Environments for Joint University-Industry Laboratories (JUIL): Micro-level dimensions and research implications

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Societal demands for innovations to address market opportunities while simultaneously generating positive human capability impacts has radically transformed how innovation is organised. This new turn has focused attention of scholars, policy makers, and practitioners to exploring the potential of Joint University-Industry Laboratories (JUIL) to generating impact from university research through knowledge and technology transfer to industry. Although there is considerable scholarly work on the environmental conditions necessary to support JUIL, specific conditions that foster the identification of opportunities for innovation in JUIL at the micro-level remains unclear. Emphasising the persistence, but also transience nature of the context within which JUIL operate, we synthesize diverse literature streams on university-industry collaborations, and the conditions in which they are induced to explicate an integrative framework that specifies how the three distinct but interrelated dimensions: individuals, processes and interaction, and structure, may drive the development of successful JUIL. We go further to present a set of propositions constituting a contribution and outline the implications of our study for the theory and practice of managing and formulating policies to developing conducive environments for JUIL.

Introduction

Joint University-Industry laboratories (JUIL), a vehicle for generating impact from university research through knowledge and technology transfer have emerged as a common response to societal demands for innovations to address market opportunities while simultaneously generating positive human capability impacts. In this regard, JUIL have come to represent a strategic vehicle for universities to pursuing and fulfilling their third mission of becoming entrepreneurial universities (Bikard, et al. 2019; Etzkowitz, 2003; Etzkowitz, 2004; Galan-Muros et al., 2017). JUIL have also been closely linked to the emphasis on broad 'technology-transfer' and 'commercialisation' of academic knowledge in the field of university-industry collaboration (Philpott, et al., 2011; Secundo, et al., 2016; Sohal, 2013). The literature on university-industry collaborations has produced a significant body of knowledge, by identifying the environmental conditions that may play a role in the successful development of university-industry collaborations such as JUIL. For example, Rybnicek and Königsgruber (2019) identified in their comprehensive review those environmental conditions which contribute to the success of university-industry collaboration. They

summarised these conditions into four distinct, overarching categories: firstly, the institutional factors, which refer to the participating institutions, e.g. resources, structure, processes (Boardman and Bozeman 2015; Canhoto, et al., 2016; Myoken, 2013; Schofield, 2013); secondly, the relationship factors, which refer to the links between those partners, e.g. trust, leadership, culture (Attia, 2015; Bstieler et al., 2017; Clauss and Kesting, 2017; Rajalo and Vadi, 2017); thirdly, the output factors, which refer to the desired results of the collaboration, e.g. objectives, knowledge transfer, technology transfer (Ankrah and Al-Tabbaa, 2015; Goel et al., 2017; Henderson et al., 2006; Philbin, 2010); and fourthly, framework factors, which refer to environmental aspects, e.g. environment, geographical distance, contracts (D'Este et al., 2012; Kozlinska, 2012; Piva and Rossi-Lamastra, 2013; Hemmert et al., 2014).

While the role of environmental conditions in developing university-industry collaboration has been recognised, most of these studies have been fragmented and focused mostly on the macro level (Arshed et at., 2021; Huang and Chen, 2017). So far, not much has been done on the micro-level of how to manage university-industry collaboration. Studies have highlighted the impact of different institutional norms across university and industry sectors (Maietta, 2015; Rajalo and Vadi, 2017). Most scholars also agree that national culture play a key role in shaping university-industry relationships (Catal, 2020). However, these macro-level perspectives tend to mask the operational peculiarities and local dynamics that often define the outcomes for specific university-industry collaborations. These can be even more important in relatively weak and unstable institutional where individual and other micro factors play more important roles in driving the success of the partnership. Moreover, JUIL as a specific mode of university-industry collaboration has micro-level origins. These have not received adequate attention in the literature. For example, Rybnicek and Königsgruber (2019, p 238) note that factors contributing to the successful implementation of university-industry collaboration such as JUIL "…interfere with the organizational level of individuals; but these studies do not investigate this question specifically and remain rather speculative on this point. It seems worth taking a closer look at these differences, because for a successful university-industry collaboration, individuals at all levels have to contribute". Based on Rybnicek and Königsgruber's (2019) observation, numerous questions remain regarding the micro-level origins of JUIL. For example, most of the literature has neither paid adequate attention to specific factors

that are relevant for different individuals – i.e., which factors are relevant for leaders and managers and which are relevant for staff members such as experts, researchers, and administrators – nor described the environmental conditions in terms of the process of JUIL. Thus, explicit links have not been established between the needs of individuals and the environmental conditions which can fulfil individuals' needs, induce, or reinforce their desire to collaborate with industry firms and thus facilitate the process of JUIL (Felin et al., 2015). Moreover, Gulbrandsen and Thune (2010) called for a more in-depth analysis of interactions at micro-level. They noted the absence of process and dynamic view toward university-industry collaborations and therefore call for a look into the 'inner life' of these settings.

To address these gaps in the literature, we build on the works on micro-foundations by Felin et al. (2012, 2015), to focus on a micro-level approach to the development of JUIL process. Felin and colleagues identified three primary categories of micro-level components, including individuals, processes and structure, which have been known to play a central role in the origins of management theory (Cyert and March, 1963; March and Simon, 1958). For instance, Barnard noted that "the individual is always the basic strategic factor of organization" (1968, p. 139). Similarly, Hitt et al. (2007) propose to approach organisations as nested arrangements, in which the organisational human capital is an over- arching concept that combines individual characteristics and serves as a bridge between different levels of analysis. In this regard, the micro-level approach in this paper proposes that the successful development of JUIL requires consideration of the lower-level entities, such as individuals, processes and interaction, and structure in a university organisation and their interactions (Felin et al., 2012; Bjerragaard, 2009).

Our paper makes two major contribution to the existing literature. First, it synthesises disparate and often competing ideas on the environmental conditions required to support JUIL to develop a novel conceptual model of Joint university-industry laboratories environment which we used to unpack the salient micro-level dimensions (i.e., individuals, processes and interaction, and structure) and explain how their interactive effects may facilitate the pioneering of successful JUIL in practice. Second, our model in seeking to extend our understanding of the primary components underlying the nurturing of JUIL in practice (Adegbile et al., 2021; Albats et al., 2020; Felin and Foss, 2005; Felin et al., 2015), sheds light on how the model components interact within or across various sociological level of analysis to account for

potential sources of heterogeneity, and differential performance between JUILs in practice (Felin et al., 2015; Rybnicek and Königsgruber, 2019).

The remainder of the paper is organised as follows. First, we review the literature on the general environmental conditions for successful JUIL; next, we develop a conceptual framework to integrate existing literature on environments for the development of JUIL by explicating the micro-level dimensions of JUIL – (1) individuals, (2) processes and interactions, (3) structure. We then introduce the core elements of the JUIL and explicitly link the micro-level dimensions to the process of JUIL, showing how micro-level components of each dimension can help increase the successful development of JUIL. We draw research implications of the integrated model, develop some propositions to facilitate future empirical research and offer some guidelines for university policymakers in developing supportive environments for university-industry collaboration.

