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A Model for Knowledge Transfer in the University-Industry Relations

1. Introduction

"Knowledge and the way how organisations work with it directly influences their readiness for action and success, especially in knowledge society" (Mládková, 2014)[6]. According to Nonaka & Takeuchi (1996)[7], most western managers understand that useful knowledge is "hard" or quantifiable (Explicit). However, these authors argue that knowledge depends on tapping the tacit and often highly subjective insights, intuitions, and ideals of employees (Tacit).

Since Nonaka, several studies have been performed on knowledge transfer distinguishing explicit from tacit knowledge. "Unfortunately, accumulated research on the performance effects of tacit and explicit knowledge has provided inconsistent results" (Park, Vertinsky, & Becerra, 2015)[8]. Becerra, Lunnan, & Huemer

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[5] csp@estg.ipp.pt School of Management and Technology – Polytechnic of Porto; INESC-TEC; CIICESI

[6] Mládková, L. (2014). Knowledge Strategy: Key Player or Relict of the Past? *Procedia – Social and Behavioral Sciences, 150,* 628–636.

[7] Nonaka, I., & Takeuchi, H. (1996). The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation. *Long Range Planning, 29*(4), 592.

[8] Park, C., Vertinsky, I., & Becerra, M. (2015). Transfers of Tacit vs. Explicit Knowledge and Performance in International Joint Ventures: The Role of Age. *International Business Review, 24*(1), 89–101.

(2008)[9] and Park et al. (2015) speculate that these inconsistencies in findings may stem from differences in the contexts in which knowledge transfers occur.

This paper's objective is not the discussion of knowledge transfer within organizations, but within the university – industry relations. Regarding these relations, from the knowledge transfer perspective, the concepts of Tacit and Explicit Knowledge are also present (Maietta, 2015; Spulber, 2012)[10]. While Spulber (2012) argues that "the inventor's tacit knowledge implies that benefits from own-use through entrepreneurship can exceed the benefits from technology transfer", Maietta (2015) argues that "university–firm R&D collaboration affects process innovation. Evidence of a more novel kind suggests that product innovation is positively affected by geographical proximity to a university".

This last conclusion leads us to the issue of the context for knowledge transfer. According to D'Este, Guy, & Iammarino (2013)[11], geographical proximity plays a fundamental role as a determinant of university–industry collaboration. In their previous research, D'Este & Patel (2007)[12] identified that the researchers' characteristics have a stronger impact on university-industry interactions than the characteristics of their departments or universities. This finding highlights the importance of policies targeting universities' encouragement to increase university-industry interactions. These policies must take into consideration the characteristics of the individual researchers engaged in such interactions.

Another relevant issue on knowledge transfer is the evaluation of the results. In many OECD countries, the results are measured by the rates of patenting and spin-off activities. "This may have the negative effect of obscuring the presence of other types of university–industry interactions that have a much less visible economic pay-off, but can be equally (or even more) important, both in terms of frequency and economic impact" (D'Este & Patel, 2007). It means that direct indicators should not measure the results from TTOs. In order to evaluate the

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[9] Becerra, M., Lunnan, R., & Huemer, L. (2008). Trustworthiness, Risk, and the Transfer of Tacit and Explicit Knowledge between Alliance Partners. *Journal of Management Studies*, *45*(4), 691–713.

[10] Maietta, O.W. (2015). Determinants of University-Firm R&D Collaboration and its Impact on Innovation: A Perspective from a Low-Tech Industry. *Research Policy*, *44*(7), 1341–1359; Spulber, D.F. (2012). Tacit Knowledge with Innovative Entrepreneurship. *International Journal of Industrial Organization*, *30*(6), 641–653.

[11] D'Este, P., Guy, F., & Iammarino, S. (2013). Shaping the Formation of University-Industry Research Collaborations: What Type of Proximity Does Really Matter? *Journal of Economic Geography*, *13*(4), 537–558.

[12] D'Este, P., & Patel, P. (2007). University-Industry Linkages in the UK: What Are the Factors Underlying the Variety of Interactions with Industry? *Research Policy*, *36*(9), 1295–1313.

real impact of TTOs, it is necessary to combine indicators such as patents or new products, but also other factors such as job creation, value added, cost reduction on firms' processes, new production systems (e.g. Lean), among others.

