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THE UBC ECOSYSTEM: PUTTING TOGETHER A COMPREHENSIVE FRAMEWORK FOR UNIVERSITY-BUSINESS COOPERATION

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THE UBC ECOSYSTEM: PUTTING TOGETHER A COMPREHENSIVE FRAMEWORK FOR UNIVERSITY-BUSINESS COOPERATION

Abstract

The potential for a functional 'triple helix' to contribute to economic development is being increasingly accepted and embraced, particularly the bilateral relationship between higher education institutions (HEIs) and business. However, university-business cooperation (UBC) is still a fragmented and indistinct field of research, and the understanding of UBC remains inadequate since most research is undertaken around specific elements, rather than as an encompassing, overarching and interconnected system.

This paper aims to fill this gap in the literature by putting the pieces together to create an integrated and comprehensive conceptual UBC framework for HEIs, the *UBC Ecosystem*. The framework illustrates the components present in the UBC environment for HEIs, such as *inputs, activities, outcomes, outputs, impacts, supporting mechanisms, circumstances and context*, specifying a wide range of sub-elements for each of them.

In doing so, this paper makes a strong theoretical contribution with the creation of a conceptual framework, highlighting the more important elements and their interrelations as well as suggesting future research. Additionally, the paper makes a practical contribution, establishing a common UBC schema for HEI managers and policymakers to make strategic and operative decisions, and used as a base for evidence-based management and policy.

Keywords: University-Business Cooperation; Framework; Management; Innovation

1. INTRODUCTION

The fruitful relationships between higher education institutions (HEIs) and public and private external organisations have increasingly been recognised as sources of innovation with a potential impact on the economic and social development (Geuna and Muscio, 2009; Lubango and Pouris, 2007), and an essential engine toward knowledge societies (Etzkowitz and Leydesdorff, 2000). There is an increasing acceptance of the value of university-business cooperation (UBC), defined in this paper as all types of direct and indirect collaborative interactions between HEIs and any public or private organisation for mutual benefit (Davey et al. 2011). UBC is progressively softening the line that has traditionally separated the isolated *ivory tower* and the self-sufficient industry, with greater recognition of how UBC contributes to their respective networks (Coombs et al., 2003), funding (Bercovitz and Feldmann 2006), competitive advantage (Tresserras et al., 2005) and reputation (Ahrweiler et al., 2011).

Consequently, UBC is receiving greater support in terms of human resources, infrastructure investments and funds invested, with policy makers worldwide embracing the potential that greater synergies between the two offer (Tartari et al. 2012). Those managing or overseeing this process are challenged with the task of maximising the results achieved from the investment, which require a strategic overview and understanding of how the whole UBC phenomenon works. Similarly, researchers in the UBC area, are expected to contribute with new conceptualisations and findings that advance UBC as a research field.

However, UBC is a highly sophisticated and complex phenomenon; far from being a straightforward and linear knowledge transfer process (Perkmann and Walsh 2007) whose practical and scientific development remains a major challenge for managers, policy makers and researchers, due to a wide variety of factors. Since there is no current conceptual framework that brings together all the elements part of the system, researchers, policy-makers and HEI managers lack an essential tool or common map necessary to advance the field.

This paper intends to address this absence of a common framework for UBC researchers, managers and policymakers that describe in an inclusive way all the elements involved in UBC, their environment and interrelations. Addressing this issue, the objective of this paper is to systematically map the different elements that are part of the UBC phenomenon at HEIs along with the specific contextual elements in a comprehensive *UBC Ecosystem Framework*. This objective is achieved through the identification and classification of the major elements of the UBC ecosystem and their inter-relationships as established in literature.

This paper contributes to simplifying the high level of complexity of UBC providing a common understanding of how UBC works within the HEI, which could be used by UBC researchers, managers and policy makers. On the one hand, this paper contributes to a better understanding of the UBC research field since it undertakes a wide literature review, and set a common map to undertake future UBC research. On the other hand, it can also be an inter-organisational performance management tool that supports UBC decision-making processes for managing HEIs relationship with external organisations, which contributes to the policy and management settings.

The paper is structured as follows: following the introduction, the second section analyses the need of a UBC framework and extracts the main elements present. Using the UBC elements established in the previous section, the third section builds the UBC Ecosystem framework for HEIs, developing the elements and specifying sub-elements of the framework, closing with the proposed UBC framework. In the conclusions section, theoretical, managerial and policy implications together with limitations are presented.

2. TOWARDS A FRAMEWORK FOR UBC

2.1 *THE NEED OF A UBC FRAMEWORK FOR UBC RESEARCH*

Scientifically, UBC has been traditionally rooted in different fields (management, economics, law, sociology, human geography, engineering, etc.), has separately addressed topics from policy, managerial and organisational perspectives (Harman 2011), has been highly focused on the commercialisation of research and entrepreneurship activities (Shane 2004, Steenhuis and de Bruijn 2002), and on one-way transactional, rather than relational exchanges (Plewa and Quester 2007), with an emphasis on US literature (Teixeira and Mota 2012), whilst describing the transactions themselves rather than the management of UBC.

These foci in literature have led to an incomplete representation of the UBC landscape, and a topic rooted in siloes. For these reasons, there have been calls to look beyond technology transfer indicators to how HEIs enrich their environment (Bercovitz and Feldmann 2006) necessitating a broadening of the UBC area (D'Este and Patel 2005). With the UBC field only emerging as its own discipline over the last 30 years (Gulbrandsen et al., 2011), it has traditionally been addressed primarily by government reports or policy-related research (Plewa et al., 2006), and

mostly developed by top-down approaches (Mowery and Sampat 2001), resulting in a gap that needs to be filled from a scientific perspective. The UBC research field is fragmented and biased, resulting in limited understanding of how UBC works, its elements and relationships. Resultantly, the establishment of a scientific and inclusive UBC field, with a dedicated UBC framework as a base, would significantly advance this area of research and enable the different actors to unite around a common map.

Literature already recognises the ability to bring diverse elements together into a conceptual framework. The most prominent conceptual framework utilised to describe UBC is the Triple Helix concept (Leydesdorff and Etzkowitz, 1996) and for HEIs, the ‘entrepreneurial’ (Etzkowitz, 1983) or ‘engaged’ universities paradigms are increasingly recognised. Nonetheless, there is a lack of supporting theories in literature or integrative framework that consider all the elements within the organisational management of UBC and all their influencing elements for a wide range of activities.

2.2 THE NEED FOR A UBC FRAMEWORK FOR UBC PRACTICE

Partially to do with the way in which the university has evolved, the management of UBC at HEIs is typically decentralised (Phan and Siegel 2006), often fragmented and operating in siloes with little cross-unit collaboration. Consequently, UBC practices are often undertaken at an individual or unit level in a manner that lacks integration or coordination, no matter whether UBC is outside faculties or inside each of them (Sam and Van der Sijde 2014). Consequently, strategic organisational opportunities, efficiencies and economies of scale are missed.

A further issue fragmenting UBC management in HEIs is that a divide exists between the different levels of UBC management, specifically the policy, strategic and operational levels, which results in a lack of parity. They generally lack a united and common vision of how universities should collaborate with businesses, often are disconnected and disaggregated and lack a common tool or framework to manage the activity. Therefore, in UBC there is presently a clear lack of clarity about the organisational level of the UBC system, about the operations made at the individual or unit levels as well as about how they coexist and complement. To face these challenges successfully, a framework for HEI mechanisms and policies is needed (Fini et al., 2011).

2.3 AIMS FOR THE CREATION OF A UBC FRAMEWORK

A framework intended to increase the understanding of UBC should provide a common map for all actors involved in developing UBC. To do so, there needs to be an inter-organisational performance management framework that supports HEIs in their efforts to effectively manage their relationship with external organisations. Apart from being useful for HEI managers, it must be usable by policy-makers and provide a framework that guides research in UBC.

As an ‘ambidextrous’ framework, it should enable strategic, analytical and operational perspectives. Moreover, it should recognise both a structural (describing elements) and functional (describing relationships) approach for optimisation of the system, and thereby making it ‘critical for practitioners and academics’ (Adams et al., 2006, p21). Additionally, it should capture both the more general and more specific elements of the UBC system.

In doing so, it allows policy and strategic stakeholders to review the broader aspects of the system ('planning'), operation stakeholders to focus on the detail of executing policy and strategic decisions ('operationalising') as well as analysts the ability to monitor system ('analysing'). At the same time, it should remain transparent, flexible, fair, measurable and efficient, giving all stakeholders the ability to discuss the UBC concept using a 'common map'.

2.4 ELEMENTS OF A UBC FRAMEWORK

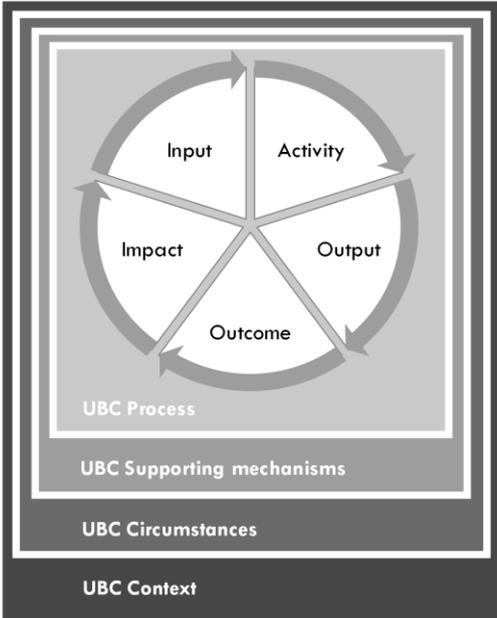
To achieve this, a number of elements need to be in place to underpin the framework.

