculum creation and enhance the quality of instruction (Santoro & Gopalakrishnan, 2000). Moreover, Harman and Sherwell (2002) propose that a significant motivation for higher education institutions to collaborate with industry is the opportunity for publication in academic journals, as generating publicly accessible information would underscore the fundamental mission of these institutions in knowledge dissemination (Newberg & Dunn, 2002).

Legitimacy. Another impetus for higher education institutions to forge partnerships with industry is an inherent aspiration to elevate their prestige (Mora-Valentin, 2000). There is an increasing societal (political and public) demand for tertiary institutions to exhibit enhanced social accountability, entrepreneurship, and overall economic significance to society (Cohen, Florida, Randazzese, & Walsh, 1998). This demand compels tertiary institutions to engage in collaborative efforts with industry through the exchange or dissemination of knowledge and technology (Siegel, Waldman, & Link, 2003), thereby facilitating their contribution to economic development (Blumenthal, 2003; Hagen, 2002). Siegel et al. (2004) noted that a key motivation for scientists in tertiary institutions is recognition within the industrial scientific world, which generally arises from collaborative publications, presentations at esteemed conferences, and research funding. Moreover, industrial sponsorship facilitates professors in undertaking research that enables them to attain academic distinction.

3.4 Sector viewpoint

The industry's incentives for engaging with postsecondary institutions encompassed all six of Oliver's contingencies, as detailed in Table 2.

Essentiality. Governments have been necessitated by swift global transformations in the competitive and technological landscape to implement measures that foster research

collaboration between the two sectors, as they contend that tertiary institutions can contribute to economic revitalisation if they share their knowledge and expertise through industry-linked partnerships (Mora-Valentin, 2000; Perkmann et al., 2013). Consequently, numerous regional and national research initiatives have been established by governments (Caloghirou, Tsakanikas, & Vonortas, 2001), including the UK Knowledge Transfer Partnerships. For industry to derive maximum value from these programs, collaboration with tertiary institutions is essential (Howells et al., 1998).

Imbalance. An impetus for industry to engage in tertiary institution-industry collaboration (TIIC) is the pursuit of commercialising technology developed by tertiary institutions for profit (Siegel, Waldman, & Link, 2003). Consequently, numerous corporations seek exclusive rights to the developed technologies. Consequently, they are apprehensive about preserving authority over the trajectory of research at higher education institutions (Newberg & Dunn, 2002) and retaining proprietary control over the technology.

Mutual exchange. Another impetus for industry to engage in TIICs is to obtain access to students for summer internships or recruitment (Ankrah, Burgess, Grimshaw, & Shaw, 2013; Siegel, Waldman, & Link, 2003). Most TIIC research programs aim to recruit the most qualified students due to the interaction (Fellera, Ailesb, & Roessnerb, 2002). Faculty members or senior researchers may also be engaged as consultants during their permitted external work hours (Perkmann, King, et al., 2011).

Effectiveness. From an efficiency perspective, there are multiple incentives for industries to engage in TIICs with higher education institutions. Cohen et al. (1998) assert that higher education institutions and industrial research can improve enterprises' sales, research and development productivity, and patenting endeavours. Companies collaborate with higher education institutions to potentially gain financially from unexpected outcomes of research endeavours, innovative products, and cost efficiencies, particularly in knowledge generation and utilisation (George, Zahra, & Wood, 2002), all of which can confer a competitive edge and enhance financial performance (Grant, 1996). Another motive is the encouragement of research and development (R&D) and technological advancement by governments through financial instruments such as grants and tax credits, alongside the establishment of a legal framework that supports R&D (Barnes et al., 2002). Furthermore, the advancement of human capital, encompassing ongoing professional education (Santoro & Chakrabarti, 1999), access to innovative technologies with a multidisciplinary approach, and state-of-the-art research facilities, constitutes industry incentives, as these factors alleviate the effects of diminishing product life cycles (PLC) and consequently bolster competitive advantage (Bonaccorsi & Piccaluga, 1994). TIIC provides firms access to a plethora of innovative competitive technologies that significantly reduce the gap between design and manufacturing (Santoro & Gopalakrishnan, 2001). This would facilitate the rapid recovery of development expenditures for a particular product, as the agreements may encompass downstream operations like development and prototyping.

Stability. The transition to a knowledge-based economy is recognised as a compelling reason for industries to engage with academic institutions (Santoro & Betts, 2002). Pavitt (1988) asserts that academic research enhances the ability of corporations to address certain complicated issues. A growing body of research indicates that TIIC effectively fosters the establishment and development of technology-driven enterprises, especially SMEs, for commercial expansion (Klofsten & Jones-Evans, 1996). The absence of in-house research and

development within the industry is identified as a significant impetus for collaboration with higher education institutions. Lopez-Martinez et al. (1994) demonstrated that the absence of internal capabilities for conducting technical research was the primary incentive for business executives. According to Schartinger, Rammer, Fischer, and Fröhlich (2002), collaboration is esteemed even among organisations with R&D, since it mitigates risk and optimises scarce resources, including people and capital assets. Additionally, access to research networks that include other higher education institutions and companies, along with the possibility of intricate collaborations through consortia comprising multiple firms, higher education institutions, and other partnerships, serve as incentives for industry to engage in collaboration with higher education institutions (George et al., 2002).

Legitimacy. Siegel, Waldman, and Link (2003) noted that companies can frequently improve their image and reputation by affiliating with a distinguished institution. Affiliations with esteemed and renowned organisations, such as prominent research tertiary institutions, could augment a company's credibility among influential stakeholders (Hong & Su, 2013; Mian, 1997).