These findings on the context and policies for knowledge transfer drive us to the concept of the Triple Helix Model: University – Industry – Government relations (Etzkowitz & Leydesdorff, 1995)[13].

"The Triple Helix thesis is that the potential for innovation and economic development in a Knowledge Society lies in a more prominent role for the university and in the hybridisation of elements from university, industry and government to generate new institutional and social formats for the production, transfer and application of knowledge. This vision encompasses not only the creative destruction that appears as a natural innovation dynamics (Schumpeter, 1942), but also the creative renewal that arises within each of the three institutional spheres of university, industry and government, as well as at their intersections" (Stanford University, 2016)[14].

Under the Triple Helix perspective, and according to Vaivode (2015)[15], R&D activities must be a well-organized process of knowledge creation, production, diffusion, and application. In other words, support (from government) to R&D activities (developed at universities) must ensure that business and local development goals are taken into consideration. Research shows that in the developed economies, government is a key player in facilitating the establishment and development of such collaboration (Perkmann, Neely, & Walsh, 2011)[16].

According to Sarpong, AbdRazak, Alexander, & Meissner (2015)[17] there are three organizational practices that may lead in turn to facilitate (or impede) a successful model of innovation from the Triple Helix perspective. Those practices are: (1) proactive development of advanced research capabilities that could lead to the production of advanced technologies… to compete in the knowledge

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[13] Etzkowitz, H., & Leydesdorff, L. (1995). The Triple Helix: University-Industry-Government Relations: A Laboratory for Knowledge-Based Economic Development. *EASST Review*, *14*, 14–19.

[14] Stanford University. (2016). triplehelix.stanford. Retrieved from http://triplehelix.stanford.edu/3helix_concept

[15] Vaivode, I. (2015). Triple Helix Model of University–Industry–Government Cooperation in the Context of Uncertainties. *Procedia – Social and Behavioral Sciences*, *213*, 1063–1067.

[16] Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., … Sobrero, M. (2013). Academic Engagement and Commercialisation: A Review of the Literature on University–Industry Relations. *Research Policy*, *42*(2), 423–442.

[17] Sarpong, D., AbdRazak, A., Alexander, E., & Meissner, D. (2015). Organizing Practices of University, Industry and Government that Facilitate (or Impede) the Transition to a Hybrid Triple Helix Model of Innovation. Technological Forecasting and Social Change, In Press.

economy; (2) the practice of (un) purposeful quantification of scientific knowledge and outputs, has a positive influence in developing innovations only if it can transmit its ideals of accountability without ambiguity to others; (3) collective entrepreneurship in order to capture the mobilization of differential visions of the three institutional spheres working in collectives to learn and (re) direct science and technology research attention to productive and predefined outcomes.

In short, the Triple Helix Model and research around this concept aim to identify the best solutions and tools to promote innovation and economic development. Knowledge transfer activities can be presented as one of those tools, since the main goal for knowledge transfer is innovation.

The most common definitions of innovation regard the creation of something new, invent and introduce change. Innovation in turn spurs economic development (Kontolaimou, Giotopoulos, & Tsakanikas, 2016)[18] that results both from entrepreneurial activity and entrepreneurship (Acs, 2009; Audretsch & Thurik, 2001; Block, Thurik, & Zhou, 2013)[19]. As previously mentioned, if universities, industry and government are able to work towards the same objectives, there is a greater chance to achieve better results. Along the process of knowledge transfer from university to industry, supported by public policies, it is possible to identify tacit (Ankrah & AL-Tabbaa, 2015)[20] and explicit knowledge. In order to better identify both types of knowledge transfer, it is important to remember the different types of innovation.

According to the OECD (2005)[21] and the European Union (2012)[22], innovation might be categorized into four types: Product (new goods or services), Process (production methods, logistic and delivery), Marketing (product or packing design, price, place, promotion) and Organizational (procedures, decision making, external relations (co-operation).