It first involves embedding a process model to capture how UBC creates impact. The paper uses the basic structure of the performance management method Logic Model (Kellogg Foundation, 2004) as a base. Its use has a precedent for performance measurement of R&D alliances involving HEIs (Perkmann et al., 2011) as well as being a practical tool for delivering services. It consists of five major elements: inputs, activities, outputs, outcomes and impact and is sometimes depicted as a circular model rather than a lineal one, with results feeding into inputs for future activities (Wholey et al., 2010).

Additionally, given that the process of undertaking UBC is affected by external factors, a set of factors affecting UBC (Wholey et al., 2010) also need to be recognised. Three types of factors are identified: mechanisms supporting the development of UBC ('supporting mechanisms'), temporary factors that either inhibit or drive the UBC process ('UBC circumstances'), and more permanent factors affecting the UBC process as well as influencing all other elements in the framework ('UBC context').

Finally, these elements, or pieces of the 'UBC puzzle', are brought together to form a skeleton; a comprehensive framework for simplifying the complexity of the real world. The next figure depicts these main macro elements of the proposed framework for managing and researching UBC in HEIs, while the next section details the elements and sub-elements of the *UBC Ecosystem Framework*.

Figure 1: Macro elements of a UBC framework



Source: Own elaboration

3. THE UBC ECOSYSTEM FRAMEWORK

Having identified the four macro-elements of a UBC Ecosystem, the following section introduces the existent elements that are included in each of them as recognised in literature.

3.1 THE UBC PROCESS

3.1.1. UBC Input

Scholars have confirmed the key role of resources in strategic alliances (Das and Teng, 2000) and in HEI-business relationships (Anderson et al., 2007) as well as the importance of the provision of resources of both partners in several ways for the success of UBC (Das and Teng, 2003). UBC inputs, also called enablers (e.g. Tornatsky et al., 2002), comprise all the resources that are available, can be potentially included in the UBC process and combined to be used in UBC activities. The identification of inputs is vital in understanding what could be invested or provided to foster UBC (Chatterton and Goddard, 2000).

Several resource typologies have been proposed; although the classification that best adapts to the UBC environment is the one originally proposed by Thursby and Thursby (2003) and later used by Anderson et al., (2007). It classifies resources into human, financial and physical resources.

- Human resources

When HEIs engage in UBC, the involvement of people is a determinant for the activity's success as their quality, skills, knowledge, time and effort make the relationships emerge and develop. Although not all of them participate in each collaborative action, they all can potentially have the role of mediators, providers or receptors of knowledge.

From the HEI perspective, **HEI managers** are mainly responsible for HEI strategies and policies, in respect to UBC apart from providing visible leadership on the area (Herrmann 2008). **Researchers** can provide their scientific knowledge and experience in commercialisation (Siegel and Phan, 2005) as well as attracting private funding. Academic research quality on both an individual and departmental level is as an important input for successful UBC (Belkhdja and Landry 2007; Schartinger et al., 2002) and the quantity of research affects the scientist's ability to contribute positively to UBC (D'Este and Perkmann, 2011).

Lecturers can act as knowledge providers to industry and students, giving business the opportunity to influence the design and delivery of the curriculum, which enriches the student's educational experience (Herrmann, 2008), whilst also supporting knowledge development for those in industry through lifelong learning, including masters and topic specific courses. **Students** act as conduits of knowledge and skill enriching industry as interns, thesis writers and employees. Additionally, students bring motivation, skills and fresh ideas to business through placements, internships or joint projects or thesis (Herrmann, 2008) while improving their skills and employability (Benneworth, 2001; Bozeman and Boardman, 2013).

Providing their experience, networks and skills, **UBC intermediaries** within and external to HEIs, can identify opportunities, mediate, advise and help writing proposals (knowledge transfer offices), encourage innovative and entrepreneurial thinking and acting (innovation or

entrepreneurship centres), provide a platform for business creation and growth (business incubators), connect students with employers (career services), etc.

- Financial resources

Funding can come from any of the three actors of the triple helix and take different forms, such as government subsidies, industry endowments, HEIs financial incentives, etc. Governments are still the primary funding provider, particularly for joint research (Salter and Martin, 2001), but some authors point out the lack of adequate governmental programmes for UBC (Muscio and Pozzali, 2012). Governmental funding is usually given to HEIs, although some call for funding to be given to academics (D'Este and Perkmann, 2011; Jankowski, 1999; Morgan and Strickland, 2001). While funding can be essential for some types of cooperation, like commercialisation or joint R&D (GCRI, 2013), it is also proven how cuts in research funding can also encourage UBC (Muscio, 2010), with HEIs and researchers seeking funding and contracts in business, as a new way to fund research (Belkhdja and Landry, 2007). Financial resources are not needed for other activities, such as joint curriculum design. Finally, the need for funds varies in each of the fields of knowledge (Carayol, 2003), with laboratory-based research in technical or biomedical fields, needing larger sums.

- Physical resources

Some forms of cooperation between HEIs and business rely on materials, equipment or facilities that are utilised in their cooperation (Tartari and Breschi 2011; Carayol 2003). HEI and business might exchange access to each other's facilities and equipment or share common facilities, which could be one of the reasons why they start to cooperate in the first place (Kitagawa and Lightowler 2013). For training and education, business can make available state of the art facilities like laboratories, workshops and manufacturing plants (Shahabudin 2006).

Whilst some of these physical resources are previously owned, others are specifically acquired, created or rented for the cooperation. Like the financial resources required varies for different activities, some UBC activities require more physical resources than others. Managers and policymakers need to consider and evaluate prior to engaging whether the expected results justify the cost of the physical resources (Bozeman et al., 2012).

3.2 UBC Activities

UBC activities can be defined as collaborative interactions and cooperative efforts to transfer or exchange knowledge, technology or other properties between a HEI academic or manager and a member of any public or private external organisation. Informal interactions, such as meetings at conferences and fairs (Grimpe and Fier 2010), although important, are not considered UBC activities, but precursors of cooperation (Plewa et al., 2013). While some shorter and easier cooperation activities (e.g. guest lecturing) are associated with early stages in the relationship, others such as joint R&D require more commitment and normally take place when the relationship is consolidated (De Man, 2004).

Nowadays, there is enough empirical evidence to suggest that UBC takes place in all three HEI missions, education, research and valorisation. Some of the most commonly recognised types of collaboration include patenting and spin-offs. However, in spite of the great attention they

receive, they are only 'the tip of the iceberg', playing a comparatively small role in this UBC process (Arundel and Geuna, 2004; D'Este and Patel, 2007; Faulkner and Senker, 1995; Sequeira and Martin, 1997) and often not delivering high returns (Agrawal and Henderson, 2002; Cohen et al., 2002; D'Este and Patel, 2007; Sampat and Ziedonis, 2003; Schartinger et al., 2001). Too much attention on these forms may obscure the presence of other UBC activities with less visible economic pay-off, but equally (or even more) important both in terms of frequency and economic impact (Mansfield and Lee, 1996; Perkmann et al., 2013), such as curriculum co-design.

Additionally, UBC activities are linked; with cooperation in one UBC activity making future possibilities of cooperation more likely (Lee, 1996; Zucker and Darby, 1996) and more diverse in nature (D'Este and Patel, 2007). This occurs because once UBC commences, many of the perceived barriers are lowered (Bruneel et al., 2010), achieving more information about the collaborator and industry sector (Hertzfeld et al., 2006), more positive attitudes towards industry by academics (van Dierdonck et al., 1990) and better understanding and adaptation by industry (Bjerregaard, 2009). These improvements contribute to the success of UBC (Barnes et al., 2002).

The more varied UBC activities a researcher undertakes, the more effective and broader his/her contribution to dissemination and knowledge transfer to practitioners can be (D'Este and Patel, 2005). Therefore, the *UBC Ecosystem* also seeks to recognise the links and potential synergies between these activities. Finally, to create value and eventually common benefits, it is essential that these collaborative interactions result in concrete outputs.

The approach of this paper uses the three missions of the HEI as a classification for describing UBC activities in order to maximise the ability of the framework to be applied by both researchers and practitioners.

- Education domain

a. Joint Curriculum Design and Delivery

Curriculum design and delivery is the joint development and supply of programmes, courses, modules, majors or minors, planned experiences as well as course delivery by delegates from external organisations within undergraduate, graduate or PhD programmes (Davey et al., 2011). Some of the forms of curriculum design and delivery include cooperative project work and work-based learning (Chatterton and Goddard, 2000), planned experiences in business for students (Davey et al., 2011), definition and organisation of new study programmes (European Commission 2009a), guest lectures by business representatives (Science Business Innovation Board, 2012; European Commission, 2009), curriculum evaluation (European Commission 2009) and joint supervision of PhDs (Caniëls and Van den Bosch, 2011).