Literature on JUIL Environment

Following Ankrah and Al-Tabbaa (2015), we define JUIL as a special form of university-industry collaboration aimed at generating impact from university research through knowledge and technology transfer to industry. In this regard, knowledge and technology transfer is perceived to be an explicit resource which universities can transfer to industry and which is generated through an on-going collaboration between universities and industry (Ankrah and Al-Tabbaa, 2015; Philbin, 2010; Schofield, 2013). As such, we consider JUIL as a rational process which specifies in advance the goal of such collaboration (a focus on knowledge and technology transfer) as well as the size and scope of an individual's involvement in the collaboration process. This implies that collaboration outcomes, in terms of knowledge and technology transfer, can be determined by the availability of environmental conditions which foster such collaborations (Datta et al, 2019; Ankrah and Al-Tabbaa, 2015; Schofield, 2013). Therefore, we refer to a "JUIL environment" as a combination of factors playing a role in the development of JUIL. First, the JUIL environment involves individual, organisational, and institutional factors influencing an individual's willingness and ability to collaborate with industry to develop JUIL. Second, it involves the availability of appropriate conditions which facilitate the JUIL process.

Much work in inter-organisational relationships, university-industry collaborations, organisation theory and organisational behaviour covers and is informed by multiple theoretical areas related to JUIL. As such, a comprehensive review of the extant empirical literature is beyond the scope of this paper. Instead, we highlight examples of work which informs our understanding of the micro-level dimensions of JUIL, as discussed later. As a result, and for the sake of brevity, we may leave out work that is complementary but speaks less directly to the environment of JUIL. Based on the aforesaid, we group the available literature on JUIL environments into three broad streams: (a) general environmental conditions for successful JUIL; (b) the role of institutional contexts in shaping JUIL environments; (c) descriptive studies of the environmental conditions of developed and developing countries.

General environmental conditions discussed in the literature include the provision of resources, trust, a non-bureaucratic and complex structure, provision of administrative support, reciprocal communication (regular, timely, adequate, and accurate), presence of good organisational culture, etc (Arvanitis et al., 2008; Attia 2015; Freitas et al., 2013a; Bstieler et al., 2017; Canhoto et al., 2016; Schofield, 2013; Şerbănică, 2011). In addition, the literature suggests that the characteristics of individuals, their expertise, experience, scientific productivity, objectives, and motivation all play important roles in JUIL (Barnes et al., 2002; Henderson et al., 2006; Logar et al., 2001). Apart from individual characteristics, the literature has also identified some organisational-level conditions for the development of university-industry collaboration such as JUIL. For example, an extensive literature has analysed the role of university and departmental features (Owen-Smith and Powell, 2001) and technology transfer infrastructures (Lockett and Wright, 2005; Siegel et al., 2003) for JUIL (see Perkmann et al. (2013) for a comprehensive review). This has shown that these organisational factors increase the likelihood of researchers collaborating with industry partners (DiGregorio and Shane, 2003; Mansfield, 1995; O'Shea et al., 2005; Owen-Smith and Powell, 2001; Sine et al., 2003). Moreover, the presence of formal management and technology transfer mechanisms is generally positively related to JUIL (Huang and Chen, 2017; Markman et al., 2005a, b).

Several theoretical perspectives have been used to explore the phenomenon of university-industry collaborations at the macro and micro levels (Geisler, 1995). Regarding theoretical underpinnings at the

macro level, six perspectives have been observed as widely used (Barringer & Harrison, 2000), including: institutional theory, strategic choice, stakeholder theory, transaction costs economics, resource dependency, and organisational learning (Ankrah and Al-Tabbaa, 2015). For example, stakeholder theory has been used to explain how universities and industry firms may seek collaboration to better understand and consider the interests of all relevant stakeholders in their key operational and strategic decisions (Abidin, *et al.*, 2016; Mcadam *et al.*, 2012; Mcadam, Miller and Mcadam, 2016a), while the transaction cost economics is argued to focus on reasons why universities and companies might be inclined to engage in a relationship; minimise the sum of their technology development cost. Also, the resource dependency theory has been used to discuss the different motives for university-industry collaborations as the universities and the industry would perceive themselves as resources dependent (Ferru, 2010; Schofield, 2013), while the strategic choice theory is argued to be a useful theoretical perspective to explain how universities and industry firms might engage for strategic reasons such as benefits from economies of scale in joint research, or gain access to technology and knowledge (Barnes, Pashby, and Gibbons, 2002; Lai and Lu, 2016; Soh and Subramanian, 2014).

Institutional theory has been the dominant prism employed to exploring how macro level institutional pressures, overtime, give form and shape to what university-industry collaborations (Adegbile et al, 2021; Rajalo and Vadi, 2017). Scholars in this regard have consistently focused on the impact of the different institutional contexts in which those academics who enable the development of JUIL operate. Perkmann et al., (2013) identify aspects of the institutional context, including the affiliation to a scientific discipline and the effect of strong institutions in terms of specific national regulations and public policies. On the one hand, scientific disciplines, such as applied fields of research, have been known to enhance the development of JUIL (Bekkers and Freitas, 2008; Boardman, 2008, 2009; Bozeman and Gaughan, 2007; Lee and Bozeman, 2005; Ponomariov, 2008), and influence the selection of knowledge transfer channels from university to industry (Bekkers and Freitas, 2008; Louis et al., 2001). On the other hand, individual academics who operate in a country with strong institutions such as government policies and regional innovation initiatives, public funding, and government support (Collier, et al., 2011; de Medeiros Rocha, et al., 2012; Flores et al., 2009; Freitas, et al., 2013; Hou et al., 2019; Schofield, 2013) are

more likely to collaborate with industry for the development of JUIL. For example, studies show that the presence of clear policy changes such as the Bayh–Dole Act in the US and the abolition of the so-called 'professor's privilege' in European countries (Mowery and Sampat, 2005; Powers and McDougall, 2005; Sampat et al., 2003) enhance the development of JUIL. Thus, these institutional factors inform the development of JUIL as they shape the norms and rules relevant for individuals, either because they are official government regulations or because they are the rules of conduct prevailing within the 'invisible colleges' in which academics operate (Crane, 1972; Perkmann et al., 2013).

Regarding theoretical underpinnings at the micro level, research on university-industry collaboration has applied social network approach (e.g., Borgatti and Molina, 2003, Brass et al., 2004), to understand the development, evaluation, and survival of university-industry collaborations (Geisler, 1995). Through the lens of this theoretical perspective, universities and industry are perceived as independent entities where university-industry collaborations can be initiated by any of these entities and this could be influenced by pre-existing relationships (Ankrah and Al-Tabbaa, 2015; Barnes, Pashby and Gibbons, 2002). Thus, the social network approach has become a useful lens in explaining the dynamics of university-industry collaborations, and how the relationships evolve through the growth in influence of commitment, trust, and communication (Al-Tabbaa and Ankrah, 2019; Guan and Zhao, 2013; Ritter and Gemünden, 2003; Thune, 2007). Together, the use of different theoretical perspectives at the macro and micro levels have helped to explain different aspects of the university-industry collaborations.