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18 Kontolaimou, A., Giotopoulos, I., & Tsakanikas, A. (2016). A Typology of European Countries Based on Innovation Efficiency and Technology Gaps: The Role of Early-Stage Entrepreneurship. *Economic Modelling*, *52*, 477–484.

19 Acs, Z.J. (2009). Knowledge Spillover Theory of Entrepreneurship. *Small Business Economics*, *32*(1), 15–30. doi:10.1007/s11187-008–9157–3; Block, J.H., Thurik, R., & Zhou, H. (2013). What Turns Knowledge into Innovative Products? The Role of Entrepreneurship and Knowledge Spillovers. *Journal of Evolutionary Economics*, *23*(4), 693–718.

20 Ankrah, S., & AL-Tabbaa, O. (2015). Universities–Industry Collaboration: A Systematic Review. *Scandinavian Journal of Management*, *31*(3), 387–408.

21 OECD. (2005). Oslo Manual Guidelines for Collecting and Interpreting Innovation in Communities. (Array, Ed.) Eurostat (Vol. Third edit.). OECD Publishing.

22 European Union. (2012). Community Innovation Survey. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Community_innovation_survey_%28CIS%29

Getting back to the concept of explicit and tacit knowledge, it is not difficult to associate some "hard" knowledge to some types of innovation (e.g. new goods or production methods) and subjective insights (e.g. organizational procedures or promotion techniques).

If a university or a unit within the university promote these kinds of knowledge transfer to the entrepreneurial world, it means promoting an internal culture of research, knowledge creation and transfer (Huang & Chen, 2015)[23]. At the same time "universities and public and private research organizations play a crucial role in regional economies that rely upon growth-oriented entrepreneurship and business innovation" (Marchese & Potter, 2010)[24]. *The collaboration between universities and industry is largely seen as one approach to improve innovation in the economy* (Ankrah & AL-Tabbaa, 2015)[25].

By promoting innovation and technological development, the university plays an important role in the promotion of best practices. It also fosters a closer connection to these firms that will also promote the disclosure of role models from the business world to the academic world. According to Venkataraman (2004)[26], the existence of successful entrepreneurs (role models) in a region will attract seed capital, new ideas and new entrepreneurs. It is a matter of local/regional culture (Woodside, Bernal, & Coduras, 2014)[27].

When the university is able to make that connection between business and academia, it does not only promote an entrepreneurial culture among its students (entrepreneurship, innovation, start-ups), but also creates external relations that provide an interesting network to support students' projects.

As the Organization for Economic Co-operation and Development (OECD) points out, fostering innovation and entrepreneurship in higher education students is especially important for the creation of start-ups and spin-offs as

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[23] Huang, M.H., & Chen, D.Z. (2015). How Can Academic Innovation Performance in University-Industry Collaboration Be Improved? *Technological Forecasting and Social Change*.

[24] Marchese, M., & Potter, J. (2010). *Entrepreneurship, SMEs and Local Development in Andalusia, Spain*. OECD.

[25] Ankrah, S., & AL-Tabbaa, O. (2015). Universities–Industry Collaboration: A Systematic Review. Scandinavian Journal of Management, 31(3), 387–408.

[26] Venkataraman, S. (2004). Regional Transformation through Technological Entrepreneurship. *Journal of Business Venturing, 19*(1), 153–167.

[27] Woodside, A.G., Bernal, P.M., & Coduras, A. (2014). The General Theory of Culture, Entrepreneurship, Innovation, and Quality-of-Life: Comparing Nurturing versus Thwarting Enterprise Start-Ups in BRIC, Denmark, Germany, and the United States. *Industrial Marketing Management*. Elsevier Inc.

governments seek to develop more innovative and entrepreneurial economies (Marchese & Potter, 2010; OECD, n.d.)[28].

Up to now, and basing on this brief literature overview, it has been possible to identify some important factors to be summarized in a concept matrix (Table 2) to identify strategies and/or procedures to promote the success (in terms of results) of TTOs.

In the next section we will present some models of knowledge transfer in order to identify the most relevant factor to promote successful results, on the promotion of entrepreneurship among students and from the university to industry and society.