In practice, curriculum design and delivery often occurs via personal relationships and through informal channels rather than being institutionalised, centrally managed and controlled. It increases **student** employability, enriches student learning, better prepares them for the world of work by aligning their skills with the needs of regional employees (Gunasekara, 2006; Ssebuwufu et al., 2012). Thus the activity can improve the universities' teaching, research and innovation (European Commission 2009) as well as reputation of **HEIs** whilst for **business** it can provide training of employees and further professional education (Davey et al. 2011). In spite of these potential benefits, other authors question whether a HEI curriculum influenced by business

is desirable (Barnett, 2002; Gillis and McNally, 2010) or are concerned that industry might manipulate scientific knowledge (Krimsky, 2003; Slaughter and Leslie, 1997).

b. Lifelong learning (LLL)

Although LLL is generally defined as 'learning throughout life' (UNESCO, 2002), in this paper it relates to UBC and thus understood as the provision of adult education, permanent education and/or continuing education by HEIs to people employed in external organisations.

Examples of LLL activities include the provision of adult education, distance and open learning (Tamilina, 2012) and continuing education for business people (European Commission 2009), as well as training courses targeting a particular skill and training needs of industry (Caniëls and van den Bosch, 2011), which are said to be the most important types of interactions (Bekkers and Bodas-Freitas, 2008).

LLL has significant effects for knowledge transfer into the workplace and can pay off for the employer through psychological contracts, like organisational commitment, continuance commitment and job satisfaction (Pate et al., 2000). Not only do HEIs create a new income source, but they also respond to the industry needs of having better or improved skills. Nevertheless, LLL is still an emerging activity as HEI open themselves up only to a very low share of the market and usually stems from cooperation and joint development.

c. Student Mobility

Temporary movement of students from HEIs to business is probably the most common UBC activity. The best known actions are placements or internships (Lamichhane and Nath Sharma 2010); however, student mobility includes doctoral studies hosted inside industrial labs (Henrekson and Rosenberg, 2001) or students hired through academic contacts (Borrell Damian, 2009). Policymakers and HEI managers recognise the importance of student mobility through its inclusion as a requirement for graduation (Neill and Mulholland, 2003).

Student mobility takes place because **students** are looking to increase their practical skills knowledge and experience and thus current and future employment opportunities (Bozeman and Boardman, 2013; Drucker and Goldstein, 2007; Lamichhane and Sharma, 2010), far from being 'tokens of exchange between academe and industry' (Slaughter et al., 2002). At the same time, **business** look for access to talent with problem-solving capacities (Debackere and Veugelers, 2005; Lee, 2011; van der Sijde, 2012) who stimulate the firm's innovation (Kaufmann and Tödtling, 2001).

Successful student mobility should be based on a partnership or collaborative work between academics and business people, but few examples are found with this approach (Christie et al., 2004; Henderson et al., 2007), showing how most HEIs do not consider student mobility as part of UBC. A prove of this is that student mobility is usually managed by career offices not coordinated with academics or other HEI units related with industry, like incubators or TTOs.

- Research domain

d. Professional Mobility

Professional mobility is the temporary movement of employees between HEIs and businesses for work-related purposes. Forms of mobility include sabbatical periods for professors (Bonaccorsi and Piccaluga 1994) and professionals, secondments (Bonaccorsi and Piccaluga 1994), adjunct

professorships for professional from industry within the HEI (Henrekson and Rosenberg 2001) non-academic 'in-residence' professionals from local communities (Kitagawa and Lightowler 2013) and professors of practice (Kitagawa and Lightowler 2013). In practice, professional mobility remains as the least developed form of cooperation in Europe (Davey et al., 2011) and acts as a bottleneck for knowledge transfer and further interactions (OECD, 2002), with large differences in mobility between scientific disciplines and European countries (Davey et al., 2011; OECD, 2002).

Professional mobility contributes to the dissemination and exchange of tacit and explicit knowledge (Arundel and Geuna, 2004; Polt et al., 2001) and greater understanding between the **business** and **HEIs** (European Commission, 2008). As a result, local networks and contacts are created (Bercovitz and Feldmann, 2006) in order to develop meaningful, long-lasting relationships (Bekkers and Bodas-Freitas, 2008; European Commission, 2008) based on trust and commitment, both required for successful UBC (Davey et al., 2011). Its success depends on the efficiency with which knowledge is absorbed and put into economic use, a challenge considering the different routines, norms and standard operating procedures of both organisations (Bercovitz and Feldmann, 2006).

e. Collaborative R&D

Collaborative R&D can be understood as arrangements under which HEIs and business cooperate to pursue research objectives together regardless of where the funding comes from. This activity includes all joint R&D activities (Cohen et al., 2002) including cooperative research projects funded by industry (Hall et al., 2001), contract research (D'Este et al., 2011), R&D consulting (Etzkowitz 2001; Cohen et al., 2002), business testing and certification (Basant and Chandra 2007), joint publications with firm scientists/researchers (Bonaccorsi and Piccaluga 1994) and co-funding PhD students and industrial PhDs (Kolmosa et al., 2008).

For **business**, collaborative R&D leads to new products and services (Tresseras et al., 2005; Bekkers and Bodas-Freitas 2008), the ability to access new discoveries at an early stage (Kock et al., 2000; Bonaccorsi and Piccaluga 1994) and the ability to share the R&D risk and expense (Bekkers and Bodas-Freitas, 2008). For **academics**, it emerges as a way to increase the understanding of how knowledge is applied in practise (van der Sijde 2012), acquire new and relevant skills and competencies (van der Sijde 2012), increase scientific productivity measured in quality and quantity of articles (Abramo et al., 2009; Beaver 2004) and find teaching inspiration (van der Sijde 2012).

- Valorisation domain

f. Commercialisation of R&D results

Commercialisation is the process of bringing scientific research and technologies to the market through the trading of intellectual property assets. Forms of commercialisation include disclosures of inventions (Bercovitz et al., 2008), patenting (Geuna and Rossi, 2011), licenses (Lowe 2006, Cohen et al., 2002) and sales (Klofsten and Jones-Evans 2000). Whilst **academics** and **HEIs** achieve income (D'Este and Perkmann 2011) and reputation (Göktepe-Hulten and Mahagaonkar 2009), **business** access new products and services (Bercovitz and Feldmann 2006, Strunz et al., 2003) generating competitive advantages (Tresseras et al., 2005).

Since the introduction of the Bayh Dole Act in 1980 in the US, UBC policy and operational spheres in developed countries have focussed more heavily on commercialisation, with HEIs policies and public initiatives promoting such activity (Clarysse et al., 2007; Link and Scott, 2012; Lockett and Wright, 2005). While the exploitation of knowledge is a key determinant of economic development (Audretsch et al., 2006; Audretsch, 1995); commercialisation is often a marginal activity skewed towards technical faculties and a very limited number of technologies (Breznitz and Feldman 2010). Only very few HEIs and departments worldwide commercialise their knowledge and technologies and generally a minority of UBC is driven by the expectations of commercial products (D'Este and Patel, 2007).

g. Entrepreneurship

Entrepreneurship in relation to UBC is described as actions involving HEIs towards the creation of new ventures by students (Tornatsky et al., 2002), by academics based or not on their research (Etzkowitz et al., 2001), and by academics and industry together (Henrekson and Rosenberg 2001). For academics, entrepreneurship in the form of start-ups or spin-outs is still only undertaken relatively few (Davey et al. 2011) and often skewed towards information technology and, increasingly, the biotechnology/medical technologies sectors (OECD, 2002). Academics frequently face legal restrictions on commencing a business, so they engage more in joint R&D (D'Este and Patel, 2007) or licensing (Markman et al., 2004). Despite this, new venture creation by academics has been a topic of increased focus (Bercovitz and Feldman 2006) in practice.

Academics receive personal pay-offs from bringing their knowledge and technologies to the market (D'Este and Perkmann 2011), gain flexibility for retaining researchers (Jones-Evans 1998) and improves their personal reputation (Göktepe-Hulten and Mahagaonkar 2009). The rate of **student** start-up creation is higher than for academics (Berggren and Lindholm-Dahlstrand, 2009), and are motivated by the access to jobs and income (Hedvall 2011) and the ability to increase their value (as employees) in the marketplace (van der Sijde, 2012).

3.3 UBC Results

With a greater pressure on HEIs to justify government expenditure (Breznitz and Feldman 2010a, Siegfried et al., 2007), there is an increasing number of attempts to capture the value or results from UBC. This challenge has been often taken up by economists and focussed on a narrow understanding of cooperation consisting of outputs from research such as patents, licences and spin-outs (Caniëls and van den Bosch, 2011) as well as jobs created. Even when more recent attempts have been made to capture 'softer' UBC results and in more varied forms of cooperation (Drucker and Goldstein, 2007), including the education domain (Healy et al., 2014), there is no commonly-accepted or agreed-upon framework for assessing the UBC effects (Healy et al., 2014). Thus UBC researchers and managers still lack an understanding of the nature, origin and types of results that emerge from UBC, as well as whom and which areas they affect (Piva and Rossi-Lamastra, 2013).

Challenges to the classification and evaluation of UBC outcomes are commonplace owing to the tacit nature of knowledge flows (Liyanage et al., 2009) as well as the related concepts of tangibility/intangibility (Perkmann et al., 2011), formality/informality (Ssebuwufu et al., 2012) and the short- versus long-term nature of UBC results (Perkmann et al., 2011) all playing a role. Depending on the purpose of measuring, it might be relevant to classify UBC results using

different criteria such as: the UBC activity that originated them, the capital that are affected by such results (van der Sijde, 2012), the stakeholders that are affected by such results, the directness and tangibility of UBC results (as established by the Logic Model and applied to UBC by Perkmann et al., 2011), the quantitative/qualitative proxies of UBC results or their positive or negative nature.