Empirical studies of JUIL environments within developed and developing countries show that developed countries have experienced a substantial increase in JUIL due to a combination of pressure on both industry and universities in these countries (Gertner et al., 2011; Giuliani and Arza, 2009; Lehrer, et al., 2009; Meyer-Krahmer and Schmoch, 1998). For instance, studies have shown that this increase has been brought about by industry pressures, such as rapid technological change, shorter product life cycles and intense global competition, as well as the challenges of rising costs, funding problems and societal pressure on universities as engines for economic growth (Chang, 2017; Hagen, 2002; Wright et al., 2008). These pressures on both parties have led to an increasing impetus for developing JUIL, which demands enhanced innovation and economic competitiveness at institutional levels (e.g., countries and sectors)

through knowledge exchange between academic and commercial domains (Datta et al., 2019; Perkmann et al., 2013). However, most of the developing countries have experienced few university-industry collaborations until quite recently, due to weak institutions. For example, the lack of regional support structures and low trust culture, have been known to have a negative impact on university collaboration with industry firms (Șerbănică, 2011). Indeed, the lack of strong institution has been a critical determinant in the lack of development of university-industry collaborations such as JUIL in developing countries (Abereijo, 2015; Rampersad, 2015). Furthermore, scholars note that environmental conditions for the successful implementation and management of university-industry collaborations in developing countries are still under-researched and deserve further examination (Monja, 2017; Zavale and Langa, 2018)

Some commonalities exist among these streams of literature. First, there is agreement among scholars that the more conducive the collaboration environment, the more likely that university-industry collaboration such as JUIL will emerge. Individual academics will more likely be committed and be willing to collaborate with industry when the social environment values university-industry collaborations, when various opportunities are available for collaboration and when they have sufficient experience and expertise to collaborate with industry. The willingness and capability to collaborate may be further enhanced if individual academics in universities do not face hurdles during the collaboration process and if they are confident that support from the university could be obtained easily when necessary. Individual university stakeholders both directly and indirectly affect the development of an environment which could support university-industry collaboration.

This literature also suggests that the need for the development of a conducive environment may be greater in developing countries because of the scarcity of university-industry collaborations and because of several environmental hostilities operating in these countries (Mgonja, 2017; Skute, 2019; Zavale and Langa, 2018; Sarpong et al, 2017). Most developing countries have experienced few university-industry collaborations until quite recently, due to the institutional and historical evolution of universities as higher education institutions with limited resources for research (Hong, et al., 2010). Furthermore, compared to industry, the government and universities have a vital role in creating a conducive environment for university-industry collaborations to fulfil their ambitions of developing entrepreneurial

universities (universities' 'third mission') and of commercialising academic knowledge (Perkmann, et al., 2013).

While scholars generally agree on the importance of several environmental conditions for university-industry collaboration, the list of environmental conditions at the micro-level is so fragmented that the available literature is of very little help in studying JUIL environments or in developing policies and programmes for JUIL development. For example, we know little about the relationship among various elements of the environment at the micro-level and about the relative importance of each element in developing JUIL. Therefore, in the next section, we develop a theoretical framework to organise various environmental conditions of JUIL at the micro-level. In the following sections, we link this framework to the process of JUIL, develop propositions to show the inter-relationships among various elements and draw further implications for research and universities.

Theoretical framework

The role of entrepreneurial universities in JUIL

Universities have been known as engines for teaching (first mission) and research (second mission). More recently, universities have begun to take on a new 'third' mission by fostering the commercialisation of research outcomes and technology transfer (Etzkowitz et al., 2000b; Gulbrandsen and Slipersæter, 2007; Perkmann et al., 2013). This 'third mission' underscores what has come to be known as the 'entrepreneurial university' – a university which is able to translate research results into intellectual property and economic activity (Etzkowitz, 2003). As such, the entrepreneurial university has therefore become an especially propitious site for the commercialisation of academic knowledge and technology transfer, due to its basic features as a natural incubator, providing a support structure for academics to disseminate their knowledge through activities that are more entrepreneurial in nature (Kirby et al., 2011; Philpott et al., 2011) as well as to initiate new ventures through collaborations with industry (Audretsch, 2014; Guerrero et al., 2012; Krabel and Mueller, 2009; Rothaermel et al., 2007). Hence, the emergence of entrepreneurial universities has led to an increasing stimulus for developing university-industry collaborations (Perkmann et al., 2013).

Amongst the various modes available for developing university-industry collaborations, JUIL - which refers to a process seeking to generate impact from university research through knowledge and technology transfer to industry – has attracted major attention within both the academic literature and the policy community (Ankrah and Al-Tabbaa, 2015; Arvanitis et al., 2008). JUIL represent an important way in which universities commercialise academic knowledge through the dissemination of knowledge and technology transfer to industry. As such, the JUIL process involves the different stages from discovery by a university scientist to the conversion of knowledge and technology into a commercialised product. The JUIL process is usually executed by key stakeholders. We contend that the key stakeholders in the JUIL process are: (1) academics/scientists, who discover new knowledge and technologies, (2) university managers and administrators, who serve as links between academic scientists and industry, and who manage the university's intellectual property, and (3) firms/entrepreneurs, who commercialise university-based technologies (Siegel et al., 2003). In this paper, we focus our attention on the role of academics/scientists and university managers/administrators, as these are key stakeholders for JUIL from the entrepreneurial university perspective.

A Framework for JUIL Environment: Micro-Level Dimensions

Three major considerations informed the development of our framework. First, we have attempted to include major environmental conditions empirically studied or mentioned in the existing literature. Second, we show inter-relationships among these conditions. Third and most importantly, we have attempted to develop a parsimonious framework that captures the richness of a conducive environment for JUIL and can be subjected to systematic research.

To develop our framework, we build on the work of Felin et al. (2012) to group the micro-level conditions of JUIL into three dimensions: (1) individuals, (2) processes and interactions, (3) structure. Our focus on these three micro-level dimensions is informed by multiple, distinct streams of research into university-industry collaboration. First, theoretical, and empirical work highlights the importance of individual 'champions' and their interactions in explaining organisational-level heterogeneity and outcomes (See e.g., Ankrah and Al-Tabbaa, 2015; Bergner et al., 2010; Hemmert et al., 2014; Santoro and

Chakrabarti, 2002). Second, other research considers the processes underlying university-industry collaboration such as JUIL. Several studies in this area highlight the different aspects of JUIL (such as the development of policies and administrative procedures for collaboration, criteria for partner selection, constant learning and evolution, meetings and networking, personnel mobility, (e.g. Barnes et al., 2002; Guan and Zhao, 2013; Ritter and Gemünden, 2003; Sherwood et al., 2004)), whereas complementary work on JUIL explores how processes and event sequences contribute to JUIL and their development (e.g. Bruneel et al., 2010). In addition, some work on inter-organisational relationships (e.g., Koka and Prescott, 2002; Nahapiet and Ghoshal, 1998) underscores the role of individuals, processes, and interactions in the development of organisational-level constructs. Last, there is research which emphasises the importance of structural aspects of organisations, such as integration and co-ordination mechanisms, in the emergence of JUIL (e.g., Huang and Chen, 2017; Schofield, 2013; Siegel, et al., 2003; Wu, 2017).

Individuals

There is no doubt that the role of the individuals is crucial to understanding university-industry collaborations such as JUIL (Ankrah and Al-Tabbaa, 2015; Barnes et al., 2002). One simple way to think about entrepreneurial universities is as an aggregation of the individuals (leaders or managers and academics) that compose them. Work shows that individual 'champions' – for example, in their capacities as leaders and staff members– greatly affect the behaviour and performance of the university in collaborating with industry (e.g., Ankrah and Al-Tabbaa, 2015; Baba et al., 2010; Bergner et al., 2010; Collier et al., 2011; Hong et al., 2010). From this perspective individuals in an entrepreneurial university serve as a micro-level dimension of JUIL in various ways. Individual-level components, such as characteristics, abilities or cognition are important building blocks for understanding the phenomena of university-industry collaboration such as JUIL. First, theories on inter-organisational relationships and behaviour emphasise that individuals make choices which are informed and rational (Felin et al., 2012). In addition, individuals may have different motivations, objectives and expectations informing and affecting their choices. Second, individuals bring different human and social capital (skills, knowledge, experience, cognitive capacities) and characteristics to a university. Variation in these dimensions may influence

university-industry collaboration, such as JUIL, arising from individuals within a university, or from their interactions. We consider these points in greater detail below.