2. Models of Knowledge Transfer

Considering that the higher education system has an enormous potential to foster innovation and entrepreneurship among their students as well as in the community, in this section we will explore some cases of knowledge transfer centers, TTOs, support services, or other types of organizations that promote entrepreneurship and innovation.

As universities gradually become the center of society's knowledge production system, their role in innovation becomes more diverse. In the pursuit of such a role, universities are encouraged to establish a university–industry collaboration (UIC) context that supports the society, faculties and students to engage in entrepreneurial activities.

When overviewing the literature, it is possible to find many different approaches and perspectives. So the task of creating a typology that shows all the possible links that could occur between universities and the industry is extremely complex (Ankrah & AL-Tabbaa, 2015; Blackman & Segal, 1991)[29].

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[28] Marchese, M., & Potter, J. (2010). *Entrepreneurship, SMEs and Local Development in Andalusia, Spain*. OECD; OECD. (n.d.). *Promoting and Supporting Graduate Entrepreneurship in Higher Education*. Retrieved from http://www.oecd.org/cfe/leed/synthesis-report-east-Germany.pdf / http://www.oecd.org/cfe/leed/graduate-entrepreneurship-Poland.pdf

[29] Ankrah, S., & AL-Tabbaa, O. (2015). Universities–Industry Collaboration: A Systematic Review. *Scandinavian Journal of Management, 31*(3), 387–408; Blackman, C., & Segal, N. (1991). Access to Skills and Knowledge: Managing the Relationships with Higher Education Institutions. *Technology Analysis & Strategic Management, 3*, 297–303.

In order to demonstrate the complexity in displaying all the links, Ankrah & AL-Tabbaa (2015) presented a framework consisting of six main categories of elements for organizational structures of UIC, namely: Personal Informal Relationships, Personal Relationships, Third Party, Formal Targeted Agreements, Formal Non-targeted Agreements and Creation of Focused Structures. This framework was developed from a previous work (Bonaccorsi & Piccaluga, 1994)[30] and is presented in Table 1.

Table 1. UIC Framework

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

[30] Bonaccorsi, A., & Piccaluga, A. (1994). A Theoretical Framework for the Evaluation of University-Industry Relationships. *R & D Management*, *24*(3), 229–247.

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

Source: (Ankrah & AL-Tabbaa, 2015)[31].

The activities presented in the table above according to the author can be grouped into five main categories: (1) Meetings & Networking; (2) Communication – Publications or co-publications of research papers, reports, newsletters, booklets, bulletins, pamphlets; (3) Training; (4) Personnel Mobility; (5) Employment (of university researchers and graduates in the business sector; Representation on Industry Boards or University Committees.

Although it is possible to find an extensive list of factors to be considered in Table 1, some other factors must be added. According to Perkmann et al. (2013)[32], tangible (e.g. funds, materials, and equipment) and intangible (e.g. technology

[31] Ankrah, S., & AL-Tabbaa, O. (2015). Universities–Industry Collaboration: A Systematic Review. *Scandinavian Journal of Management*, *31*(3), 387–408.

[32] Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., … Sobrero, M. (2013). Academic Engagement and Commercialisation: A Review of the Literature on University–Industry Relations. *Research Policy*, *42*(2), 423–442.

and data) resources must be exchanged between the industry and universities. This resources exchange leads us to the concept of knowledge exchange (Ankrah & AL-Tabbaa, 2015; Salleh & Omar, 2013)[33] that goes beyond the concept of knowledge transfer. Knowledge Exchange presents a wider perspective for UIC as it implies a bi-directional exchange of knowledge. From this perspective, the customer's role is no longer to be a passive recipient of value at the end of a transaction, but is to co-create value with the supplier during the exchange (Canhoto, Quinton, Jackson, & Dibb, 2016)[34].

Another important factor highlighted by Ankrah & AL-Tabbaa (2015) was the use of resources coming from the university (graduates and scientists). However, universities can also hire industry experts to seek potential partners for UIC, in order to increase interaction between universities and the industry, increasing it as the number of partnerships (Huang & Chen, 2015)[35].

"As universities gradually become the center of society's knowledge production system, their role in innovation becomes more diverse. In the pursuit of such a role, universities are encouraged to establish a university–industry collaboration (UIC) context that supports faculties and students to engage in entrepreneurial activities" (Huang & Chen, 2015). This leads us to the role of industry in providing training for students, and involving students in industrial projects.