This paper presents some results found in literature (not an exhaustive list) and classify them using two of the previous criteria. These are the directness and tangibility of results, which classifies them into outputs, outcomes and impacts and the stakeholder group affected by the UBC results, which includes individual (academics and students), institutional (HEIs and business) and community stakeholders (van der Sijde 2012). In terms of the process, outputs can be measured in a relatively straightforward way (European Commission 2009), however outcomes and impacts are more difficult to measure due to their lower tangibility and higher tacit knowledge (Caniëls and van den Bosch, 2011).

Regarding the processes, outputs should ideally convert into outcomes; but do not always do so. This is because knowledge transmission, transferred in a coded form such as a report or technology, requires the sender to encode the information and the receiver to be willing and able to interpret it (Cohen and Levinthal, 1989). This failure to convert the output into outcomes and impacts has been recognised to considerably inhibit the success of UBC (Pertuze et al., 2010). Additionally, UBC results can provide inputs to either future UBC or to support the HEIs education and research, which contribute back to business through new research and educated human capital (Ginzburg and Houli, 2013).

- Outputs of UBC

Outputs are the direct products, services or other properties that are delivered as a result of the UBC activity. They are typically tangible and countable and are delivered to individual and institutional stakeholders in the short term.

For **academics**, UBC generates publications (Breschi et al., 2007; van Looy et al., 2006), research results (Carayol, 2003), new content in the form of prepared workshops and seminars (Shahabudin, 2006) income (Wood 2011) and business ventures (Shahabudin, 2006), although UBC has also been found to restrict research results and provide fewer publications (Carayol, 2003).

For **businesses**, UBC outputs involve completed projects or products (Perkmann et al., 2011), technology prototypes (Markman et al., 2005), reports and data (Berman, 2008), licenced material (Siegel et al., 2003a) and software (Cohen et al., 1998), new product and services (Tresseras et al., 2005; Bekkers and Bodas-Freitas, 2008, Bercovitz and Feldmann, 2006, Strunz et al., 2003) and intellectual property such as patents (van der Sijde, 2012).

The major UBC outputs for **HEIs** comprise new workshops, seminars and courses (Wilson, 2012), new findings, methodologies and approaches (Debackere and Veugelers, 2005), patents, sponsored research agreements (Siegel et al., 2003a) and income (Bercovitz and Feldmann, 2006).

Students also receive outputs from UBC, including data for publications, thesis opportunities (Hedvall, 2011), completed publications and completed thesis (Breznitz and Feldman 2010b),

income from internship employment (Ginzburg and Houli 2013) and potential business start-ups (Shahabudin, 2006).

- Outcomes of UBC

UBC outcomes are the direct benefits or detriments of UBC experienced by individuals, and institutions (van der Sijde, 2012). UBC outcomes result from outputs and can be positive or negative for the stakeholder, tangible or intangible and be experienced directly or indirectly over a wide time range.

Academic UBC outcomes include uncovering knowledge gaps (D'Este and Perkmann, 2011), the practical application of research results (D'Este and Patel, 2007) and the creation of future research opportunities and sabbatical opportunities (Bonaccorsi and Piccaluga 1994), accessing equipment and resources (Tartari and Breschi, 2011), income or financial gain (Wood, 2011), new business opportunities (Shahabudin, 2006) and industry partners and networks (Bozeman et al., 2012).

Outcomes for **students** include increased practical skills knowledge and experience (Drucker and Goldstein, 2007), opportunities to apply their theoretical knowledge to the 'real world' (D'Este and Patel, 2007), improved soft skills (Strunz et al., 2003), improved personal networks (van der Sijde, 2012), accessing employment opportunities (Knouse et al., 1999), new venture creation (Shahabudin, 2006) and access to funding (Hedvall, 2011), among others.

In addition to the benefits experienced by academics, UBC outcomes for **HEIs** include access to industrial knowledge and applied technological fields (Arvanitis et al., 2008), support of curriculum development and delivery (Wilson, 2012), improvement of capabilities of academics (van der Sijde, 2012) and better preparation of students for industry (Strunz et al., 2003), provision of sources of income (Bercovitz and Feldmann, 2006) and funding (Lee, 2011) and access to state of the art research and training facilities (Shahabudin, 2006).

Outcomes for **business** include accessing new knowledge (Teixeira and Mota, 2012), discoveries (Lee, 2000) and insights into emerging technologies (Perkmann et al., 2011), stimulating innovation (Kaufmann et al., 2011), providing problem-solving capabilities (van der Sijde 2012), receiving a 'tidbit of knowledge' to assist development efforts (Siegel et al., 2003), upskilling existing staff (van der Sijde 2012), strengthening networks (Plewa et al., 2005), providing access to qualified graduates (Baadsgaard, 2012) and improving attractiveness as a prospective employer (Ginzburg and Houli 2013). Additionally, contributions entail the provision of future income through product and service development (Huang and Yu, 2011) as well as reduced R&D risk (Barnes et al., 2002) and expense (Bekkers and Bodas-Freitas, 2008).

- Impacts of UBC

UBC impacts are the UBC results experienced indirectly by individuals, institutions and societies (Kellogg Foundation 2004), thus the directness of the effect is the main difference with outcomes (Perkmann et al., 2011). UBC stakeholders receiving indirect impacts from UBC over the medium to long term include individuals, institutions and societies.

Impacts for **academic** comprise increased professionalism (van der Sijde, 2012), reputation (Davey et al., 2011) and scientific productivity (Abramo et al., 2009), improved access to industry partners and networks and better fitting curriculum design and delivery (Carayol,

2003). Impacts for **students** include increased practical skills knowledge and experience (Drucker and Goldstein, 2007), increased value in the labour market (van der Sijde, 2012) creating improved employability (European Commission, 2009), and higher starting salaries (Gault et al., 2000).

HEIs are impacted by fulfilling 'third mission' responsibilities (Drucker and Goldstein, 2007), improving reputation and image (Ahrweiler et al., 2011), improving the relevance of teaching (van der Sijde, 2012) and research (Gibbons, 1997). Also better preparing students (Strunz et al., 2003), connecting them with the local market (Lee, 2011) and retaining staff (Plewa et al., 2005) as well as increasing student numbers (GCRI, 2012) and third-party income (Bercovitz and Feldmann, 2006). Impacts for **business** involve improved quality of recruitment (Bekkers and Bodas-Freitas, 2008), improved long-term innovation and technology pipeline (Bercovitz and Feldmann 2006; Shahabudin 2006), enhanced corporate image, reputation (Perkmann et al. 2011) and competitive advantage (Tresseras et al., 2005) as well as new long-term income sources (Huang and Yu 2011) and increased shareholder value (van der Sijde 2012).

Some of the impacts documented for **communities**, such as regions, industry, science and society occur through the process of knowledge and technology creation, transfer and exchange (Etzkowitz and Leydesdorff, 2000). Impacts for society in literature impact communities such as science, industry and regions. Impacts for **science** include the generation of income for scientific endeavours (Grossman et al., 2001), the advancing of the discipline (Bonaccorsi and Piccaluga 1994) and improvement of scientific networks (van der Sijde 2012). For **industry**, UBC impacts embrace improved business networks (van der Sijde 2012), increased workforce development (GCRI 2012), spill-overs from HEIs for SMEs (Acs et al., 1994), development of knowledge-based graduates (Boucher et al., 2003) and new business start-ups (Kirchhoff et al., 2002). **Regions** also benefit through the support of local business, stimulation of economic growth, creating jobs and increase living standards (Etzkowitz and Leydesdorff, 2000), providing more relevant knowledge and skills (Razvan and Dainora, 2009), by attracting and retaining technology-intensive firms (Drucker and Goldstein, 2007) and providing the regional labour force with modern knowledge skill (Drucker and Goldstein, 2007).

3.4 UBC Supporting mechanisms

Supporting mechanisms are measures to develop and administer UBC, put in place by HEI managers or governments to create favourable conditions in which UBC can prosper and deliver benefit to society. Due to the fact that humans' resistance to change is a natural phenomenon (Bovey and Hede, 2001; Piderit, 2000) and that the process of change opens up competition and hostility (Lindblom, 1994), mechanisms aim to change the culture of HEIs (Kliewe et al., 2013) and bridge the substantial cultural differences between HEIs and businesses (Jones-Evans, 1998). Without mechanisms, UBC would likely remain an isolated and rare activity reliant on the whims of individuals.

The identification and management of these supporting mechanisms is essential to understand, analyse and improve UBC (Geissler et al., 2006; Korff et al., 2014; Polt et al., 2001). Their effectiveness has been widely recognised (Fini et al., 2011; Herrmann, 2008; Tornatzky et al., 2002) to either remove or reduce barriers or drive UBC, although they need to be adapted to the specific cooperation activity (Henrekson and Rosenberg 2001). Mechanisms can be in form

of policies, strategies, structures and activities (Davey et al., 2011) even if discussions tend to be too focussed on TTOs and incubators (Plewa et al., 2006).