3.5 What is the process by which TIICs are established and implemented?

Numerous models on the genesis of TIICs are documented in the literature (e.g. Tuten & Urban, 2001). The Mitsuhashi (2002) model for business-to-business alliance building is deemed pertinent for the adaption of TIICs formation. Mitsuhashi delineates the process of alliance formation in five stages, commencing with the identification of alliance opportunities and concluding with the execution of the agreement. A revised iteration of Mitsuhashi's model is illustrated in Table 3 for TIIC development, grounded in the evidence derived from the systematic review. The number of stages in the construction of a certain organisational structure of TIIC is contingent upon its level of formality and complexity. The initial two phases of Mitsuhashi's methodology (Defining Alliance Opportunities and Identifying Prospective Partners) have been consolidated into Stage 1 (Partnership Identification) in Table 3. The third procedure in Mitsuhashi's approach, referred to as Making Contacts, has been retained as Stage 2, designated Make Contact. The fourth procedure in Mitsuhashi's paradigm, termed Due Diligence, is delineated into two parts in Table 3: Stage 3 (Partner Assessment and Selection) and Stage 4 (Partnership Negotiation). The final procedure in Mitsuhashi's approach, previously termed Making Deals, is now designated as Agreement Signing, Stage 5 in Table 3. The initial stage in forming a TIIC is to define the partnership's purpose, followed by identifying a partner. A variety of criteria have been proposed for partner selection. Barnes et al. (2002) recommend that regardless of the criteria for partner selection, a thorough evaluation of potential partners should be conducted, as significant advantages may be derived from this process, particularly in ensuring that the collaboration is tailored to the specific TIIC.
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A characteristic highlighted in the research that aids partner evaluation is pre-existing relationships. Numerous research indicates that the results of TIICs improve when partners possess prior collaborative experiences (e.g. Dill, 1990; Geisler, 1995). Culati and Gargiulo (1999) assert that pre-existing relationships between partners are significant, as prior experiences with a potential partner may foster trust between organisations. This interorganizational trust is gradually established through repeated interactions and mutual adaptations to the expectations, developments, and requirements of previous alliances. Schartinger, Schibany, and Gassler (2001) concur and assert that prior collaborative experience is essential, as satisfaction with previous interactions—on personal, technological, and scientific dimensions—diminishes interpersonal and institutional barriers, hence increasing the

likelihood of tertiary institution-industry collaboration (TIIC). Peterson (1995) emphasises the necessity of explicitly delineating the managerial and administrative obligations of the TIIC, including financial accountability, during the formation stage. Furthermore, Peterson proposes that a cohesive organisational framework, appropriate for the partners and the partnership's goals, should be established under the guidance of a general manager appointed by the partners. Moreover, the equitable involvement of participants in guiding the collaborative endeavour is essential (Peterson, 1995). The project plan, characterised by Buttrick (2000) as a critical success factor, must be jointly endorsed by the partners, with clearly defined milestones. Moreover, Peterson (1995) posits that success metrics must be established, interim and final deliverables delineated, and all discrepancies among partners reconciled to prevent disputes during the partnership.

Table 3. TIIC formation process

Stages	Steps
Formation process	– Establish the purpose
Stage 1: Partnership Identification	– Obtain general knowledge of the capabilities of potential partners – Consider pre-existent relationships
Stage 2: Make Contact	– Identify prospective partners –
Stage 3: Partner Assessment and Selection	– Objectively assess the strategic interests of the potential partners – Analyze actual versus professed capabilities of potential partners – Determine and organize the appropriate mix of partners – Choose the partners
Stage 4: Partnership Negotiation	– Define the partnership – Define and agree on the partnership's documented purpose or mission/vision – Determine the specific common goals/objectives for the particular effort – Define the organizational structure of the partnership – Define the management and administration of the partnership with clearly defined responsibilities – Agree on the plan – Specify the milestones – Identify the measures/indicators for success – Specify the interim and/or final deliverables
Stage 5: Agreement Signing	– Preparation and signing of collaboration agreement and/or intellectual property agreement

Upon establishing the relationship, it is imperative, contingent upon the formality and intricacy of the TIIC, to formalise it with a legal contract (Kanter, 1994). However, the significance of commitment is paramount, sustained not solely by formal agreements but also by informal dedication cultivated through camaraderie and mutual trust (Babaa, Shichijo, & Seditac, 2009). Peterson (1995) recommends that the legal document, which may serve as the intellectual property agreement for certain TIICs, must delineate all relationships and agreements among the partners, both throughout the research collaboration and after the project's conclusion, and it should receive approval from all partners. Subsequent to the establishment of the TIIC, the relationship transitions into an operational phase (Sherwood et al., 2004), characterised by a continuous process of learning and evolution (Ritter & Gemu¨nden, 2003), wherein various

factors either facilitate or impede the relationship (these factors are detailed below). During the operational phase, several actions occur among the organisations aimed at fulfilling the objectives of the TIIC (Ritter & Gemu¨nden, 2003). The activities and their occurrences are summarised in Table 4.

Table 4 was created by extracting pertinent themes from the studies included in the systematic review and categorising them into six sub-headings: (1) Meetings & Networking; (2) Communication; (3) Training; (4) Personnel Mobility; (5) Employment; and (6) Other Activities. The frequency and quantity of actions within a specific organisational structure of TIIC were determined to be contingent upon the formality and intricacy of the relationship.

3.6 What variables assist or impede the operation of TIIC?

Numerous factors that either promote or obstruct the functioning of TIICs were identified in nearly all reviewed studies, corroborating the assertion by various researchers that the literature on the factors influencing TIIC is indeed extensive (Bruneel et al., 2010; Cricelli & Grimaldi, 2010). The factors, if properly handled, were determined to positively influence the perceived success of knowledge and technology transfer. Conversely, when the same characteristics were overlooked or poorly managed, there was often a comparable detrimental effect on the perceived efficacy of knowledge and technology transfer. The factors are encapsulated in Table 5, categorised under seven headings: (1) Capacity and Resources; (2) Legal Issues, Institutional Policies, and Contractual Mechanisms; (3) Management and Organisational Issues; (4) Technological Issues; (5) Political Issues; (6) Social Issues; and (7) Miscellaneous Issues. Table 5 was produced by utilising the initial two categories (i.e. Capacity and Resources, and Legal Issues, Institutional Policies, and Contractual Mechanisms) from Fairweather (1991), while devising the subsequent five categories to align with the identified sub-themes.

The array of parameters substantiated Barnes et al.'s (2002) assertion that the efficacy of a collaborative project is dictated by a complex interplay of elements, alongside the aggregate effect of both adverse and beneficial influences from those elements. Moreover, among the total identified factors, those pertaining to management and organisation constituted 45%, surpassing all other categories. This aligns with the findings of Siegel, Waldman, and Link (2003), which indicated that organisational and managerial issues are pivotal factors that either facilitate or impede relationships between tertiary institutions and industry.