Characteristics and abilities

The impact of individuals at the coalface of managing and organizing university-industry collaborations such as JUIL cannot be overemphasized (e.g., Ankrah and Al-Tabbaa, 2015; Barnes et al., 2002). At the most fundamental level, this includes variation in what these individual champions bring with them to a university, such as characteristics (e.g., willingness to change, commitment), preferences, and knowledge or experience (e.g., education level, job tenure) (Ankrah and Al-Tabbaa; Attia, 2015; Logar et al., 2001; Ryan, 2007, 2009). In a nutshell, the human and social capital of individuals within a university matter for JUIL (Al-Tabbaa and Ankrah, 2015). Moreover, differences in individuals' skills or abilities could be general in nature or specific to forming and developing collaborations such as JUIL. The category of 'general skills and abilities' includes elements which may affect collaboration indirectly. For example, since universities' collaboration with industry involves a series of interdependent actions and events carried out by different actors, an individual's ability to have good personal relationships with potential industry partners, or to be able to communicate in creating a shared understanding, is known to be the basis for facilitating linkages between universities and industry partners (Barnes et al., 2002; Collier et al., 2011). In this regard, Wu (2017) noted that contacts and actions (such as regular interaction, continuous feedback, mutual exchange of information and updating partners about incidents or new activities) are very important for the development and management of JUIL, both at the management level and operational level. Similarly, general skills such as finding an appropriate 'language' suitable for industry partners may directly influence the development and management of university-industry collaboration such as JUIL (Baba, et al., 2010; Gawel, 2014). Alternatively, specific skills and abilities, such as individual scientific productivity in terms of quality and success, have been known to be influential to the development of JUIL (Perkmann et al., 2013) e.g., scientists' quality, and success (Bekkers and Freitas, 2008; Gulbrandsen and Smeby, 2005; Haeussler and Colyvas, 2011). Perkmann et al. (2013) noted that the best and most successful scientists are also those who are more likely to collaborate with industrial

partners. In addition, individuals' ability to mobilise resources for their research is also positively linked to collaboration with industry (Boardman, 2009; Boardman and Ponomariov, 2009; Bozeman and Gaughan, 2007; Lee and Bozeman, 2005; Link et al., 2007).

Behavioural and psychological foundations

Various normative behavioural and psychological factors have been found to influence the development of university-industry collaboration such as JUIL. First, research on organisational behaviour directs attention to the role of individuals in explaining organisational outcomes. Felin et al. (2012) noted that the concept of bounded rationality can serve as a starting point for the analysis of individual-level components in explaining organisational level outcomes. Behavioural theories have focused on the experiential and learning-related aspects of rationality. As individuals take actions informed in part by their beliefs, they gain feedback and experience and in turn learn about the environment (Felin et al., 2012). This learning is bounded by the cognitive limitations of actors and by their experiential data. Such experiential learning is a central facet of university-industry collaboration and one input to the development of JUIL. For example, Barnes et al. (2002) note that past experiences in working together, historical experiences in collaborating, or undertaking smaller projects are all vital to maintaining personal contacts at the beginning of a new partnership. Several studies have also found that the outcome of university-industry collaboration such as JUIL will be better if the partners have previous co-operative experiences (e.g., Dill, 1990; Geisler, 1995). Culati and Gargiulo (1999) explain that pre-existing relationships between potential partners are vital, because trust may already exist between the organisations from prior experience and because trust in inter-organisational relationships develops gradually as partners repeatedly interact and mutually adjust to the expectations, evolution and demands of prior alliances. Schartinger, Schibany and Gassler (2001) agree and add that past collaborative experience is crucial because satisfaction with past interactions on a personal, technological and research level lowers individual and institutional barriers and renders university-industry collaboration such as JUIL more likely. Second, research into organisational psychology can help explain some of the psychological foundations of university-industry collaboration such as JUIL. In this regard, an important

stream of research looks at cognition in terms of bounded rationality and inter-organisational relationships. Some works on university-industry collaboration have examined how universities perceive their 'third mission' after the two traditional core missions of research and teaching, namely facilitating linkages with industry (Link, et al., 2017; Marhl and Pausits, 2011; Perkmann et al., 2013) and how various characteristics of university leaders and academics lead to different cognitive orientations (e.g., Jacobsson, et al., 2013). For example, Kaymaz and Eryiğit, (2011) showed how the beliefs of individual academic staff, caused by organisation-level actions, have a direct bearing on the success of collaboration with industry. Hence, individuals may invoke various psychological processes when carrying out their parts in the development and management of university-industry collaboration such as JUIL. In addition, individuals' internal states adapt and evolve over time. The implication of this is that individuals' psychological processes might affect university-industry collaboration such as JUIL and is an important micro-level component to be considered in the development of JUIL.

In summary, individual-level elements, such as characteristics, abilities, cognitions, and beliefs are important building blocks for understanding collective phenomena such as JUIL. Next, we discuss the micro-level dimensions of processes and interactions that may influence university-industry collaboration such as JUIL.

Processes and interactions

Here we highlight the importance of historical and contextual factors which contribute to the development of JUIL. We argue that the time-dependent processes can influence the development of JUIL in two fundamental ways. First, a process involves a series of interdependent events that can help contextualise the development of JUIL. Second, the translation of processes into action does not occur in isolation, but rather requires the involvement of individuals. Consequently, the interplay of individuals and processes in universities may provide insights into how JUIL emerges. These process-based origins of JUIL are strongly evident in extant empirical work (e.g., Barnes et al., 2002; Ritter and Gemünden, 2003).

Different processes are required for the development of university-industry collaboration such as JUIL. First is the formation process of the university-industry collaboration. Ankrah and Al-Tabbaa (2015) identified five steps in the formation process of university-industry collaboration: 1) partner identification;

2) contacting the industry partner; 3) the assessment and selection of the partner; 4) negotiation with the industry partner; 5) the signing of the agreement. Second is the operational phase process characterised by constant learning and evolution (Ritter and Gemünden, 2003; Sherwood et al., 2004), and other activities which take place between the university and their potential industry partners, such as meeting and networking, training, communication, personnel mobility (Ritter and Gemünden, 2003). These two processes have different implications for collaboration with industry partners in the development of JUIL. Different activities arising from these processes may result in variation at the organisational level and the focal collaboration over time, and thus heterogeneity within and among entrepreneurial universities. We identified two micro-level components arising from processes and interactions which may influence university-industry collaboration such as JUIL: i) method of co-ordination and integration ii) technology and ecology. We discuss these two micro-level dimensions in turn below:

Methods of coordination and integration

The interactions between individuals and processes within a university shape its JUIL in critical ways. Research shows that both formal (e.g., contract agreement) and informal (e.g., experience, norms, values) forms of co-ordination influence sequences of interdependent events or actions (Ankrah and Al-Tabbaa, 2015; Siegel et al., 2003). A number of studies have analysed a variety of formal co-ordination processes relevant for the development of university-industry collaboration such as JUIL, both within the university (e.g., Barnes et al., 2002) and outside the university with industry partners (e.g. Attia, 2015; Bruneel et al., 2010; Perkmann and Salter, 2012; Perkmann and Schildt, 2015; Rampersad, 2015; Starbuck, 2001). For example, in a study of three university research centres' processes in Singapore, Lee and Win (2004) find that commitment, ongoing communication, and knowledge and technology transfer mechanisms are distinct co-ordination processes critical for a successful relationship between university and industry. Some other studies highlight how formal processes support the integration of different university organisational elements, such as individuals, teams, departments, or inter-disciplinary knowledge resources (e.g., Bercovitz and Feldman, 2008; DiGregorio and Shane, 2003; O'Shea et al., 2005; Owen-Smith and Powell, 2001; Sine et al., 2003; Stuart and Ding, 2006). Such integrating mechanisms

facilitate co-operation and co-ordination among individuals and in turn shape the collective interest in the JUIL process (Arvanitis, et al., 2008; Huang and Chen, 2017; Kaymaz and Eryiğit, 2011; Schein, 2004). Furthermore, some work also explores the informal aspects of co-ordination at multiple levels of analysis, and how trust (Barnes et al. 2002; Bstieler et al., 2017) and culture (Barnes et al., 2002; Schein, 2004) affect co-ordination. Other studies explore how institutional processes and norms influence co-ordination and hence JUIL development (Bekkers and Freitas, 2008; Boardman, 2008, 2009; Bozeman and Gaughan, 2007; Lee and Bozeman, 2005; Martinelli et al., 2008; Ponomariov, 2008).

Technology and ecology

Another type of interface between individuals and processes involves a university's technology and ecology. Some studies have examined the role of technologies in shaping organisational outcomes. For example, the use of specific technologies can structure social interaction among university stakeholders and helps as a repository of knowledge about industry partners, past transactions, and engagements (Raj Adhikari, 2010). Similarly, the implementation of new technologies to innovate internal processes facilitates the success of JUIL, as Wynn (2018) illustrates in a study of 3 university-industry projects undertaken via the UK Knowledge Transfer Partnership scheme. The author stresses the role of 'overall upskilling of staff to use certain technologies', suggesting that collaboration hinges on individual interactions with technology in context. Regarding ecology, university-industry collaboration such as JUIL is influenced by a multitude of factors with which individuals interact within a university. Such factors could be physical workspaces, facilities, training, reports of successful commercialisation and grant funding from industry, etc. They help to decode signals for collaboration with industry and thus enable or reinforce collaborative behaviour. For example, one study by Mahdad (2017) and another by Villani et al. (2017) show that geographical proximity at the micro-level (e.g., the spatial closeness of actors) can be considered as a prerequisite for establishing successful JUIL. Similarly, Bercovitz and Feldman (2004) show the influence of peer, leadership, and training factors in engagement with collaborative activities.

Structure

Some studies have also identified different forms of organisational structure as another micro-level dimension for JUIL. Structures, whether amongst universities or within one university, enable and constrain individual and collective action and establish the context for interactions within an organisation. Felin et al. (2012) note that structures may constrain behaviour but also enable efficient information processing, knowledge development or sharing, co-ordination, integration and, more generally, collective action. We highlight two areas of work which build connections between structure and the micro-level dimensions of JUIL.

Design of decision-making:

The structure or design of decision-making activities within a university may affect the development of JUIL. For example, academic members of universities often make choices in the face of organisational and institutional constraints (see Link and Siegel, 2005). In addition, universities typically establish governance policies and rules which guide decision making. As university management and leadership gain experience, they may change the policies or the structure of the rules, to enhance decision making (e.g., Fernandes et al., 2020; Mahdad et al., 2018) or to align with changing conditions. For example, some universities might allow for more flexibility in rule systems, whereas others may develop complex rule structures (e.g., centralised decision making) to govern collaboration activities and processes (Boardman, 2012). The efficacy of these different approaches may affect how JUIL is developed and evolves in universities.

Design of organisational structure:

A vast body of work considers how differences in the design of organisational structures may affect collaborations (e.g., Battaglia et al., 2017; Sánchez-Barrioluengo and Benneworth, 2019). It is widely recognised that the bureaucracy, the complex structure, and the inflexibility of universities (Anderson et al., 2007; Schofield, 2013) impact the success of collaborations, because universities' rigid frameworks do not allow for autonomy, they maximise the information held by academic members and they create problems for effective co-ordination. At the same time, a university's design might give rise to gaps in

shared knowledge across parts of the organisation and, in turn, compromise co-ordination and integration (Boardman and Bozeman, 2015; Schofield, 2013). Bozeman and Gaughan (2007) noted that dedicated entities within universities, such as research centres, have been found to positively influence engagement with industry partners. For example, in their study of factors determining the propensity of Swiss science institutions to get involved in a wide spectrum of knowledge and technology transfer (KTT) activities with industry, Arvanitis et al. (2008) found that scientific institutes with a stronger orientation to applied research and/or lower teaching obligations are more inclined to get involved in overall KTT activities. Additionally, university organisational structures which draw on expertise from multiple fields are known to influence university collaboration with the industry (Perkmann et al., 2013).

To conclude, the above discussion shows that the existence of various micro-level environmental conditions increases the chances of JUIL emergence. Though we suggest that each micro-level dimension may have significant effects on JUIL, each dimension does not operate in a vacuum. Instead, they are enmeshed in different interactions within an entrepreneurial university (individuals interacting with individuals, individuals with processes, etc.). Hence, interactions within and among different organisational levels of individuals also form a set of contributory factors for the collective development of JUIL. In addition, we recognise that the study of micro-level dimensions benefits from both aggregating micro-level elements and disaggregating JUIL over time within a university organisation. Consequently, our study of micro-level dimensions may benefit from these two paths of analysis – aggregating from micro-level dimensions to collective (university organisation) level constructs and disaggregating collective (university organisation) level constructs into their constituent micro-level dimensions. Finally, we note that an entrepreneurial university organisation may be affected by the context, or macro-social structure, in which they are embedded. Consistent with our micro-level focus, however, the formal boundaries of an entrepreneurial university condition our line of inquiry.

Insert Table 1 about here

Core elements for a JUIL development Process

Certain key factors may increase an individual university stakeholder's desire and decision to collaborate with industry. Examples of such factors include an individual's perception of desirability and feasibility of collaboration (Lam, 2010; Logar et al., 2001; Sellenthin, 2011) or the person's propensity and intention to collaborate with industry partners and his or her sense-making about the various opportunities for collaboration (Davies, 2001; De Silva et al., 2020; Siegel, et al., 2004). In their systematic review of the literature Ankrah and Al-Tabbaa (2015) identified two elements in the development of university-industry collaborations: motivations for collaboration, and formation/operationalisation of collaboration. Some literature suggests that for a university to collaborate successfully with industry, individuals should already be interested in such collaboration to perceive that a collaborative opportunity exists; they should feel confident that they possess the necessary skills to collaborate, and they should take the initiative to collaborate with industry. This section builds on these factors, especially those articulated by Ankrah and Al-Tabbaa, by redefining 'motivation' as 'propensity to collaborate' and 'formation/operationalisation' as 'ability to collaborate'. We conceptualise three key elements of a JUIL development process as *opportunity, propensity to collaborate* and *ability to collaborate.*

Opportunity

Opportunity refers to the extent to which possibilities for collaboration exist and the extent to which individuals have the agency to influence their participation in JUIL. Collaboration opportunities tend to be higher in universities which have a strong entrepreneurial orientation towards the commercialisation of academic knowledge, where there exists an environment (such as university structure, culture, policies, and governance) which facilitates collaboration (D'Este and Patel, 2007; Sánchez-Barrioluengo and Benneworth, 2019; Todorovic et al., 2011). An assessment of the university from individual academics' perspectives provides information about how the individuals' perceptions influence their collaboration with industry partners (Fischer, et al., 2019; Hunter et al., 2011). This shows that a university environment, in terms of its orientation, structure, culture, policies and governance, affects collaboration opportunities (Grimaldi et al., 2011; Lin, 2017; Sánchez-Barrioluengo and Benneworth, 2019). Opportunity will influence an individual's propensity to collaborate and ability to collaborate (Kozlinska, 2012).