Additionally, these mechanisms need to be aligned with a mission and culture for UBC through strategy development (Siegel and Phan, 2005) and link all levels of the institution (Rasmussen et al., 2006). As an example, policies provide the regulatory and economic conditions (e.g. tax concessions for R&D) in which UBC strategic mechanisms are created (e.g. UBC strategy with a dedication of resources) often involving the creation of structural mechanisms (e.g. creation of a knowledge transfer centre or position), which can then initiate operational mechanisms (e.g. UBC workshops addressing academics).

Challenges exist to provide favourable conditions for UBC, including having the right mix of support, incentives, drivers and liberty from barriers whether they be top-down or bottom up (Korff et al., 2014), create efficient and aligned mechanisms and optimize the use of funds (Department for Business Innovation and Skills, 2014).

- Policy mechanisms to support UBC

UBC policy mechanisms encompass all the regulations of the UBC field at different levels, from organisational policy to international regulation. Policies mechanisms are known as conditions applied by regional, national and international governments to maximise the long term economic performance, welfare or other policy objectives which are focussed on directly or indirectly encouraging UBC. Borrás and Edquist (2013) identified some primary forms of UBC policies as follows:

In order to provide specific pecuniary incentives (or disincentives) and support specific social and economic activities, *economic and financial mechanisms* are created. Literature recognises a number of these mechanisms including funding, grants and subsidies, stimulus packages, infrastructure (Harman, 2011; Polt et al., 2001), taxation concessions and public seed capital (OECD, 2002).

Limiting and restraining UBC are a set of *regulatory mechanisms*. These mechanisms set the frameworks allowing something or banning it and include UBC laws and regulations (Tartari and Breschi 2011).

Mechanisms that do not belong to either of the two categories are termed *other policy mechanisms*. These mechanisms provide recommendations, make normative appeals or offer voluntary or contractual agreements and they are non-coercive. They include governance, government programmes, education and training programmes (Reynold et al., 2002), public promotion programmes (Polt et al., 2001), and hiring policies (Tartari et al., 2012).

- Strategic mechanisms to support UBC

There is recognition that the creation of a HEI culture encouraging UBC can be driven through a long term top-level buy-in supported with UBC strategic mechanisms (Davey et al., 2008; Korff et al., 2014). Strategies are 'the drafting and implementation of cross-functional long-term decisions by a HEI that enable it to achieve its long-term objectives with respect to UBC' (Davey and Galan Muros 2013, p.545). UBC strategic mechanisms recognised in literature are:

Documented strategic mechanisms, which are instituted at the top of the HEI, include creating a mission, vision, strategy documents and goal statements that reflect a UBC emphasis (Ssebuwufu et al., 2012) and are generally aimed at developing a culture for UBC.

Implementation strategic mechanisms are designed to embed UBC concept within the HEI and are a further commitment from the documented strategies. They include incentives for involvement in UBC (D'Este and Perkmann, 2011), resource allocation like funding, in-house support and access to infrastructure (European Commission 2009), as well as internal/external promotion of UBC (van der Sijde, 2012).

- Structural mechanisms to support UBC

UBC structural mechanisms 'include the creation or development of institutions, positions, methods and programmes' (Davey and Galan Muros 2013, p.545). Literature recognises different structural mechanisms:

People-based structural mechanisms are commonly recognised and include board level positions for UBC (Davey et al., 2011), cross-institutional board appointments and advisory boards (Tornatzky et al., 2002), employing people with business experience within the HEI (Lubango and Pouris 2007) as well as UBC intermediaries (Gulbrandsen and Nerdrum, 2009), and networks (Rogers, 2002).

The most recognised mechanisms are *office / centre-based* structural mechanisms. These include TTOs (Markman et al., 2004), incubator facilities (Phan and Siegel, 2006), specialist scientific and technological centres and parks (Etzkowitz, 2001), career offices (Davey et al., 2011) and centres for further learning (Gnahs et al., 2008), among others.

Programme-based structural mechanisms are also recognised in literature, including joint research and education programmes (OECD 2007), programmes facilitating interaction between HEI and industry (Ponomariov and Boardman 2008), programmes to educate businesspeople (Lubango and Pouris, 2007), and alumni programmes (Plewa et al., 2015), among others.

- Operational mechanisms to support UBC

UBC operational mechanisms are 'actions of a practical nature undertaken by a HEI to create and support HEI-business activity whose scope and volume can be described/measured' (Davey and Galán-Muros, 2013, p.545). Operational activities target a range of stakeholders including students, academics, researchers, businesses and other groups and include:

Communication and exchange mechanisms, such as communications and research dissemination (Mitton et al., 2007) or internal and external marketing (van der Sijde, 2012) that aim to promote UBC at all levels.

Linking and support mechanisms, which aim to bridge the HEI and business worlds and include UBC support actions (Gulbrandsen and Nerdrum, 2009), actions facilitating student and academic interaction with business (Davey et al., 2011), UBC networking, advocacy, liaison and assistance (Dottore et al., 2010).

Training and seminar mechanisms aim to foster business and entrepreneurial skills and mind-sets in academics and students necessary for UBC. Literature recognises these as entrepreneurship

and UBC-related education sessions (Mitton et al., 2007), workshops, information sessions and forums (Davey et al., 2011).

3.5 UBC Circumstances

The UBC system is affected by both internal HEI factors and external environmental ones. As UBC is a discretionary activity for academics (D'Este and Perkmann, 2011), it is logical that an individual's perception of the activity and the surrounding environment (supportive or otherwise) along with the culture in which they operate (Plewa et al., 2006) become important. This complex array of temporary internal and external influencing elements, which can be changed through management actions, are named *UBC circumstances*.

Literature recognises two primary forms of *UBC Circumstances*: (i) *barriers* that inhibit or prevent the UBC activity (Bruneel et al., 2010) and (ii) drivers or motivators that facilitate and motivate it (D'Este and Perkmann 2011). To develop UBC activity, UBC actors need to be aware of how these elements affect their local UBC systems by determining the greatest barriers or strongest drivers. A number of individual, organisational and institutional factors effecting UBC have been identified (Perkmann et al., 2013).

Linking barriers to drivers, it has been found that if academics perceive drivers (or reasons for undertaking UBC) they overcome UBC barriers more easily (Bruneel et al., 2011), whilst the trade-off between the two significantly affect an academic's decision to cooperate with business (Tartari and Breschi, 2011).

- Barriers for UBC

For the commencement of relations, *connection* and *awareness barriers* exists affecting both business and HEIs because the opportunities for interaction are very limited (Kaufmann and Tödtling, 2001; Muscio and Pozzali, 2012). There is a lack of awareness of each other's existence and offerings so relations often commence through introductory conversations with an adequate interlocutor (Barnes et al., 2002; Mitton et al., 2007; Plewa et al., 2013).

The lack of *funding* is another obstacle for UBC; particularly in times of crisis (OECD, 2014). The negative effect of this lack of funding on UBC has been investigated for governments (Bercovitz and Feldmann, 2006; Perkmann et al., 2011; Muscio and Pozzali, 2012; van der Sijde, 2012), HEIs (Etzkowitz, 1998; Schartinger et al., 2002; Belkhodja and Landry, 2007) and industry (Amara and Ouimet, 2006).

The vast differences in *organisational culture* between HEIs and business represent another obstacle (Perkmann et al., 2011). A number of cultural factors significantly affect UBC, including differences in goals (Meyer-Krahmer and Schmoch, 1998; van der Sijde, 2012), time horizons (Phan and Siegel, 2006; Plewa, 2009), level of bureaucracy (Hülsbeck et al., 2011; Siegel et al., 2003; Rhodes et al., 2008), flexibility (Plewa, 2009), incentives (Siegel, et al., 2003a) (Bekkers and Bodas-Freitas, 2008) and communication styles (Plewa, 2005; McNichols, 2010; Siguaw et al., 2003; Muscio and Pozzali, 2012).

From the HEI point of view, some *organisational characteristics* of business hinder successful UBC. The most cited obstacle is the business' lack of absorption capacity of the knowledge or technology transferred, either from research findings (Hasselmo and McKinnell 2001; Mitton et

al., 2007) or internships or projects (Collins and Wakoh, 2000; Perkmann and Walsh, 2007). Moreover, the business focus on creating practical results (Mowery and Shane, 2002; Bruneel et al., 2010), their need for confidentiality and the fear of disclosures (Hall et al., 2001; Carayol, 2003; Perkmann and Walsh, 2007) are further barriers for UBC. On the HEI side, the academic nature of the HEI and the coexistence with the teaching and research function (Bruneel et al., 2010) might cause the feeling for academics of UBC hindering their scientific careers (Siegel et al., 2003).

- Drivers of UBC

HEIs and business access each other's resources when they cooperate, which gives them both competitive advantages and helps society (Eztkowitz and Leydesdorff, 2000) due to the complementarity of the *available resources*. Business can access the best students and graduates (Kock et al., 2000; McNichols, 2010), skilled scientists (Tresserras et al., 2005), cutting-edge research (Kock et al., 2000; Lee, 2000) and innovative products and services (Bercovitz and Feldmann, 2006; Bekkers and Bodas-Freitas, 2008). Conversely, HEIs access industry knowledge and business sector R&D facilities (Tartari and Breschi, 2011).