3.7 What are the results of TIIC?

Like any other form of inter-organizational interaction, TIIC presents distinct advantages and disadvantages for both entities involved. Numerous research (e.g. Geisler, 1995; Lee, 2000) have correlated motivations with the rewards later attained in TIIC. Nonetheless, not all advantages can be shown by the aforementioned motivations. Consequently, the particular advantages delineated in the studies are addressed individually in this section.

Table 4. Activities during TIIC

Activities	Results
Meetings & Networking	– Meetings (often in a formal way) – Conferences/Workshops/Seminars/Symposia/Forums – Expositions, Trade Shows/Fairs/Exhibitions – Informal social gatherings (e.g. U-I get-togethers, breakfast meetings) – Networking activities (the process of contacting and being contacted and maintaining these relationships/links)

Communication	– Communications by voice/mail/email/conference calls (formal or informal) – Publications or co-publications of research papers, reports, newsletters, booklets, bulletins, pamphlets
Training	– Tailored educational programmes for industrial personnel – Internships in company for students – Students' involvement in industrial projects – Joint supervision of Masters degree dissertations and PhD Thesis by academic and industry personnel – Industrial fellowships for students and faculty – Industry involvement in curriculum development
Personnel Mobility Employment	– Exchange of personnel to work at one another's research facilities – Lectures by industry members at tertiary institutions and vice versa – Employment of tertiary institution researchers in the business sector – Employment of graduates particularly those related to the project

3.8 Advantages that contribute to the overall economy

1. Economic;
2. Institutional Benefits (i.e., advantages obtained by Tertiary institutions and Industry); and
3. Social Benefits (i.e., advantages pertaining to communal engagement or fostering sociability), as seen in Table 6.

Conversely, numerous disadvantages have been noted in the literature, with certain researchers contending that while the advantages of TIIC significantly surpass any risks, it is crucial for both higher education institutions and industry, especially the former, to acknowledge the potential drawbacks. This recognition is essential for implementing robust policies and administrative procedures (Harman & Sherwell, 2002) to prevent failure and ensure the success of the partnership. The disadvantages have been categorised into four relevant classifications: (1) Deviation from Mission or Objective; (2) Quality Issues; (3) Conflicts; and (4) Risks. Table 6 consolidates these limitations for both higher education institutions and industry. Notably, research on TIIC predominantly focusses on tertiary institutions rather than industry when examining its possible disadvantages. This can be elucidated by examining the motivations of tertiary institutions about TIIC. Table 2 reveals that access to research funding is the predominant reason for tertiary institution-industry collaboration among tertiary institutions in the literature. Tertiary institutions, motivated primarily by economic factors and informed by resource dependence theory (Pfeffer & Salancik, 1978), are likely to occupy a precarious position due to their diminished power and control over agreements, a common characteristic in cross-sector collaborations involving industry as a principal stakeholder (Al-Tabbaa, Leach, & March, 2014). This precarious situation is likely to engender numerous other problems, such

as industry pressure for expedited outcomes or the potential restriction of knowledge distribution generated by the TIIC in accordance with industry demands.

Table 5. Factors facilitate or impede TIICs

Main categories	The factors
Capacity and Resources	– Adequate resources (funding, human and facilities) – Incentive structures for tertiary institution researchers – Recruitment and training of technology transfer staff – Capacity constraints of SMEs
Legal issues, and Contractual Mechanisms	– Inflexible tertiary institution policies including intellectual property rights (IPR), patents, and licenses and contractual mechanisms – Treatment of confidential and proprietary information Moral responsibility versus legal restrictions (research on humans) –
Management and Orga Issues	– Leadership/Top management commitment and support – Collaboration champion – Teamwork and flexibility to adapt – Communication – Mutual trust and commitment (and personal relationships) – Corporate stability – Project management – Organization culture (cultural differences between the world of academia and of industry) – Organization structure (tertiary institution administrative structure and firm structure) – Firm size (size of organization) – Absorptive capacity – Skill and role of both tertiary institution and industry boundary spanners – Human capital mobility/personnel exchange
Issues Relating to the Technology	– Nature of the technology/knowledge to be transferred (tacit or explicit; generic or specialized; academic rigor or industrial relevance)
Political Issues	– Policy/legislation/regulation to guide/support/encourage UIC (support such as tax credits, information networks and direct advisory assistance to industry)
Social Issues	Enhancement in reputation/prestige –
Other Issues	– Low level of awareness of tertiary inst capabilities – Use of intermediary (third party) – Risk of research – Cross-sector differences/similarities – Geographic proximity

Table 6. TIIC outcomes

Benefits	Tertiary institutions	Industry

Economic-related	— Source of revenue (both public and private)	– Patents/IPRs/licensing income – Additional income or financial benefit to researchers – Create business opportunities – Contribution to local/regional economic development	– New products and/or processes – Improved products and/or processes – Patents, prototypes, generate IPRs, etc – More cost-effective than similar research in-house – Improved competitiveness – Access public grants – Promote economic growth/enhancement of wealth creation
Institutionalrelated	Exposure of students and faculty to practical problems/new ideas and/or to state-of-theart technology, with positive effects on the curriculum – Provide a ‘‘test bed’’ for feedback on research ideas, results/interpretations for other		– Improved innovative ability and capacity/ Keep up to date with major technological developments – Advance new technologies – Accelerates commercialization of technologies/Increases speed of innovation to enhancement of academic ideas/theories – Stimulate technological advancement and/or research activities in certain key areas – Acquisition of or access to up-to-date

equipment
– Training and employment opportunities for students
– Build credibility and trust for the academic research among practitioners
– Stimulate the development of spinoffs (or spin-off companies)
– Provide opportunity for companies to influence and encourage the development of particular lines of tertiary institution research
– Joint publications with industry