Propensity to collaborate

An emerging stream of research have emphasis the profound influence of psychological and behavioural characteristics of individuals on university-industry collaboration. The most common of these are the high need for commitment (Ankrah and Al-Tabbaa, 2015; Attia, 2015; Link et al., 2007), attitude towards collaboration (Sellenthin, 2011), financial gains (Siegel, et al., 2004), exposure to the industrial environment (Santoro and Chakrabarti, 2001), enhancing prestige and recognition (Valentin, 2000; Siegel, et al., 2003) and key personal characteristics (Boardman, 2009; Boardman and Corley, 2008; D'Este and Perkmann, 2011; Haeussler and Colyvas, 2011). Research has shown that more successful outcomes in JUIL are achieved by individuals who are committed to collaboration and its goals, who are willing to change, who have a high volume of scientific productivity or grant funding and who have previous experience with industry (Boardman and Ponomariov, 2009; D'Este and Patel, 2007; D'Este and Perkmann, 2011; Giuliani et al., 2010; Haeussler and Colyvas, 2011).

The literature on individual characteristics as predictors for likelihood to collaborate argues that individuals with certain behavioural characteristics can perceive the opportunities for collaboration, seize such opportunities and then turn such opportunities into the development of JUIL. Yet a personality or behaviour profile is not alone sufficient for individuals to collaborate in the development of JUIL. An individual with high propensity to collaborate is more likely to collaborate with industry partners when he or she sees several collaboration opportunities in the university environment. Furthermore, the propensity to collaborate will be enhanced when an individual feels confident in his or her ability to collaborate.

Ability to collaborate

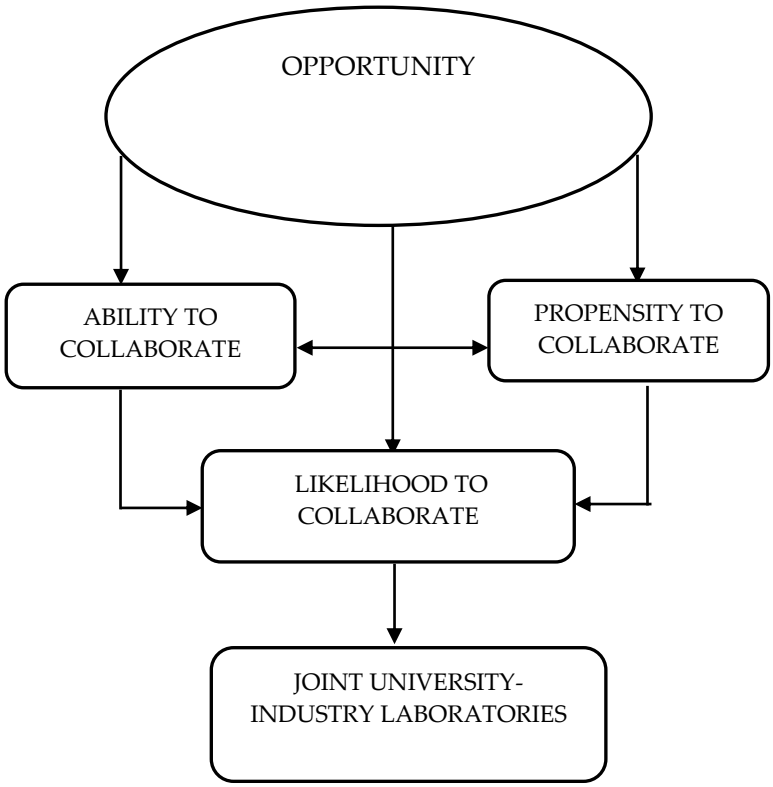
Ability to collaborate refers to the sum of technical and relational know-how required to develop JUIL. While 'technical know-how' refers to the technical skills, 'relational know-how' refers to the knowledge and skills in various functional aspects of collaboration with industry (Ankrah and Al-Tabbaa, 2015), such as partner identification, making contact, partner assessment and selection, partnership negotiation, agreement signing, etc. Without having the ability to collaborate, individuals may neither be able to seize the opportunities available to them nor successfully go through various university-industry collaboration

activities such as JUIL. Individuals with the necessary ability to collaborate, when combined with an enhanced propensity to collaborate, will increase the chances of collaboration taking place.

A crucial requirement in the development of JUIL is a match between the opportunity, the propensity to collaborate and the ability to collaborate. While the opportunity may enhance an individual's propensity to collaborate, individuals with a high propensity to collaborate will perhaps be better able to identify the opportunities for collaboration. Similarly, the ability to collaborate may depend upon the nature of available opportunities. Some individuals may have high relational and social skills but the opportunity for the use of such skills may be low. Individuals with a high ability to collaborate may also be more able to identify opportunities than those with a lower ability to collaborate. The likelihood of collaborating rises with an increase in the propensity and ability to collaborate when matched with available opportunities. Thus, a high level of opportunity, propensity to collaborate and the ability to collaborate will positively correlate with an individual's likelihood of collaborating with industry. Figure 1 is a model showing the relationship between opportunity, propensity to collaborate and ability to collaborate.

The model shows that the process of developing competent individuals and increasing their likelihood of collaborating involves, identifying collaboration opportunities, enhancing an individual's propensity to collaborate, and developing their capability to collaborate. Competent individuals will be able to take advantage of most opportunities for commercialising academic knowledge. A key role of an entrepreneurial university in the development of JUIL is to help individuals develop both the propensity to collaborate and the ability to collaborate. Individuals with a low propensity to collaborate lack the necessary motivation and mind-set required to develop JUIL, whereas individuals with low ability to collaborate lack the skills needed to manage the formation and subsequent development processes of JUIL.

Figure 1: Core Elements of Joint University-Industry Laboratories



The Integrated Model and its Implication for Research

Integrating the discussion of the environmental conditions and the core elements of JUIL development, we develop some propositions to facilitate future empirical research that may seek to extend our understanding of the environmental conditions and contexts within which JUIL are developed. As shown in. Figure 2 our integrated model suggest that each micro-level dimension is related to a specific aspect of the core elements of the development of JUIL. Generally, the availability of opportunities is a primary element for enhancing the propensity and ability to collaborate and consequently the likelihood to collaborate. The micro-level dimension of the environment, directly related to the opportunity, is structure, which includes the organisational structure and the design of decision-making activities. The better the organisational structure and decision-making framework for the efficient functioning of the collaboration, and the fewer the barriers that constrain individuals to pursue collaborative opportunities, the greater the likelihood of collaboration for the development of JUIL.

For the individual dimension of the environment, behavioural and psychological components are the micro-level components which relate to the propensity to collaborate. The greater the importance

placed by individuals on attitude, commitment, and collaborative experience and the larger the proportion of experienced individuals, the more likely that the propensity to collaborate is high.