Moving a bit deeper in the literature review it is possible to find other authors discussing the same subject: UIC. According to Alshehri et al. (2016)[36] there are some elements that must be considered under UIC:

- Licensing deals or equity deals with new companies;
- Promotion of young entrepreneurs and encouragement of new ideas;
- University Curriculum and strategy alignment to meet their entrepreneurial goals;
- Student training;
- Funded research projects;

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[33] Ankrah, S., & AL-Tabbaa, O. (2015). Universities–Industry Collaboration: A Systematic Review. *Scandinavian Journal of Management*, *31*(3), 387–408; Salleh, M.S., & Omar, M.Z. (2013). University-Industry Collaboration Models in Malaysia. *Procedia – Social and Behavioral Sciences*, *102* (Ifee 2012), 654–664.

[34] Canhoto, A.I., Quinton, S., Jackson, P., & Dibb, S. (2016). The Co-Production of Value in Digital, University–Industry R&D Collaborative Projects. *Industrial Marketing Management*.

[35] Huang, M.H., & Chen, D.Z. (2015). How Can Academic Innovation Performance in University-Industry Collaboration Be Improved? *Technological Forecasting and Social Change*.

[36] Alshehri, A., Gutub, S.A., Ebrahim, M.A.B., Shafeek, H., Soliman, M.F., & Abdel-Aziz, M.H. (2016). Integration between Industry and University: Case Study, Faculty of Engineering at Rabigh, Saudi Arabia. *Education for Chemical Engineers*, *14*, 24–34.

- Joint research projects with co-publication results;
- Firms' employees working with the university;
- Collaborative technology development resulting in inventing and/or assigning competent people;
- University scientists working at firms;
- Companies licensing university patents;
- University scientists undertaking short-term consultancies;
- Participation in formal and informal networks;
- Consultative committees.

In another research (Bekkers & Freitas, 2008)[37] identified six clusters of channels of knowledge transfer which are:

- Scientific output, informal contacts and students;
- Labour mobility;
- Collaborative and Contract Research;
- Contacts via alumni or professional organizations;
- Specific organized activities;
- Patents and licenses.

Salleh & Omar (2013)[38] present in their work a review of various models of UIC. Basing on the Warwick University model, they identified as the most important factors:

- Knowledge exchange;
- R&D activities;
- Training of firm employees;
- Consultation work;
- Product commercialization.

From Cambridge and MIT, the authors present the model that is based on six components of a Knowledge Integration Community. The main element that can be identified from this model is the lessons learnt concept (a concept quite popular in Project Management).

Another model was the Kebangsaan University in Malaysia. In this model the authors identified:

- Innovation and R&D activities;
- Technology transfer;

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[37] Bekkers, R., & Freitas, I.M.B. (2008). Analysing Knowledge Transfer Channels between Universities and Industry: To What Degree Do Sectors Also Matter? *Research Policy, 37(*10), 1837–1853.

[38] Salleh, M.S., & Omar, M.Z. (2013). University-Industry Collaboration Models in Malaysia. *Procedia – Social and Behavioral Sciences, 102* (Ifee 2012), 654–664.

- Consultancy;
- Product commercialization.

The authors also mention the importance of the existence of a University-Industry-Higher Education collaboration council.

Considering that knowledge should be available for firms of different size, Fernández-Esquinas et al. (2015)[39] suggest that small firms may need other interaction channels, such as consultancy and specialized training.

UIC, no matter a firm's size, is viewed as a rational process. Strategic effect occurs when organizations rationalize their inter-organizational relationships as a means to acquire the resources they lack [(AIRTO, 2001) and (Koka & Prescott, 2002)][40]. "In other words, UIC is perceived as a rational process when it is primarily sought for pooling and exchange of resources of all kinds" (Ankrah & AL-Tabbaa, 2015)[41].