		– Publication of papers by academics	
		market – No inter-firm conflicts of interest – Provide much needed legitimacy for industry products (e.g. software programme) – Access to new knowledge and leading edge technologies and/or a wide variety of multidisciplinary research expertise and research infrastructure – Influence tertiary institution research directions and new programs for industry good – Access to specialized consultancy/Identify relevant problems/Solve specific technical problems – Product testing with independent credibility in testing – Training/continued professional development – Opportunity to access a wider international network of expertise – Act as a catalyst that leads to other collaborative ventures – Joint publications – Hiring of talent graduates	
Social-related	Service to the community	– Enhancement of tertiary institution's reputation	– Enhance reputation by becoming more social responsible business
Drawbacks	– Threats to research autonomy or integrity for commercial advantage that may have a negative impact on culture of open science and affect or tertiary institution mission (Core Ethic) – Confidentiality agreements may block the dissemination of knowledge – Could result in the abandonment of long-term basic research in favor of results-oriented, short-term, applied research and technology transfer – Concern that the end result of collaboration could be short-term contracts in which industry would require 'quick and dirty' solutions to problems, with tertiary institution departments acting as extensions to the research activities of firms	Deviation from Mission Objective	
	– Slow academic bureaucracies may stifle technology commercialization, depress the firm's performance and delay the fulfillment of the firm's objectives – Diversion away from the 'bottom-line' issues of industry like return on capital investment – Collaboration may be costly due to increase in administrative overheads, as industry may have to Quality Issues Potential diversion of energy and commitment of individual staff who are involved in interaction with		

		ational activities – Could affect types of research questions addressed and reduce the quantity and quality of basic research	– Low intellectual level of some contract work – Results in theoretical and impracticable solutions since tertiary institution staff are too theoretical and not very practical whereas industry's focus is much more problem centered on critical situations requiring immediate attention
	develop specific managerial and administrative competencies, which may be a time-consuming process		
Conflicts	Conflicts between researchers and company over the release of adverse results/damage in professional relationships among the researchers – Biased reporting by researchers sponsored by companies in favor of positive experimental results relating to company products		– Disharmony and discord during R&D development – Intellectual property disputes and patenting disagreement
Risks	— Dilemma of either publishing results for short-term revenue and academic recognition or withholding until they are patented, with the risk of the technology becoming obsolete – Risks that academic—industry relationships pose to human subjects of research and to the integrity of academic investigation		– Diminished of control or leakage of proprietary information – High failure rate collaborations – Financial risk to industry – Risk of incomplete transfer or non-performance of technology – Market risk where there is uncertainty of the success of the product launched in the market

4. DISCUSSION

The partnership between higher education institutions and industry is primarily seen as a method to enhance economic innovation by promoting the transfer and application of technology-related knowledge and expertise across sectors (Inzelt, 2004; Perkmann, Neely, et al., 2011). This collaboration possesses two different traits. TIIC represents a collaborative framework between higher education institutions and commercial organisations for the interchange of both tangible resources (such as funding, materials, and equipment) and intangible resources (including technology and data) (Perkmann et al., 2013). Secondly, akin

to cross-sector collaboration (e.g., Kindred & Petrescu, 2014; Kivleniece & Quelin, 2012), partners generally possess both distinct (e.g., academic publishing for higher education institutions and technical problem-solving for industry) and shared objectives (e.g., generating impact by delivering solutions to societal issues) that motivate their collaborative efforts. This illustrates the strategic impact of collaboration, as TIIC is perceived as a logical process. Strategic effect transpires when organisations justify their inter-organizational ties as a means to obtain the resources they lack (Airto, 2001; Koka & Prescott, 2002). In other terms, TIIC is seen as a logical process when it is predominantly pursued for the aggregation and exchange of various resources.

TIIC, as a distinct type of inter-organizational connection, can be perceived as a process aimed at knowledge production, resulting in the generation of new knowledge that neither party previously held (Hardy, Phillips, & Lawrence, 2003; Mowery, Oxley, & Silverman, 1996). In this context, knowledge is viewed as a tacit, context-dependent entity, rather than a codifiable and transferable resource between organisations, generated through continuous social interactions among the actors of the partners throughout the duration of the collaboration (Powell, Koput, & Smith-Doerr, 1996). This indicates that the efficacy of collaboration, regarding knowledge generation, can be assessed by the diversity and strength of an organization's external connections (Huggins, Johnston, & Thompson, 2012; Nonaka, 1994; Simonin, 1997). Consequently, Powell et al. (1996) propose that a distinction be made between information transmission and knowledge generation when examining collaboration outcomes. The former views the inter-organizational interaction as a rational process that delineates the objectives of the relationship, along with the extent and scope of each organization's participation. In the latter scenario, collaboration is characterised as an illogical, informal, and unstructured process wherein the relationship between two organisations develops organically through unanticipated and ongoing encounters among participants from both entities. This discussion concludes that TIIC may be perceived as either a rational process, emphasising planned resource and knowledge transfer, or an irrational process, where knowledge production occurs through informal social interactions between organisations. Nevertheless, our study revealed that the perception of TIIC as a rational process is predominantly represented in the TIIC literature. This perspective may be elucidated by the process through which the partnership is executed, strategised, and implemented. Generally, every TIIC undergoes an extensive evaluation process by both partners prior to the formulation and signing of an agreement (Bruneel et al., 2010). Two primary issues necessitate comprehensive assessment and investigation.

Due to economic pressures, stakeholders of tertiary institutions and companies hold elevated expectations for their organisations to exhibit accountability and effectiveness in resource utilisation when forming inter-organizational connections (Nahapiet & Ghoshal, 1998). For instance, governmental and other funding entities anticipate that tertiary institutions will employ TIIC to tackle societal social or economic issues (e.g., enhancing the employability of graduates), while corporate shareholders expect their companies to pursue TIIC to ascertain the commercialisation of new technologies (Adler & Kwon, 2002). Secondly, collaboration across sector borders poses the potential of mission creep for tertiary institutions (cf. Careya, Lawsonb, & Krausec, 2011). This occurs when the primary goals and functions of tertiary institutions are affected by the commercial objectives of their business partners. Furthermore, as noted in the disadvantages section, tertiary institutions may experience reputational harm if any of its commercial partners engage in unethical or socially unacceptable conduct. This

danger is particularly pertinent as, in recent years, business has increasingly been perceived as a significant contributor to social, environmental, and economic issues. Corporations are commonly viewed as thriving at the detriment of the larger community (Porter & Kramer, 2011, p. 64). Based on these two issues, the prevailing view of TIIC as a rational process is justifiable, as both partners aim to identify specific and measurable objectives for their interaction, plan requisite procedures or activities, and clarify the potential impact on organisations and society. Moreover, perceiving TIIC as a rational process would enable higher education institutions to judiciously choose their business partners and delineate the parameters of their engagement regarding resources and responsibilities, thereby safeguarding these institutions from the potential loss of legitimacy should their partners' reputations decline due to social or environmental transgressions. A methodical procedure is essential to structure this relationship and prevent tertiary institutions from straying from their primary objective: education and knowledge advancement.