Personal relationships between academics and businesspeople and how they interact is considered a key influencing element. Trust as an antecedent of knowledge transfer (McNichols, 2010) is essential for relationship maintenance and success (Plewa, 2005; Bruneel et al., 2010) due to the unfamiliar processes and environment (Mora-Valentin et al., 2004), and its absence constitute a barrier for UBC (Mitton et al., 2007). This is similar in the case of mutual commitment (Barnes et al., 2002; Mora-Valentin et al., 2004). Additionally, if expectations are coordinated, a shared goal can be achieved, driving UBC (Farr and Fischer, 1992; Barnes et al., 2002; Mora-Valentin, 2002; Bekkers and Bodas-Freitas, 2008; Bruneel et al., 2010) and reducing misunderstanding and conflicts (Arvanitis and Wörter, 2007; Koch, 2011; Lee, 2011). Drivers to commercialise research through patenting and spin-off activity are finances whereas collaborative research and consulting are driven more by research-related motives (D'Este and Perkmann, 2011).

3.6 UBC Context

UBC is also affected by fixed factors that cannot be changed by managerial actions, at least in the short and medium term (E3M Consortium, 2008). Whilst it was established by Phan and Siegel (2006) earlier in UBC literature, it was expanded on by Perkmann et al. (2013) in their extensive review of previous studies on academic engagement. They identified three levels, the individual, organisation and environment (it was referred to as 'institutional' factors), as elements that influence UBC.

Individual (age of participants, their gender, their field of knowledge, the experience on business and the experience on HEIs), *organisational* (HEIs type, size, etc.) and *environmental* factors (political, economic, social, technological, legal and environmental) are relevant. It has been found that the local social community or culture has a mediating and moderating effect on the entrepreneurial behaviour of academics (Mazzarol, 2007).

While some authors argue that demographic characteristics are the most influential factors to predict the formation of UBC (Elisa Giuliani et al., 2010), others dispute this finding (Boardman

and Ponomariov, 2009). Ponomariov (2008) proposes institutional elements to be the greatest determinants for foreseeing an individuals' engagement with private organisations and D'Este and Patel (2007) suggest individual specific factors to be relevant for estimating the variety of UBC operational actions. Based on the above, it becomes evident that there is no single answer in the combination of personal, institutional and company specific characteristics to predict UBC operational actions.

- Individual factors affecting UBC

Gender is an individual factor that has been identified to influence UBC. The probability to engage with business in general is found to be higher for males than for females (Azagra-Caro, 2007; Boardman, 2008; Giuliani et al., 2010; Goktepe-Hulten, 2010; Link et al., 2007; Rijnsoever et al., 2008), especially in commercialisation and informal knowledge transfer (Murray and Graham 2007) and entrepreneurial activities (Clarysse et al., 2011; Klofsten and Jones-Evans, 2000).

Regarding academics' age, some authors do not find any clear relationship with their UBC engagement (Boardman and Ponomariov, 2009; Gulbrandsen and Smeby, 2005; Renault, 2006) while others find a significant relation, which in some cases is positive i.e. UBC activity increases with age (Boardman and Ponomariov, 2009; Haeussler and Colyvas, 2011; Link et al., 2007) and in others negative i.e. UBC activity decreases with age (Bekkers and Bodas-Freitas, 2008; D'Este and Patel, 2007; D'Este and Perkmann, 2011; Giuliani et al., 2010).

The *fields of knowledge* in which academics teach and undertake research (i.e. technology and engineering, biomedical sciences, social sciences and humanities) have also been found to make a difference in the degree of engagement, with more applied fields having stronger industry ties (Arvanitis et al., 2008; Boardman, 2008, 2009; Bozeman and Gaughan, 2007; Lee, 1996; Lee and Bozeman, 2005; Ponomariov, 2008). Specific fields of knowledge have been more associated with certain UBC activities, like consulting in technology and engineering fields (Bekkers and Bodas-Freitas, 2008).

The academics' *experience in business* is a further factor that positively influences the academic engagement in UBC (Galan-Muros and Plewa, 2016), since they gain access to larger networks (Melin, 2000), particularly in their sector (van Rijnsoever et al., 2008) and are more capable of finding potential business partners efficiently (Perkmann et al., 2013; Giuliani et al., 2010; Haeussler and Colyvas, 2011; Landry et al., 2006). Academics with business experience have been found to increase knowledge transfer (Lubango and Pouris, 2007) and technology transfer (Siegel et al., 2003), in the research domain (Ponomariov and Boardman, 2008; van Rijnsoever and Hessels, 2011) and commercialisation (Nilsson et al., 2010; Clarysse et al., 2011).

Similarly, the *academics' experience in the HEI* seems to have certain influence on UBC engagement (Galan-Muros and Plewa, 2016). Although the number of studies regarding HEI experience as influencer of UBC is quite limited, the studies suggest that experience in the HEI provide academics with more opportunities for networking with industry (Lee and Bozeman, 2005), more time for dedicate to conduct R&D projects with companies (Ponomariov and Boardman, 2008) and the skills to manage joint projects with business (Dutrénit et al., 2010).

- Organisational factors affecting UBC

The *type of HEI* in which the academic or student operate has an influence on the extent of UBC. Based on the fact that applied knowledge fields (where cooperation is more common) are mainly part of polytechnics and universities of applied sciences, these type of HEIs are found to be more engaged with industry, also helped by the fact that their technology transfer policies are often more developed (Perkmann 2012; Renault 2006).

Concerning the influence of the *size of the HEI* on UBC, studied by a very limited number of authors, it seems to be also relevant for UBC engagement with Van Geenhuizen (2010) identifying that it was especially relevant for knowledge valorisation. In UK studies, small HEIs were found to collaborate more domestically and with industrial partners (Katz, 2000) whilst larger HEIs were found to receive more knowledge exchange public funding per academic (Rossi and Rosli, 2013).

- Environmental factors

Literature shows that the *characteristics of the environment where the HEI operates* also have an effect on the development of UBC. The unique political, economic, social, technological, legal and environmental characteristics of each specific location affect UBC differently. The complex mix of these factors results in environments that can support or inhibit UBC (Geuna and Nesta, 2006), with historical development also playing an important role in creating these environments (Plewa et al., 2006). Even though the number of international comparative UBC studies is scarce (Perkmann et al., 2013), they suggest that the development of UBC in different countries is varied (Davey et al., 2011; Kaufmann and Tödting 2001; Klofsten and Jones-Evans, 2000).

For example, in the USA, there is a long history of UBC (Bower, 1993), in Australia UBC is more recent (Harman, 2011) and Japan has enhanced its UBC over the last 20 years (Baba and Kamibeppu, 2000), whereas UBC is a rather recent phenomenon to most African HEIs (Stackhouse et al., 2001). These differences would have an effect on the openness of actors to UBC as well as the development of the regulation or structures in place. Moreover, it has been found that the accessibility of knowledge and skills in the location and access to infrastructures are equally relevant for UBC (Chatterton and Goddard, 2000). Furthermore, findings show that the HEI curricula tends to change from basic to applied research when close to a science park (Siegel and Phan, 2005) and that technology transfer is higher in regions with a concentration of high-tech firms (Friedman and Silberman, 2003).

3.7 The Summary and Representation of the UBC Ecosystem

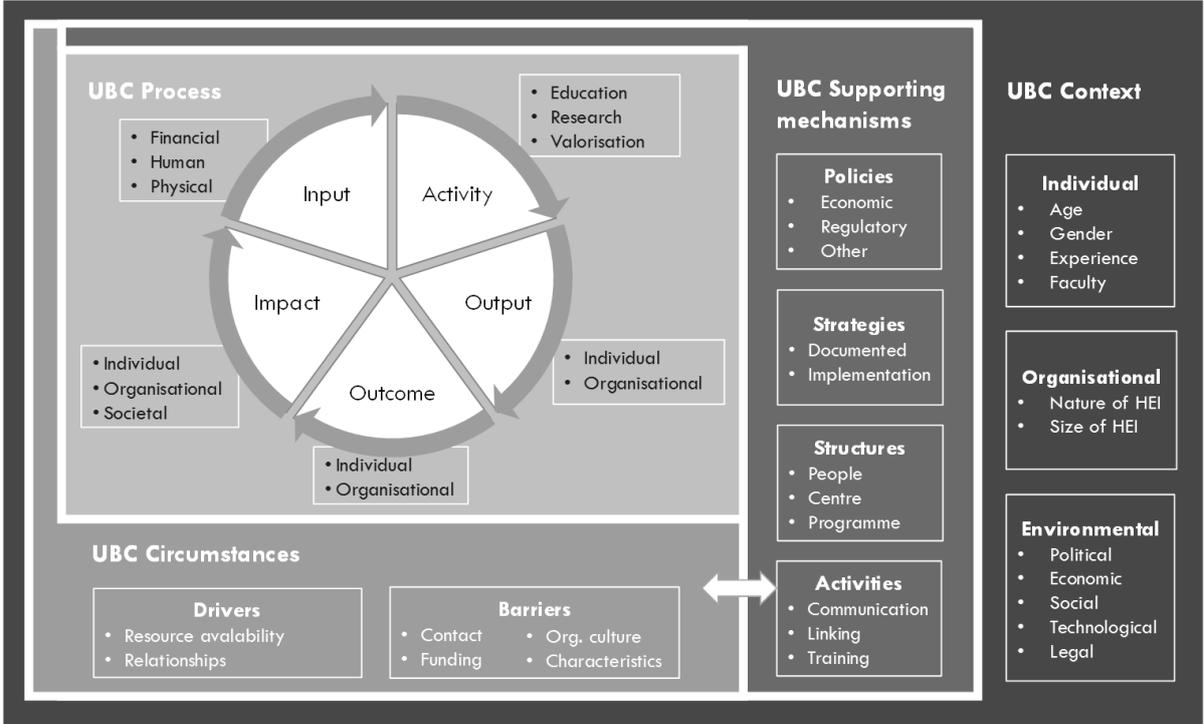
Built on the skeleton of the macro *UBC framework* detailed in section 2, the *UBC Ecosystem* has fleshed out a series of sub-elements using literature to provide a common map for managing UBC within HEIs. The UBC Ecosystem places the **UBC process** at the centre, including the elements that occur in UBC: inputs, activities, outputs, outcomes and impacts. In doing so, the UBC activity is operationalised, allowing the monitoring, analysis and optimisation of the UBC system from inputs to impacts.