The identification of common interests is particularly relevant, in order to find a win-win game (Veugelers & Cassiman, 2005)[42]. According to the literature, there are several factors that can be taken into consideration. Besides the factors identification, in order to better understand UIC, it is also relevant to identify the motives for that cooperation. Ankrah, Burgess, Grimshaw, & Shaw (2013)[43] identified six main motives: Necessity, Asymmetry, Reciprocity, Efficiency, Stability and Legitimacy.

"Businesses seek specific research applications to shorten the time between discovery and implementation. Universities respond to industry needs by providing meaningful knowledge with practical applications" (Lockett,

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39 Fernández-Esquinas, M., Pinto, H., Yruela, M.P., & Pereira, T.S. (2015). Tracing the Flows of Knowledge Transfer: Latent Dimensions and Determinants of University–Industry Interactions in Peripheral Innovation Systems. *Technological Forecasting and Social Change*.

40 AIRTO. (2001). *The Contribution of Faraday Partnerships to Growth in Innovation Intensity in the UK Economy*; Koka, B.R., & Prescott, J.E. (2002). Strategic Alliances as Social Capital: A Multidimensional View. *Strategic Management Journal, 23*(9), 795–816.

41 Ankrah, S., & AL-Tabbaa, O. (2015). Universities–Industry Collaboration: A Systematic Review. *Scandinavian Journal of Management, 31*(3), 387–408.

42 Veugelers, R., & Cassiman, B. (2005). R&D Cooperation between Firms and Universities. Some Empirical Evidence from Belgian Manufacturing. *International Journal of Industrial Organization*.

43 Ankrah, S., Burgess, T., Grimshaw, P., & Shaw, N.. (2013). Asking Both University and Industry Actors about Their Engagement in Knowledge Transfer: What Single-Group Studies of Motives Omit. *Technovation, 33* (2-3), 50–65.

Wright, & Franklin, 2003[44] apud Berbegal-Mirabent, Sánchez García, & Ribeiro-Soriano, 2015[45]).

There are several types of organizations within universities in order to promote UIC. TTOs are the main institutions responsible for the establishment of that co-operation (Berbegal-Mirabent et al., 2015). For the aim of this paper, we did not consider the different designations (Research Center, TTOs, Technology Transfer Center, …). Instead we were looking for important factors in knowledge transfer (or exchange) under UIC.

When these types of institutions exist within the university, they play an important role among students. TTOs complement the services provided in order to foster entrepreneurship, as they provide access to networks in the innovation and business eco-system. For someone that is discovering the entrepreneurial world, the establishment of "one-stop-shops" that provide assistance, mentorship, and information on patenting and licensing processes, which are extremely useful.

In this relation with students, sometimes it is possible to find academic spin-offs that constitute the direct mechanism, representing the entrepreneurial route to commercializing public research (Berbegal-Mirabent et al., 2015). Licensing arrangements of university inventions, incubator facilities, R&D contracts, and consulting services are other factors identified by these authors in order to improve the results from UIC.

Up to now in this paper it has been possible to identify several models, perspectives, and approaches to UIC. In Table 2 the main concepts in the literature review are identified. In this table, not all the elements will be listed. Some of the elements identified by some authors that seem to be obvious (R&D activities) will not be included. Some others that were identified just by one author from a specific perspective also were not included.

In the next table (chapter 3) we propose a matrix based on the concepts from Table 2. The matrix has two main goals: (1) A self-evaluation model for each Institution; (2) The identification of possible indicators to evaluate the Center performance.

These goals are justified by the "need to investigate other alternatives to more objectively measure the effectiveness of UIC, in addition to the subjective measure currently employed. For example, to what extent the number of new patents,

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[44] Lockett, A., Wright, M., & Franklin, S. (2003). Technology Transfer and Universities' Spin-Out Strategies. *Small Business Economics*.

[45] Berbegal-Mirabent, J., Sánchez García, J.L., & Ribeiro-Soriano, D.E. (2015). University–Industry Partnerships for the Provision of R&D Services. *Journal of Business Research, 68*(7), 1407–1413.

products, publication can reflect the real value of the UIC and justify its cost and risk" (Ankrah & AL-Tabbaa, 2015; Barnes, Pashby, & Gibbons, 2002)[46]. In this case the authors criticize the results measurement based on explicit knowledge.