Nonetheless, we do not want to reach a normative conclusion in this context. We do not contend that the logical perspective is superior than the irrational one in the examination of TIIC. We want to offer an explanatory account of the predominance of the rational perspective in the existing literature, as evidenced by our analytical findings. Although infrequent in literature, the irrational perspective remains a significant and complementary theoretical framework for analysing the nature of TIIC. Understanding collaboration as a political and social interaction process is crucial for comprehending how knowledge is generated when partners from diverse sectors, such as academic institutions and industry, work together. Furthermore, the irrational perspective is pertinent when examining the development of informal 'personalised' collaboration between organisations, including higher education institutions and industry (De Carolis & Saparito, 2006), where "certain critical R&D practices appear to pursue their own paths and 'rationalities' independent of deliberate managerial oversight and direction" (De Carolis & Saparito, 2006, p. 190). Consequently, examining the influence of both informal and formal relationships and social interactions is crucial for comprehending the innovation process in TIIC (Dess & Shaw, 2001), as this process is fundamentally based on the socially embedded nature of knowledge creation (Sirmon, Hitt, & Ireland, 2007).

4.1 The foundational philosophy of TIIC: advancing an integrated perspective

As previously said, TIIC in the literature has been perceived as both a rational and an irrational process. This indicates that scholars in this field highlight the significance of interdependency (the rational perspective of TIIC) and interaction (the irrational perspective of TIIC) theories in the formation, evolution, and sustenance of these connections. Interdependency theories emphasise the influence of the external environment on the establishment of TIIC, whereas interaction theories examine the internal development and sustenance of these relationships (Geisler, 1995).

The literature presents various perspectives on interdependency theories, including sociological viewpoints, behaviorally-oriented paradigms, and those derived from economics. Six prevalent viewpoints have been identified (Barringer & Harrison, 2000), namely: Transaction Cost Economics, Resource Dependency, Strategic Choice, Stakeholder Theory, Organisational Learning, and Institutional Theory. Transaction Cost Economics (TCE) posits that transactions, or economic exchanges, serve as the fundamental unit of analysis for an organization's economic interactions, which aim to minimise production costs and enhance efficiency (Tadelis & Williamson, 2012). Consequently, it may elucidate the rationale behind the propensity of

educational institutions and corporations to establish partnerships aimed at reducing their technological development expenditures. Nonetheless, TEC faces criticism for its narrow emphasis on efficiency maximisation and cost minimisation, neglecting other significant factors such as relational learning (Dekker, 2004). Likewise, the Resource Dependency (RD) theory may elucidate the motivations for Tertiary institution-Industry Collaboration (TIIC), as both academic institutions and the industry regard themselves as reliant on resources. Although RD theory is highly enticing, it possesses many limitations. It primarily neglects to elucidate why organisations may opt for alternative strategies beyond alliances to address perceived resource deficiencies, such as raising new capital to acquire resources through market transactions (Child, Faulkner, & Tallman, 2005), which is frequently preferred over alliance formation. Furthermore, not every organisation within an interorganizational field serves as a viable resource for the other party (Pennings, 1981; Powell et al., 1996), reflecting the irrational process perspective of TIIC. The Strategic Choice (SC) theory is a valuable theoretical framework that elucidates organisations' strategic decisions regarding competitiveness. Decisions are deemed reasonable if they cultivate a competitive advantage for a corporation or enable it to acquire greater influence in a certain market (Santos & Eisenhardt, 2005). This viewpoint may also be pertinent, as higher education institutions and corporations may collaborate for strategic purposes (e.g., advantages from economies of scale in collaborative research or expedited access to emerging technology). Nonetheless, a significant flaw of this theory is the lack of consensus on categorising the various extant TIIC techniques into coherent categories for analysis (Barringer & Harrison, 2000). Furthermore, techniques exhibit varying degrees of success across different contextual situations (Kent, 1991).

Stakeholder Theory (ST) posits that an organization’s stakeholder groups—individuals or entities that can influence or are influenced by the organization’s aims (Freeman, 1984)—are crucial for sustaining its social legitimacy (Dacin, Oliver, & Roy, 2007). Organisational legitimacy is attained when its operations align with the societal norms and regulations of its operational context (Zukin & Dimaggio, 1990). Consequently, by contemplating the TIIC environment, higher education institutions and corporations may pursue partnerships to enhance their comprehension of and regard for the objectives of all pertinent stakeholders in their principal operational and strategic choices (Adler & Kwon, 2002). Despite its robustness, stakeholder theory is characterised by ambiguity regarding the prioritisation of stakeholder interests (Langtry, 1994), and it is deficient in context and causal laws to elucidate the process (Jensen, 2002). Learning Theory (LT) underscores the significance of information in establishing and sustaining competitive advantages (Larsson, Bengtsson, Henriksson, & Sparks, 1998). However, due to the often tacit nature of knowledge, which complicates its valuation and acquisition in the marketplace, an organisation seeking to acquire a specific skill is more likely to succeed by establishing a partnership with an organisation that excels in that domain (Barringer & Harrison, 2000). From this viewpoint, it can be asserted that TIIC occurs to leverage learning chances, as TIIC is very proficient in facilitating knowledge exchange among organisations (Hoffmann & Schlosser, 2001). While the LT seems conceptually appropriate for elucidating TIIC, a limitation of the theory is its focus on competency and skill development and transfer, neglecting the associated costs and the risk of losing proprietary information beyond the intended scope of collaboration (Hamel, Doz, & Prahalad, 1989). Finally, Institutional Theory (IT) posits that organisations face institutional forces that compel them to adopt particular practices to align more closely with the norms of their external contexts (DiMaggio & Powell, 1983). Motivated by these forces, tertiary institutions and business may pursue partnership to attain legitimacy and adhere to established societal standards, as a

consequence of institutional pressure. A firm may pursue TIIC to project an image of "social responsibility" by investing in societal issues through partnership, while tertiary institutions may aim for TIIC to enhance practical relevance and so be viewed as effective and accountable. However, it emphasises institutionalisation as a conclusion rather than a process, so disregarding the influence of power (Zucker, 1987) and group interests (Perrow, 1986). Furthermore, it is challenging within the realm of IT to elucidate the rationale behind the existence of certain interaction forms, particularly when they deviate from the status quo (Barringer & Harrison, 2000).