Affecting the UBC process are a series of **influencing elements** including *mechanisms supporting UBC*, which can be actively implemented, as well as *UBC circumstances and context*, which play the role of inhibiting or accelerating UBC. These include the policy, strategy, structural and operational supporting mechanisms, the elements of the context related to the demographics

and experience of the individual and organisation and finally a range of UBC circumstances including barriers and drivers that could affect the UBC process. Figure 2 represents the UBC Ecosystem framework, including all the elements identified.

Figure 2: The UBC Ecosystem Framework (for HEIs)

Source: Own elaboration



The following table summarises the elements of the UBC Ecosystem for HEIs, offering a definition for each and the question they aim to answer.

Table 1: Summary of the elements in the framework

	Macro-elements	Question	Definition	Elements	Sub-elements
UBC PROCESS	INPUT	Which are the resources put into the system?	Resources utilised to undertake UBC activities	Human	<ul style="list-style-type: none"> • Students as conduits of knowledge and skill • Researchers as providers of scientific knowledge • Researcher quality and quantity • Lecturers as knowledge providers • Intermediaries as connectors and facilitators • HEI managers as leaders
				Financial	<ul style="list-style-type: none"> • UBC Funding by government • UBC Funding by business • UBC Funding by HEIs
				Physical	<ul style="list-style-type: none"> • Materials for UBC • Equipment for UBC • Facilities for UBC
	ACTIVITIES	Which are the UBC actions taking place?	UBC actions undertaken to bring about the intended outcomes	Education	<ul style="list-style-type: none"> • Joint curriculum design and delivery • Lifelong learning • Student mobility
				Research	<ul style="list-style-type: none"> • Professional mobility • Joint R&D
				Valorisation	<ul style="list-style-type: none"> • Commercialisation of R&D results • Entrepreneurship
	OUTPUTS	Which are the products, services and properties derived from the UBC activity?	Direct products, services or other properties that are delivered as a direct result of the UBC activity	Individual	<ul style="list-style-type: none"> • Academics and student outputs
				Organisational	<ul style="list-style-type: none"> • HEIs and business outputs
	OUTCOMES	Which are the results of these outputs for individuals and organisations?	Results that flow from the UBC outputs	Individual	<ul style="list-style-type: none"> • Academics and student outcomes
				Organisational	<ul style="list-style-type: none"> • HEIs and business outcomes
				Community	<ul style="list-style-type: none"> • Industry, science, society
	IMPACTS	Which are the changes that occur as a result of UBC for individuals, organisations and societies?	Social, economic, civic and/or regional consequences or changes resulting from the UBC outcomes, intended or unintended.	Individual	<ul style="list-style-type: none"> • Academics and student impacts
				Organisational	<ul style="list-style-type: none"> • HEIs and business impacts
				Community	<ul style="list-style-type: none"> • Industry, science, society
					Policy

	Macro-elements	Question	Definition	Elements	Sub-elements
INFLUENCING ELEMENTS	UBC SUPPORTING MECHANISMS	What are the mechanisms supporting UBC?	Interventions in the form of policies, strategies, structural and operational mechanisms that support UBC		<ul style="list-style-type: none"> • Other policy mechanisms
				Strategic	<ul style="list-style-type: none"> • Documented strategic mechanisms • Implementation strategic mechanisms
				Structural	<ul style="list-style-type: none"> • People-based structural mechanisms • Office / centre-based structural mechanisms • Programme-based structural mechanisms
				Operational	<ul style="list-style-type: none"> • Communication and exchange mechanisms • Linking and support mechanisms • Training and seminar mechanisms
	UBC CIRCUMSTANCES	Which are the temporary conditions that affect the UBC process?	Factors that can have a positive or negative influence on UBC and can be modified in the short/medium term	Barriers	<ul style="list-style-type: none"> • Initiation and awareness barrier • Funding barriers • Organisational culture • Organisational characteristics
				Drivers	<ul style="list-style-type: none"> • Resource Availability • Personal relationships
	UBC CONTEXT	Which is the fixed environment that affect the UBC process?	Individual, organisational or community characteristics, that can have a positive or negative influence on UBC	Individual	<ul style="list-style-type: none"> • Gender • Age • Fields of knowledge • Academics' experience in business • Academics' experience in the HEI
				Organisational	<ul style="list-style-type: none"> • Type of HEI • Size of the HEI
				Environmental	<ul style="list-style-type: none"> • Political • Economic • Social • Technological • Legal • Environmental

Source: Own elaboration

4. **CONCLUSIONS**

The UBC Ecosystem framework fills a gap in the UBC literature by offering a holistic and integrative framework that captures the complexity of the UBC phenomenon in a simplified and useful manner. Following a descriptive approach, previous literature was collected, analysed and synthesised into an integrated conceptual framework to provide a useable and common roadmap of the elements (strategic) and processes (operational) of UBC. In this way the UBC Ecosystem provides a 'common map' for policy makers, HEI managers, involved stakeholders and researchers to discuss, plan, execute and analyse the UBC phenomenon.

The UBC Ecosystem, organised along the Logic Model, provides a framework that is clear, yet customisable combining (i) an overarching macro approach identifying the major elements to consider for policy and strategy work, (ii) a process orientation specifying the relationships between elements that allows strategic and managerial work and (iii) detailed sub-elements influencing the UBC process to populate the general elements, which facilitates strategic and analytical work and can be personalised for each HEI. This way, the framework recognises the unique nature of each HEI, acknowledging that the specific sub-elements for each HEI may change. The sub-elements mentioned in this paper however, are not an exhaustive list owing to the fact that the elements are only included if they were recognised in literature. For this reason, future research could also focus on new and emerging micro-elements.

Lastly, the importance of a description of a *process* in performance management literature (Wholey et al., 2010), innovation management (Brown and Svenson, 1988) as well as UBC (Perkmann et al., 2011) has been discussed, emphasising the need for a process in a multipurpose UBC framework. The process nature of the model was linked with external factors influencing the process (Wholey et al., 2010) such as the supporting mechanisms, UBC circumstances and context.

4.1 **THEORETICAL CONTRIBUTIONS**

The *UBC Ecosystem* is the first framework that gathers and structures a rapidly growing and highly fragmented bank of literature accounting for the complex nature of UBC, thus contributing to the theoretical development of UBC. The comprehensive conceptual framework goes beyond the widely used case study method, historic analysis (Debackere and Veugelers, 2005) and the quantitative analysis of a single HEI (van Looy et al., 2004). Because it is robustly grounded in scientific literature, the *UBC Ecosystem* provides a map for researchers in the UBC research field, providing common definitions of concepts that serve to better identify research gaps and make studies comparable. This paper points out the extant research coverage of the framework, specifying the factors or relationships found in literature and implicitly those gaps in which research is limited as follows.

UBC *inputs* (except financial resources) are often ignored by both research and practice (e.g. Bercovitz and Feldmann 2006). Whilst this may be partly due to 'inputs' being viewed or described differently such as interventions or enablers (e.g. Tornatsky et al., 2002), or are focussed on the situation characteristics of the individual or organisation (e.g. Phan and Siegel 2006), this lack of understanding of how inputs contribute to successful UBC highlights an essential area for further

research. More specifically, it would be desirable to understand how UBC skill, knowledge and experience as well as research and teaching competencies of the individual and institution (human capital) impact successful UBC, what are the type of resources that contribute to successful UBC, particularly in respect to the lesser researched UBC activities, or addressing the entire range of UBC activities together.

The framework considers seven UBC activities, following authors who called for the need to research a wider range of activities and their links (D'Este and Patel 2005), although links remain under researched. In respect to specific UBC **activities**, *joint curriculum design and delivery* has received very little academic attention (Donald S. Siegel, Wright, and Lockett, 2007), with few papers (Plewa et al., 2015; Stephan, 2001) or case studies (Stewart and Rosemann, 2001) in the topic. It has been best captured in policy and professional reports with an educational focus (European Commission, 2009; OECD, 2012) due to the pressures faced by HEIs to ensure high levels of graduate employability, particularly in locations with high unemployment, such as Europe (Eurostat, 2015).

Student mobility is another activity whose management is seldom investigated, evaluated and supported (Neill and Mulholland, 2003) and its literature rarely involves the concept of 'partnership' or collaborative work with business (Henderson et al., 2007). Future research of student mobility should be undertaken from a UBC perspective, recognising the ability of students to transfer knowledge or initiate more/deeper relationships between HEIs and business (Healy et al., 2014).