Another relevant issue is that "none of the reviewed studies have addressed the consequences of this engagement on, for example, teaching and learning experience of students affiliated to universities that engaged with the industry. This line of research can provide supporting evidence to the intangible potential value of the UIC" (Ankrah & AL-Tabbaa, 2015; Perkmann et al., 2013)[47]. In this case, there is a suggestion of effectiveness measurement by considering tacit knowledge.

Table 2. Concept Matrix

Elements	Author
University-Industry-Government	(Etzkowitz & Leydesdorff, 1995) and several other authors
Academic Spin-offs – Product Commercialization	(Ankrah & AL-Tabbaa, 2015); (Salleh & Omar, 2013); (Berbegal-Mirabent et al., 2015)
Cooperation Council	(Salleh & Omar, 2013); (Ankrah & AL-Tabbaa, 2015); (Alshehri et al., 2016); (Salleh & Omar, 2013)
Consultancy	(D'Este & Patel, 2007); (Ankrah & AL-Tabbaa, 2015); (Alshehri et al., 2016); (Bekkers & Freitas, 2008); (Salleh & Omar, 2013); (Fernández-Esquinas et al., 2015); (Berbegal-Mirabent et al., 2015)
Contract research	(D'Este & Patel, 2007) (Ankrah & AL-Tabbaa, 2015); (Bekkers & Freitas, 2008); (Berbegal-Mirabent et al., 2015)
Employment of students and/or scientists	(Ankrah & AL-Tabbaa, 2015); (Alshehri et al., 2016); (Bekkers & Freitas, 2008)
Employment of industry staff by the university	(Huang & Chen, 2015); (Alshehri et al., 2016); (Bekkers & Freitas, 2008)

[46] Ankrah, S., & AL-Tabbaa, O. (2015). Universities–Industry Collaboration: A Systematic Review. *Scandinavian Journal of Management, 31*(3), 387–408; Barnes, T., Pashby, I., & Gibbons, A. (2002). Effective University – Industry Interaction: A Multi-Case Evaluation of Collaborative R&D Projects. *European Management Journal, 20*(3), 272–285.

[47] Ankrah, S., & AL-Tabbaa, O. (2015). Universities–Industry Collaboration: A Systematic Review. *Scandinavian Journal of Management, 31*(3), 387–408; Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., … Sobrero, M. (2013). Academic Engagement and Commercialisation: A Review of the Literature on University–Industry Relations. *Research Policy, 42*(2), 423–442.

Elements	Author
Funded Research Projects	(Ankrah & AL-Tabbaa, 2015); (Alshehri et al., 2016)
Informal meetings and networking (including personal contacts)	(Ankrah & AL-Tabbaa, 2015); (Alshehri et al., 2016); (Bekkers & Freitas, 2008); (Plewa et al., 2013)
Joint research/publications	(D'Este & Patel, 2007); (Ankrah & AL-Tabbaa, 2015); (Alshehri et al., 2016)
Knowledge exchange (bidirectional); Co-creation	(Salleh & Omar, 2013); (Ankrah & AL-Tabbaa, 2015); (Canhoto et al., 2016)
Lectures with industry staff; Joint Master/PhD supervisions; Joint Curriculum development	(Ankrah & AL-Tabbaa, 2015); (Alshehri et al., 2016)
Lessons Learnt	(Salleh & Omar, 2013); (Carayannis, Popescu, Sipp, & Stewart, 2006); (McAdam, Miller, McAdam, & Teague, 2012)
Motives for UIC	(Ankrah et al., 2013); (AIRTO, 2001); (Koka & Prescott, 2002); (Berbegal-Mirabent et al., 2015)
Patenting and Licensing Agreements	(Ankrah & AL-Tabbaa, 2015); (D'Este & Patel, 2007); (Alshehri et al., 2016); (Bekkers & Freitas, 2008); (Berbegal-Mirabent, Lafuente, & Solé, 2013)
Possibility of facilities usage from University or Industry	(Ankrah & AL-Tabbaa, 2015); (Perkmann et al., 2013)
Programs to foster students' innovation and entrepreneurship skills	(Marchese & Potter, 2010); (Alshehri et al., 2016)
Training for students in Industry	(D'Este & Patel, 2007); (Ankrah & AL-Tabbaa, 2015); (Huang & Chen, 2015); (Alshehri et al., 2016)
Training for employees	(Ankrah & AL-Tabbaa, 2015); (Salleh & Omar, 2013); (Fernández-Esquinas et al., 2015)
University Industry Proximity	(D'Este et al., 2013); (Maietta, 2015)

Source: The authors' own elaboration based on literature studies.