Interaction theories (ITs), including the social network approach (e.g., Borgatti & Molina, 2003; Brass, Galaskiewicz, Greve, & Tsai, 2004), are crucial in comprehending the formation, assessment, and sustainability of TIIC (Geisler, 1995). The ITs view tertiary institutions and industry as autonomous entities, suggesting that a partnership could commence if either entity takes the initiative. Furthermore, the establishment of organisational connections may be enhanced by pre-existing relationships (Turnbull, Ford, & Cunningham, 1996). Consequently, the ITs elucidate the dynamics of TIIC and the evolution of relationships through the increasing importance of commitment, trust, and communication (Levinthal & Fichman, 1988; Ritter & Gemu¨nden, 2003). Nonetheless, these theories are constrained as they primarily emphasise the continuous social interactions among organisational actors, while neglecting the significance of managing TIIC as a rational strategy that necessitates a premeditated and systematic perspective on the collaboration process and its anticipated results, as previously elucidated. The ITs assert that inter-organizational cooperation emerges within particular relationships and develops via continuous interaction (Heide & Miner, 1992). In other words, ITs focus on the relationship process dynamically, in contrast to the static and preset nature of interdependency theories (Geisler, 1995).

4.2 A systematic examination of partnership between tertiary institutions and industry

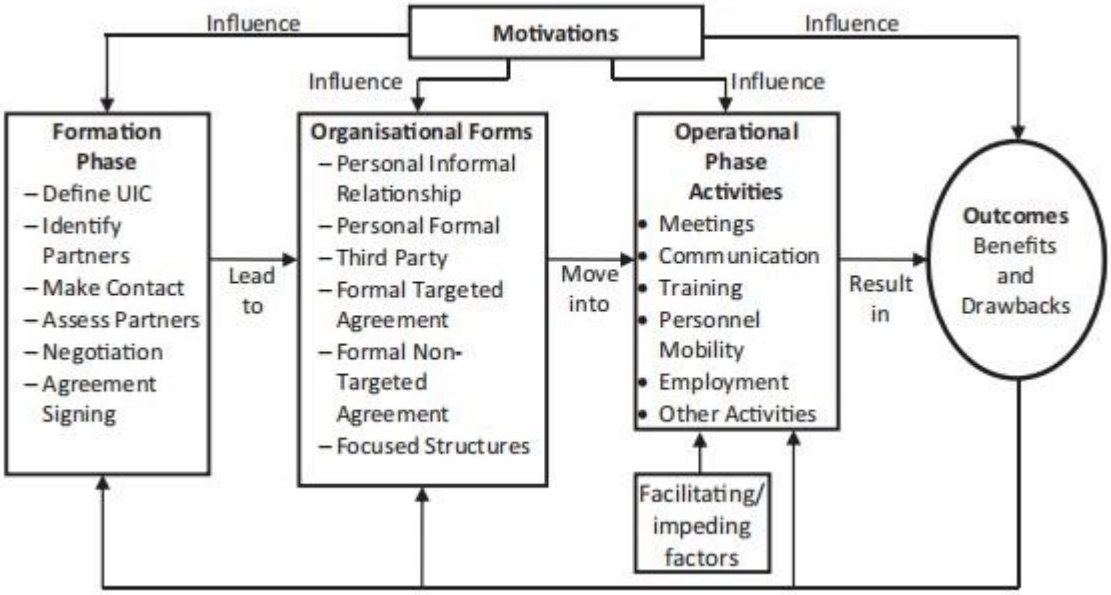

Figure 1. Conceptual framework for TIIC: a comprehensive perspective.

Although interdependency and interaction theories have yielded significant insights into particular elements of TIIC, they are insufficient for constructing a comprehensive understanding of this phenomenon. This suggests a lack of a middle-range theory, which is situated between the large theories of interdependency and interaction, that may explain both the observed phenomena and the systematic explanations of specifics in TIIC. Consequently, the results of the review are effectively incorporated into the conceptual framework illustrated in Figure One. Depending on the intricacy of the relationship, a certain type of TIIC may bypass certain stages of the formation phase and may not undergo all operational phase activities or achieve all objectives.

The interaction between the two organisations arises from their shared influences and diverse motivations. The construction of relationships results in a specific organisational structure based on the objectives or motivations of the connection in question. Subsequent to the formation, the connection transitions into the operational phase, marked by diverse activities and influenced by several elements that either promote or hinder the partnership. The connection has yielded several advantages and certain disadvantages for both organisations as a result. While the motivations of both organisations are crucial to the relationship, they must also recognise the factors that facilitate and hinder this relationship, as well as its potential drawbacks. This awareness enables them to implement well-developed policies and administrative procedures, as noted by Harman and Sherwell (2002), to ensure the successful achievement of both organisations' objectives. Feedback loops from the "Outcomes" to the other primary stages suggest that the TIIC may be altered as a consequence of the outcomes. Conclusions and avenues for future research

This report delineates the findings of a systematic review on TIIC covering the period from 1990 to 2014. Out of more than 1500 studies deemed relevant to the issue, 109 were selected. The investigations were subsequently analysed in relation to five inductively identified features using techniques from qualitative data analysis. The primary aspects, represented by the five questions, were categorised into several sub-themes, which were subsequently analysed for both tertiary institutions and industry. A comprehensive procedural structure was established to integrate the diverse components of the review.

The review and framework have significantly contributed by offering a coherent integrated analysis of the literature's current condition and highlighting areas necessitating additional exploration. The review indicated that the assessment of technology translation outcomes, encompassing the advantages and success of the partnership, is typically reliant on the evaluations of industry or higher education stakeholders, who may have established the results by contrasting prior needs and expectations with subsequent actual or perceived satisfaction. Nonetheless, a challenge related to this form of evaluation is that stakeholders from the business and higher education institutions may differ in their definitions of the success of the interaction and its results (Barnes et al., 2002). Consequently, it is essential to explore additional methods to more scientifically assess the efficacy of TIIC, beyond the already utilised subjective metric. To what degree can the quantity of new patents, products, and publications accurately represent the true value of the TIIC and substantiate its cost and risk? Similarly, it is essential to investigate whether higher education institutions would benefit more from persisting in the creation of spin-out firms or if they should confine their goals to roles that do not replicate industrial functions. There is insufficient data concerning the optimal metrics for assessing these spin-outs, including financial returns and survival rates (Lockett & Wright, 2005). The

influence of intellectual participation in the TIIC process is largely neglected. None of the examined studies have investigated the impact of this engagement on the teaching and learning experiences of students associated with higher institutions that collaborated with the sector. This research may offer corroborative evidence for the intangible potential worth of the TIIC (Perkmann et al., 2013).