Similarly, LLL is a concept that is rarely documented in relation with UBC, but with increasing attention in policy circles (UNESCO, OECD, European Commission, etc.), due to its large impact. Thus more systematic research in joint curriculum design and delivery, student mobility and LLL is suggested to improve employability and entrepreneurial behaviour (Asderaki, 2009).

In the research area, there is a growing literature stating the importance of professional mobility, however empirical studies or statistics dedicated to the topic are scarce (OECD, 2002). *Joint R&D* is one of the most commonly recorded and researched UBC activities due to its importance (Bekkers and Bodas Freitas, 2008), whilst in the valorisation area, commercialisation and entrepreneurship have a large and rapidly growing body of literature (Perkmann et al., 2013).

Literature on UBC **results** focuses on creating outputs from activities, specifically measurable outputs such as patents, licences and spin-outs (Siegel et al., 2003), from activities with economic pay-off, like commercialisation or joint R&D. The higher recognition of tangible and explicit results rather than intangible or tacit, makes outcomes from the education domain more difficult to transfer through commercial transactions (Bonaccorsi and Piccaluga 1994) and thus less researched. Unlike business outcomes, outcomes for academics and students are quite well documented in literature although greater focus on how UBC contributes to the work evaluation of academics is required.

The full extent of UBC is difficult to capture given the high amounts of tacit knowledge exchange in knowledge transfer and exchange, with a high reliance on social interactions (Nonaka and Takeuchi 1995). Further research would increase the understanding of how each stage of the framework is transformed into the next (i.e. how do inputs become activities? How do activities become outputs? etc.). Ideally, flows could be traced along the ecosystem, from inputs to impacts, determining the

antecedents of UBC success and identifying the exact contribution of the various factors to UBC development.

Supporting mechanisms are highly debated in literature, given their high cost, the need of the right people to make mechanisms efficient or the possibility to undertake UBC activities outside the institutional channels. However, it is broadly accepted that in given situations these mechanisms play a role in supporting UBC activities, or in creating a culture for UBC within the HEI, with a crucial link between the individual and their environment (Korff et al., 2014). Literature focusses on structures to facilitate entrepreneurship and technology commercialisation (O'Shea et al., 2008) such as TTOs, science parks (Siegel et al., 2003) and incubators (Siegel and Phan, 2005) over career offices, alumni offices or corporate relations offices.

Resulting from this work, and apart from the coverage of certain topics, this paper can be used as the base for other relevant future research. Firstly, the empirical testing of the different elements of the framework, as well as their relationships (i.e. how do UBC activities link with each other?), would provide greater validity to the framework and deepen the knowledge of UBC generally. Specific measures could be developed in order to quantify each of the elements described in the ecosystem as a first step towards inter-organisational benchmarking.

This framework can be further validated by applying it in different geographical locations, in different types of HEIs, in HEIs of diverse size and in different fields of knowledge. Within a detailed perspective, personalised frameworks for different environment can be designed and specific profiles can be created. Finally, a UBC Ecosystem framework for business could be created in order to complement this one and help the theoretical and practical development of UBC from the industry perspective.

4.2 MANAGERIAL IMPLICATIONS

In the UBC Ecosystem framework, HEI managers can find a common ground for discussions within the HEI about their interaction with external collaboration. The elements of the framework, which are fixed and always exist, play a role in any UBC situation and thus represent the primary areas for management and planning. However, UBC is not a 'one size fits all' endeavour because the conditions surrounding and within organisations are unique and require solutions that are adaptable to their needs and make best use of their strengths and weaknesses. This adaptation occur in the sub-elements, which provides enough detail and flexibility for personalisation, depending on the setting to be implemented.

With the overview of the whole environment offered, the efficient allocation of limited resources into the most needed factors can be better planned to maximise the impact delivered by HEIs and relationship can be better managed as strategic alliances, instead of one-off transactions. Using the UBC Ecosystem as a 'common map', managers can better communicate the UBC concept to both superiors and colleagues to maximise staff engagement, development, and performance whilst better aligning staff roles and goals with the HEI mission.

Furthermore, due to its alignment with the Logic Model (Frechtling, 2007), the *UBC Ecosystem* can also be used as a framework performance management system. More specifically, from an

evidence-based management approach, the process of analysis-strategy-implementation-review is followed. Firstly, a set of diagnostics can determine the current UBC situation at organisational or intra-organisational level, including the influencing elements. From this analysis, objectives and priorities are established, creating a systematic UBC strategy for the whole ecosystem. Following implementation of the strategy, the actual performance against the objectives can be assessed and over the long term, HEI managers can use the framework to optimise the UBC processes (Medeiros et al., 2005).

4.3 POLICY IMPLICATIONS

The complexity and the transdisciplinary nature of UBC demands a common understanding for its regulation. In taking up this challenge, the *UBC Ecosystem* serves as a communal map for a collective understanding of UBC among policymakers, improving coordination and effectiveness. In this way, the framework would also assist policymakers in making tough choices in the allocation of resources that can considerably affect the educational, scientific and industrial systems in a context of increasing budgetary stringency. Moreover, when communicating with UBC stakeholders, the framework unites understanding of the complex UBC system and allows greater mutual understanding and agreement.

The *UBC Ecosystem* can be used to deal with the current horizontal and vertical overlapping of UBC policies. The horizontal overlapping derives from the diverse nature of UBC, which incorporates components from the science, technology, industry and education fields. This suggests that policymakers would need to combine different policy instruments from different fields, to create an effective policy-mix, being the choice of policy instruments critical for the success of innovation policy (Borrás and Edquist, 2013). From another angle, since UBC is regulated by policymakers in different fields, the *UBC Ecosystem* facilitates coordination among the different policymakers, and an alignment of their policies to avoid overlapping and contradictory effects. Vertically, UBC policy faces the challenge of being multi-layered, meaning that policymakers at different levels (local, regional, national and international) all regulate (partly or fully) the *UBC Ecosystem*. In this context, the coordination of all these policies could greatly increase the UBC success (Magro et al., 2014) as challenging as this might be.

The *UBC Ecosystem* suggests two main directions for UBC policy, due to the fact that European HEIs are heterogeneous across Europe and that no one single mechanism can fit the different contexts (Davey et al., 2011). On the one hand, policy needs to be evidence-based and adapted to the specific context. Using this evidence-based policy approach, the framework therefore ensures that policy is based upon the specific factors and characteristics of the region in which the framework is applied, instead of copying UBC policies from other regions or countries. As a result, more customised policy making can be applied, based upon a solid generalised UBC foundation. Additionally, the *UBC Ecosystem* can be used as a framework for the basis of national or regional benchmarking and assessment tools, which in turn provides a foundation of knowledge to make informed, and data driven, decisions.

On the other hand, due to the interconnections of the factors, the policy approach needs to be systemic to address the whole ecosystem simultaneously. The need for a systemic approach to

innovation policies has also been recognised in the European context in order to tackle the main problems that Europe is presently facing (Social Innovation Europe, 2012), because whilst policies have traditionally focused upon individual elements of the innovation ecosystem (Lundvall, 1992; Nelson, 1993) (structural approach), nowadays the focus is shifting toward what happens in the system (functional approach) (Edquist, 2011). In order to achieve this, the UBC policy process can follow the systemic innovation policy framework (Wieczorek and Hekkert, 2012). Policymakers could use the *UBC Ecosystem* framework to map the structural dimensions and their capabilities and then undertake a functional and a structural analysis of the UBC ecosystem. With the results of the analysis, policymakers should identify which are the systemic problems (actors, interactions, infrastructure, etc.), set the systemic instruments goals and design the systemic policy instruments.

4.4 LIMITATIONS

The first limitation is that many of the concepts integrated were not well defined in literature, such as knowledge transfer, UBC, outputs, outcomes or impact. This lack of consensus in prior literature on some of the main concepts used make the comparison with many previous studies impossible. However, to address this, the Logic Model was used, which was supplemented with definitions created by the authors in relevant sections. Therefore, both the exploratory and descriptive approaches coexist in this paper.

Also, many of the relationships between factors in the UBC Ecosystem are not empirically proven (or not tested when controlling for other elements) rather they are conceptual principles supplemented by literature. Thus the framework still require empirical validation. However, many of the relationships might be impossible to prove empirically, such as the contribution of UBC inputs to impacts. This is due to the huge number of influencing elements and thus the difficulty in tracing the flows of knowledge, money and technologies along the system during long periods of time.

Furthermore, in respect to the measurement of UBC, despite the *UBC Ecosystem* framework describing factors and relationships more thoroughly than previous models, it does not specify which particular measures would be suitable for each of the elements in place. Even if measures are determined, there may potentially be some difficulty in obtaining the data required at the different stages. Additionally, due to the fact that this paper is based upon published literature, new and emerging UBC activities, supporting mechanisms or stakeholders might not be fully captured. However, the framework allows flexibility to incorporate any new sub-elements within the macro-elements once identified.

Finally, the *UBC Ecosystem* framework remains somewhat general in nature. However, this is intentional because the framework does not pretend to be a comprehensive list of all micro elements as it only names the most prominent ones found in literature. With most literature focussed on the US and Europe, and relatively little accounting for UBC in the rest of the world, it is acknowledged that specific regional, institutional and individual factors might vary across the global spectrum. The framework has been established in such a way so that any unique regional factors could be easily incorporated into the framework to customise it to local conditions.

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