The level of individuals' abilities and characteristics is the dimension which relates to the likelihood to collaborate. Where availability of technical and collaborative-related training is high, individuals will be better able to collaborate with industry partners. Thus, if individuals have a high propensity to collaborate but a low ability to collaborate, university interventions will be needed to develop the characteristics and abilities of these individuals. Conversely, if individuals have high ability to collaborate but a low propensity to collaborate, university interventions will need to be oriented towards making the behavioural and psychological conditions conducive for collaboration. The above analysis suggests the following propositions.

P1: The higher the opportunity to collaborate, propensity to collaborate and ability to collaborate of individuals, the higher the likelihood of collaboration.

P2: The more favourable the design of design-making activities and organisational structure by individuals in management and leadership, the higher the opportunity for individual academics to collaborate.

P3: The more individual possess favourable characteristics and abilities needed for collaboration, the greater their ability to collaborate.

P4: The more individuals possess favourable behavioural and psychological attributes, the greater the propensity to collaborate.

As argued earlier, an individual with a high propensity to collaborate may collaborate with industry; yet if he or she lacks the ability to collaborate, that individual is likely to fail either at the formation process of the collaboration or later at the operational phase. Conversely, an individual with a high ability to collaborate but a low propensity to collaborate lacks adequate motivation to collaborate with industry partners. Successful collaboration thus requires high levels of propensity and ability to collaborate. Therefore,

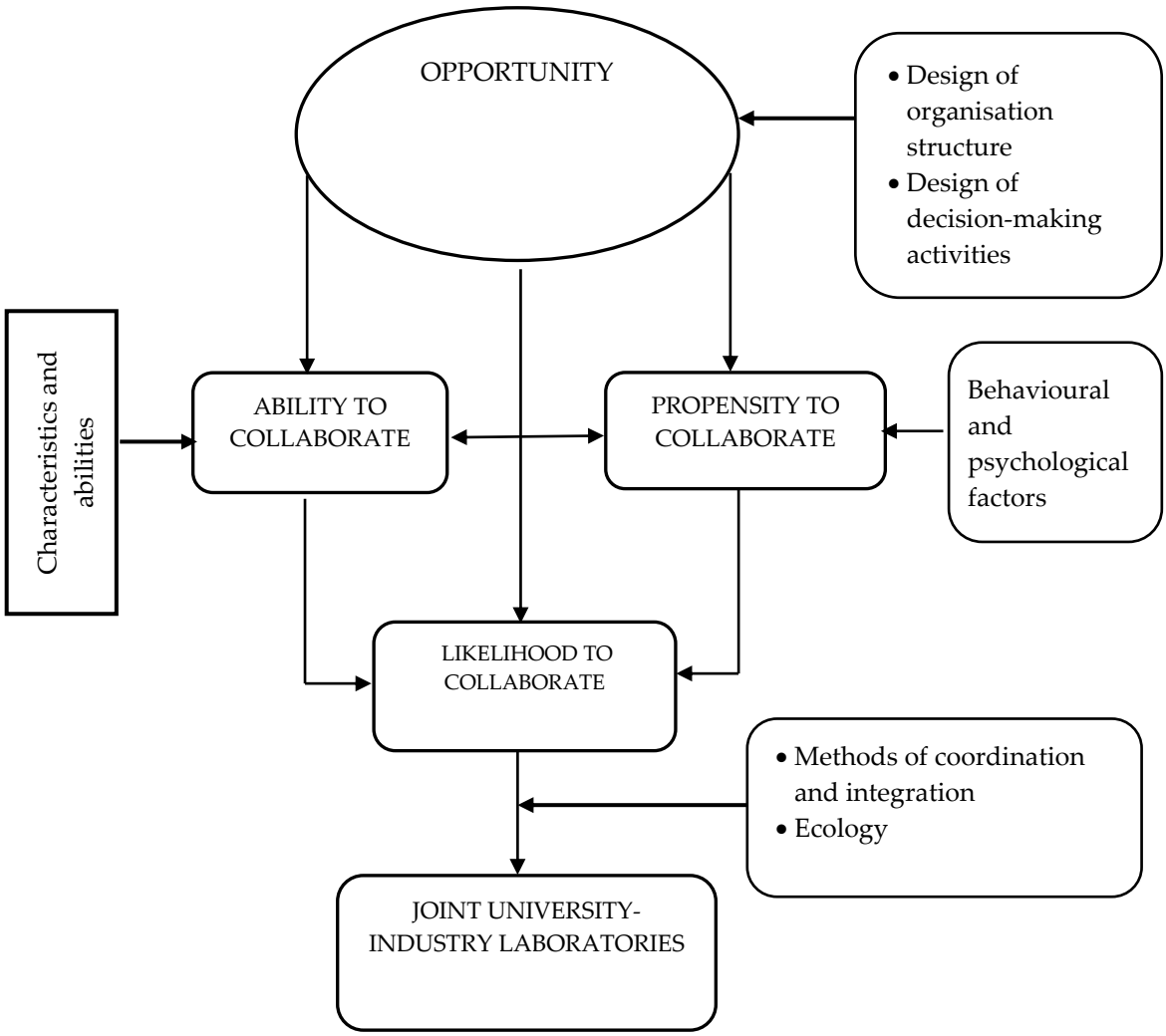
P5: The higher the likelihood of collaborating, the higher the emergence of JUIL.

The model (Figure 2) shows that the method of co-ordination and integration, together with technology and ecology, appear important only if the overall likelihood to collaborate is high. Previous studies (e.g., Arvanitis, et al., 2008; Huang and Chen, 2017; Lee and Win, 2004; Wynn, 2018) have shown that

management, knowledge, and technology transfer mechanisms were important when individuals had higher motivation to collaborate with potential industry partners. Therefore,

> **P6:** The higher the likelihood of collaborating, effective methods of co-ordination and integration, and favourable organisation of technology and ecology, the higher the emergence of JUIL.

Figure 2: An Integrative Model of Joint University-Industry Laboratories Environment



Implications for Research and Universities policies

Implication and suggestion for future research

Ideally, research aimed at studying conducive environments should include the triple helix – universities, government, and industries - as key informants. This is because it is the perception of university stakeholders about the conducive environment which shapes their actions; it is the set of frameworks such as the design of organisational structure and framework of decision-making activities that influence the opportunity, propensity to collaborate and ability to collaborate. Furthermore, it is the overall attitude of

the individuals which influences their propensity to collaborate. Research studying the opportunity and the design of organisational structure and decision-making activities should use individuals as key informants together with other groups of stakeholders such as industry partners, if resources permit this. Additionally, the use of the individuals is extremely important if the research is focused on the propensity to collaborate and the behavioural and psychological foundations of the micro-level components of the environment. Similarly, individuals need to be taken as key informants when studying the ability to collaborate and the characteristics and ability micro-level components of the individual dimension of the environment.

An important agenda for research is to identify the relative importance of each component of the micro-level dimensions of JUIL in developing university-industry collaboration such as JUIL. It would be useful to know the relative importance of each micro-level component and the interplay of these components in a university organisation. Also, it might be appropriate to study inter-individual differences in the level of ability and propensity to collaborate, especially with reference to the universities oriented towards commercialisation of research result. Secondary and unobtrusive sources provide data on the current design of organisational structure and decision-making activities, the extent of available technical and collaborative training, methods of co-ordination, and technology and organisational ecology. Interviews and questionnaires will be useful for collecting data about individuals' attitudes towards collaboration, their perceptions about their ability to collaborate and propensity to collaborate, and the overall university environment in fostering collaboration such as JUIL.