Third, the evaluation clearly indicated the necessity to assess the degree to which the TIIC may transition from a complementary resource strategy to one that leverages the competitive advantages of the participating companies. Although numerous research (e.g. Das & Teng, 2000) exist about within-sector collaboration (i.e. business to company), it is uncertain whether this approach is applicable to TIIC. For instance, can the intellectual exchange and novel perspectives of academic collaborators, stemming from their continual engagement with cutting-edge information, substitute for or at least enhance a company's R&D capabilities? A valid study conclusion in this area can significantly influence industry investment decisions in TIIC. Fourth, further investigation is required to analyse the government's participation in TIIC. In developed countries, research indicates that the government plays a crucial role in fostering the establishment and advancement of such partnership (Perkmann, Neely, et al., 2011). Nonetheless, it remains uncertain whether governance in rising and developing nations, whose tertiary institutions are regarded as wholly or partially public entities, would adhere to the same trend. The institutional relationship among tertiary institutions, industry, and government, known as the Triple-Helix model, comprises three primary configurations (Ranga & Etzkowitz, 2013):

(1) government directs the tertiary institution-industry collaboration (TIIC) by establishing objectives and constraints for their interaction,
(2) industry serves as the principal force in the TIIC, with tertiary institutions and government playing limited roles—tertiary institutions provide academic talent while government regulates social and economic mechanisms,
(3) all three entities collaborate as partners to facilitate the transfer of knowledge to society, with the tertiary institution potentially assuming a leadership role in this arrangement.

Although Ranga and Etzkowitz (2013) propose that the latter configuration provides the most significant insights for innovation, its validity across all economies remains uncertain. Consequently, a crucial aim for forthcoming study is to investigate whether government participation should occur at all stages of collaboration or be restricted to particular phases (e.g., funding and policy formulation). Similarly, with TIIC in underdeveloped nations, additional enquiries may encompass how corporations might avert knowledge leaking when partnering with public tertiary schools that lack adequate regulatory frameworks to safeguard their intellectual property and proprietary information. Fifth, it is essential to perform comparison studies on TIIC across various countries. It is uncertain if this type of connection can thrive under these settings (Hong, Heikkinen, & Blomqvist, 2010). Moreover, research in this domain can examine the degree to which inter-country TIIC can enhance the national innovation capability of the host country (Jin, Wu, & Chen, 2009). We contend that research in this domain should not focus on validating existing theories or concepts related to TIIC; instead, it is essential to cultivate both theoretical and empirical comprehension of the factors that facilitate or hinder the emergence of global TIICs, such as cultural implications, policy inconsistencies, and misalignment of national objectives. Ultimately, our analysis indicates that the predominant category of the examined papers consists of cross-sectional research. Consequently, a longitudinal study approach is necessary to yield further insights into causal

dynamics and to evaluate the 'worth' of the comprehensive results of these interactions across both short-term and long-term periods.

5. CONCLUSION AND PATHWAYS TO FUTURE RESEARCH

This paper presents the results of a systematic review on TIIC for the period 1990—2014. 109 studies were selected out of over 1500 studies considered as being pertinent to the topic. These studies were then analyzed against five inductively- identified aspects by means of techniques from the field of qualitative data analysis. In the process, the main aspects (embodied by the five questions) were subdivided into various sub-themes, which were further analyzed for the two parties, tertiary institutions and industry. Finally, an overarching process framework was developed to link together the various elements of the review.

The review and framework have not only provided a substantial contribution by creating a clear integrated analysis of the state of the literature, but also have indicated areas that require further investigation. First, it was observed through the review that the evaluation of the outcome of technology translation, including the benefits and the success of the alliance, is normally based on the judgment of industry or tertiary institutions actors who might have determined the outcomes by comparison of a prior needs and expectations and a posteriori, actual or perceived satisfaction. However, one of the problems associated with this type of evaluation is that the actors from the industry and tertiary institutions may vary in definition of the success of the inter- action and its outcomes (Barnes et al., 2002). Therefore, there is a need to investigate other alternatives to more objectively measure the effectiveness of UIC, in addition to the subjective measure currently employed. For example, to what extent the number of new patents, products, publication can reflect the real value of the UIC and justify its cost and risk. In the same vein, there is a need to explore whether tertiary institutions would be better off by continuing to be involved in the generation of spin-out companies or whether they should limit their objectives to functions that do not duplicate the function of industry. Specifically, there is no sufficient evidence regarding the best dimensions to evaluate these spin-out, such as financial gains and rate of survival (Lockett & Wright, 2005). Second, the impact of academic engagement in the process of UIC is almost overlooked. For example, none of the reviewed studies have addressed the consequences of this engagement on, for example, teaching and learning experience of students affiliated to tertiary institutions that engaged with the industry. This line of research can provide supporting evidence to the intangible potential value of the UIC (Perkmann et al., 2013). Third, it was evident in the review that there is a need to examine the extent of which the UIC can move from resources complementary approach to be utilized in leveraging the competitive advantages of the engaged companies. Despite several studies (e.g. Das & Teng, 2000) that can be found in the area of within- sector collaboration (i.e. business to business), it was unclear whether this would work in the case of UIC. For example, do the intellectual exchange and the fresh perspective of aca- demic collaborators (resulting from their consistent interaction with the state-of-art knowledge) can replace or at least contribute to the R&D capabilities of a company. Valid research outcome in this direction can be critical in affecting the decision making regarding the investment in UIC by the industry. Fourth, more research is needed to examine the role of government in UIC. In the developed economies, research shows that government is a key player in facilitating the establishment and development of such collaboration (Perkmann, Neely, et al., 2011). However, we do not know if government in the emerging and developing countries, where tertiary institutions are considered as pure or semi-public institutions, would follow the same pattern. In principle, the institutional relationship

between the tertiary institution, industry and government (or the Triple-Helix model) has three main configurations (Ranga & Etzkowitz, 2013):

(1) government leads the UIC by defining objectives and putting limitations for the interaction between tertiary institution and industry,
(2) industry becomes the driving force for the UIC, where both tertiary institution and government have limited roles (tertiary institution acts as provider of academic talents, where government role is to regulate the social and economic mechanisms),
(3) the three actors act as partners aiming for the transition of knowledge to society, however the tertiary institution can take the lead in this configuration.

Despite Ranga and Etzkowitz (2013) suggest that the latter configuration offers the most important insights for innovation, we are not sure if this suggestion is valid in all economies. Therefore, an important objective for future research is to examine whether it is better that government intervenes at all collaboration stages, or limit this intervention at specific stages (e.g. funding and policy-making). In the same vein (i.e. UIC in developing economies), other questions might include how companies can prevent knowledge-leakage when collaborating with public tertiary institutions that lacks proper legal systems to protect their intellectual properties and know-how secrets. Fifth, there is a need to conduct comparative studies across different countries in relation to UIC. We do not know whether this kind of interaction can succeed in such conditions (Hong, Heikkinen, & Blomqvist, 2010). Furthermore, research in this area can investigate the extent of which inter-country UIC can contribute to the national innovation capacity of the hosting country (Jin, Wu, & Chen, 2009). Yet, it is our belief that studies in this area should not be pursued as testing existing theories/concepts about UIC, but rather there is a need to develop theoretical and empirical under- standing regarding the circumstances that promote and/or restrict (e.g. cultural implication, policies inconsistencies, mismatching of national objectives) the emergence of global UICs. Finally, our study reveals that the majority of the reviewed papers are actually cross-sectional studies. There- fore, there is a need for longitudinal line of research to provide additional insights into cause and effect dynamics and also help in assessing the 'value' of the full range of outcomes of these relationships in both short term and long-term scales.

Appendix A

Journal title	Total no. of articles	Articles included in the analysis
Technovation	11	Acworth (2008), Arvanitis, Kubli, and Woerter (2008), Babaa et al. (2009), Bekkers and Bodas Freitas (2008), Boardman and Corley (2008), Bodas Freitas, Marques, and Silva (2013), Bruneel et al. (2010), D'este and Patel (2007), Eom and Lee (2010), Etzkowitz (1998), Etzkowitz and Leydesdorff (2000), Fellera et al. (2002), Fontana, Geuna, and Matt (2006), Giuliani and Arza (2009), Hayashi (2003), Hong and Su (2013), Inzelt (2004), Kaufmann and To¨dtling (2001), Lee (1996), Lehrer et al. (2009), Lockett and Wright (2005), Mansfield and Lee (1996), Meyer-Krahmer and Schmoch (1998), Motohashi (2005), Mueller (2006), Pavitt (1988), Santoro and Chakrabarti (2002), Schartinger et al. (2002), Segarra-Blasco and ArauzoCarod (2008), Siegel, Waldman, and Link (2003), Welsh, Glenna, Lacy, and Biscotti (2008), Woolgar (2007) and Wright et al. (2008)
R&D Management	9	Bonarccorsi and Piccaluga (1994), Chiesa and Manzini (1998), Dill (1990), Enkel and Gassmann (2010), Jacob et al. (2000), Lee (2011), Lo´pez-Mart´ınez et al. (1994), Perkmann, Neely, et al. (2011), Plewa, Korff, Baaken, and Macpherson (2013)
Journal of Technology Transfer	10	Abramo, D'angelo, Di Costa, and Solazzi (2011), Caloghirou et al. (2001), Hall et al. (2001), Lee (2000), Muscio and Pozzali (2013), Okamuro and Nishimura (2013), Ponomariov (2013), Santoro and Gopalakrishnan (2001), Schartinger et al. (2001), Thune and Gulbrandsen (2014)
International Journal of Technology Management	4	Autio and Laamanen (1995), Howells and Nedeva (2003), Shenhar (1993), Wong (1999)
IEEE Transactions on Engineering Management	4	Gopalakrishnan and Santoro (2004), Santoro and Saparito (2006), Santoro and Chakrabarti (2001), Santoro and Saparito (2003)
Journal of Business Venturing	4	George (2002), Harmon et al. (1997), Mian (1997), Soh and Subramanian (2014)
International Journal of Management Reviews	3	Agrawal (2001), Dess and Shaw (2001), Santoro and Chakrabarti (1999)
Technology Analysis & Strategic Management	3	Bell (1993), Blackman and Seagal (1991), Geisler (1995)

Academy of Management Review, *European Management J.*, *J. of Management*, *Long Range Planning*, *American J. of Sociology*, *Organizational Dynamics*, *J. for Higher Education Management*, *Management Science*, *Organization Studies*, *J. of Higher Education Policy and Management*, *Industry and Higher Education*, *J. of Product and Brand Management*, *American Business Law J.*, *Computers Industrial Engineering*, *J. of Engineering and Technology Management*, *European J. of Innovation Management*, *Research Technology Management*, *Oxford Review of Economic Policy*, *J. of Product innovation management*, *The J. of High Technology Management Research*, *Policy Studies Journal*, *Higher education*, *I. J. of Innovation Management*, *Research evaluation*, *Science and Public Policy*, *Technological Forecasting and Social Change*, *Papers in Regional Science*	28 (28 articles from 28 different journals.)	Ring and Van De Ven (1994), Barnes et al. (2002), Barringer and Harrison (2000), Bower (1993), Culati and Gargiulo (1999), Cyert and Goodman (1997), Powers (2003), Owen- Smith, Riccaboni, Pammolli, and Powell (2002), De Carolis and Saparito (2006), Harman and Sherwell (2002), Mora- Valentin (2000), Logar et al. (2001), Newberg and Dunn (2002), Peterson (1995), Santoro and Gopalakrishnan(2000), Philbin (2008), Santoro and Betts (2002), Poyago- Theotoky et al. (2002), Duggan (1997), Siegel, Waldman, Atwater, and Link (2003), Lee (1998), Turk-Bicakci and Brint (2005), Shichijo, Baba, and Yarime (2010), Lebeau, Laframboise, Larivie`re, and Gingras (2008), Etzkowitz (2002), Guan and Zhao (2013), Muscio (2013), D'este, Guy, and Iammarino (2013)
Total number of articles included in the review	109	

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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