Altogether, the investigated literature supports the notion that some of our factors interfere with the organisational level of individuals, but these studies do not investigate this question specifically and remain rather speculative on this point. It seems worth taking a closer look at these differences because, for successful university-industry collaboration such as JUIL, individuals at all levels must contribute. Hence, it will be advantageous to have a better understanding of which factors are relevant for leaders and managers and which for staff members such as academics, researchers, and administrators.

Implication for university policies

Our paper also has important implications for entrepreneurial universities and for the design and implementation of programmes to develop collaborations such as JUIL. The entrepreneurial university is broadly defined as the university that embraces the third mission of fostering the commercialisation of research outcomes and technology transfer, along with teaching and research. The emergence of the entrepreneurial university is underpinned by the recognition that the university is a cost-effective transfer agent of both knowledge and technology (Etzkowitz *et al.*, 2000). In line with this third mission to commercialise academic knowledge, the entrepreneurial university incentivises individual stakeholders by supporting their initiatives and activities to collaborate with the industry. In other words, the entrepreneurial university actively promotes micro-level factors for joint-university collaborations. They also invariably reinforce macro-level dimensions, for example through the alignment of university towards typically industry-oriented commercial outcomes. Therefore, we argue that universities aiming to develop conducive environments for JUIL may experience greater efficiency if they address the specific elements of our model. The following points summarise the guidelines for developing JUIL which evolve from our model.

First, universities can contribute to JUIL by adopting policies and procedures to provide a broader scope of opportunities to individual academics. Examples of possible interventions are the provision of governance and policies to let individuals freely exercise their collaborative talents, and minimum rules and regulations for individuals to follow so that the barriers to collaboration can be minimised. Second, universities whose individual academics have a low propensity to collaborate but a high ability to collaborate could design policies and programmes aimed at improving the behavioural and psychological dimension of the environment. Short-term interventions could include such programmes as the 'best industry collaborator of the year' award, provisions of networking fairs and similar activities in order to reward collaboration activities and increase overall individual awareness toward university-industry collaborations. A possible long-term policy approach is to introduce collaboration values and collaboration thinking in the university system.

Third, universities whose individual academics have a low level of ability to collaborate but a high level of propensity to collaborate could try to develop policies and programmes to enhance the

relational and collaborative skills of the individual. Examples of useful interventions are technical and networking training or workshops on the development and management of collaboration with industry, aimed at enhancing specific collaboration skills. Lastly, some caution is needed in offering broad-based co-ordination and integration, technology, and ecology to individual academics in universities where propensity and ability to collaborate are low. If the propensity and ability to collaborate are low, policies and programmes should also be directed towards developing the propensity and ability to collaborate. This is because even if there are effective methods of co-ordination and integration, and favourable organisation technology and ecology, individuals with low propensity and ability to collaborate may not collaborate with potential industry partners or, even if they do, they may not be able to develop and manage the collaboration. The greater the likelihood of collaborating, the greater the role of co-ordination and integration methods, and technology and ecology, in creating JUIL.

Fourth, our model- oriented in micro-level dimensions- provides a more effective framework to interrogate the similarities and differences between universities and JUIL in developed and developing countries. It is often assumed that macro-level factors in developed countries are more conducive to the development of entrepreneurial universities because of strong institutional environments, national culture, government policies and other macro factors. However, in reality, significant differences remain among these universities in terms of their entrepreneurial profile and success. We argue that our model provides a more promising framework to understand these differences. Conversely, universities in developing countries often grapple with institutional weaknesses, inadequate policies and other macro factors that hinder entrepreneurial activities. However, these countries also have excellent examples of entrepreneurial universities with records of successful university-industry collaboration, effectively against the "run of play" in the harsh institutional environment. Thus, here again, micro-level factors appear to make the big difference. In effect, our model can help illuminate these and reclaim hidden knowledge about JUIL in both developed and developing countries contexts.

In sum, we suggest that, to develop JUIL, entrepreneurial universities should focus on the analysis of the extent of the opportunity, propensity to collaborate, and ability to collaborate; they should identify weak areas and then formulate policies and programmes to strengthen the weaker areas. The

framework presented in Table 1 provides a useful heuristic guideline for formulating policies and designing programmes for the development of JUIL.

Conclusion

The literature on university-industry collaborations has produced a significant body of knowledge by identifying the environmental conditions which may play a role in the successful development of university-industry collaborations (Ankrah and Al-Tabbaa, 2015; Perkmann et al., 2013; Rybnicek and Königsgruber, 2019). However, these studies have mostly focused on the macro level and not much has been done on the micro-level of how to develop university-industry collaborations. More importantly, an integrated framework is not available for studying the environmental conditions conducive for joint university-industry laboratories, despite their importance as one of the key modes for university-industry collaboration for an entrepreneurial university. Our goal in this paper is to develop such a framework, consisting of micro-level dimensions of environments, and to link these dimensions to the core elements of the successful joint university-industry laboratories process. Specific emphasis is given to the role of environmental conditions at the micro-level dimensions in developing opportunities and in enhancing individuals' propensity and ability to develop joint university-industry laboratories. A major theory of this paper is that university-industry collaboration such as JUIL can flourish if individual academics find opportunities in the environment, if environmental conditions motivate individual academics to take advantage of these opportunities and if environmental conditions enhance individual academics' ability to collaborate for the development of JUIL. We have shown how the framework of collaborative environments and the model developed in this paper provide a basis for studying micro-level dimensions of collaborative environments, enabling the development of richer theories in university-industry collaborations and the formulation of university policy.

The first and most obvious contribution of this model is that it provides a comprehensive and integrated view of collaborative environments for university-industry collaborations with guidelines for conducting future empirical research. The model and propositions developed in this paper provide a starting point for the study of an entrepreneurial university environment conducive to successful development of university-industry collaborations such as JUIL. The model developed in this paper also

provides a basis for formulating university policy on collaboration with industry. The common areas to be addressed by the university policy are: (a) increasing the opportunity for individual academics and creating a general environment which fosters collaboration with industry; (b) encouraging the establishment of systems to support individual academics; (c) providing effective methods of co-ordination and integration, and favourable organisation technology and ecology once individual academics' likelihood to collaborate has been enhanced. We show how the importance of each dimension of the collaborative environment for JUIL varies across universities. For example, in universities where opportunities are few, the focus should be on improving the industry collaboration policies and procedures and on developing an institutional framework for the efficient functioning of the university-industry collaboration processes. The reason is clear: if there are no attractive opportunities in the university environment, individual academics will not collaborate with industry. Also, the paper argues that not all environmental factors are equally important in all universities or at the same time. The role of each environmental factor varies depending upon the specific aspect of the university-industry collaborations (e.g., JUIL) development process which the university intends to address.

Finally, as Rybnicek and Königsgruber (2011) note, factors that contribute to the successful implementation of university-industry collaboration such as JUIL "…interfere with the organizational level of individuals; but these studies do not investigate this question specifically and remain rather speculative on this point. It seems worth taking a closer look at these differences, because for a successful university-industry collaboration, individuals at all levels have to contribute" (2019, p 238). We have developed a useful model to advance these arguments. We believe that the model and testable propositions developed in this paper will be useful for researchers interested in studying collaborative environments and for practitioners involved in designing and improving policies and programmes to enhance university-industry collaborations such as JUIL.

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