The concepts presented in Table 2 are supported by the identified authors as well as other authors. Analyzing the papers referred to, it was possible to identify other supporting references to concepts. During the literature review many other papers were taken into consideration, however, the identified factors did not vary from those presented here.

In the next section the concepts presented in Table 2 will be translated to questions in order to suggest a self-evaluation model for each Institution as well as the identification of possible indicators to evaluate UIC results.

3. A Matrix Proposal

From the literature review it was possible to identify some important factors for an effective knowledge transfer/exchange. After identifying the concepts, the next step is to develop a matrix translating those concepts into yes/no questions. Some of the concepts that are possible to quantify will be also signed as "Quant".

Table 3. Self-Evaluation and Indicators Proposal

	Yes	No	Quant
Is the government (local or national) a relevant stakeholder involved in the Center strategy?			-
Does the Center support academic Spin-offs? How many products were commercialized under the Spin-off?			
Does there exist a Cooperation Council where the UIC strategy is discussed and approved?			-
Does the center provide consultancy services to the industry?			-
Does there exist Contract research? How much is/was active last year?			
Is the industry employing students and/or scientists through the Center? How many during the last year?			
Is the university employing industry staff?			-
How many as teachers?	-	-	
How many in other functions?	-	-	
Does the Center have research projects funded by the industry? How many during the last year?			
Does the Center organize informal meetings and networking (including personal contacts)?			-
Are informal personal contacts between the Center and industry staff known and supported by the Center (e.g.: informal lunches or visits)?			-
How many joint publications/research (Center and industry staff) were taken up during the last year?	-	-	
Is there a policy of Knowledge exchange (bidirectional)?			-
Is there a policy of Co-creation?			-
Are lectures in the university under the responsibility of industrial staff? How many courses (%) are under industry staff responsibility?			
Are Master/PhD Theses supervised by industry staff? How many supervisions (%) are under industry staff responsibility?			
Does the industry formally collaborate in curriculum development?			-

	Yes	No	Quant
Does the center have a formal procedure for Lessons Learnt?			-
Does the Center identify the motives for cooperation?			-
Does the Center support patenting and licensing agreements? How many during the last year?			
Is it possible for the industry to use the university facilities?			-
Is it possible for university staff to use industrial facilities?			-
Does the Center promote programs to foster students' innovation and entrepreneurship skills? How many during the last year?			
Is the Center a bridge for training for students in the Industry? Does the Center act as a network for internships and projects?			-
Does the Center/university provide training for industrial staff? How many during the last year?			
Is the Center strategically located? Close to the industry?			-

Source: The authors' own elaboration based on literature and interviews with the directors of evaluated entities.

The previous questions were organized taking into consideration the most relevant concepts for UIC identified during the literature review. This is an initial proposal for an evaluation model that can also contribute to defining the best indicators to analyze the Center performance.

The next step is to present the possible answers to this matrix, identifying other important elements, if missing, in this model.

4. Case Study

In this chapter we will conduct a brief description of two Centers that are linked to the higher education system. One of them located in Portugal – *Gabinete de Apoio ao Empreendedor* (the Entrepreneur Support Office) – GAE, and the other one located in Poland – TechTransBalt Ltd. (TTB).

The GAE is an interface office, recently created (2014/15), grounded on a strategic triadic relationship model with a twofold perspective of action. It aims at fostering the entrepreneurship culture developing new initiatives to support innovation and creativity and promoting a network to enhance the regional economic growth. To accomplish this mission, the GAE has established a dynamic relationship model based on the main actors of the economic development of the region: the local government, the regional business council and the academy.

The GAE assumes a pivotal role in this network, as the main driving force for supporting and strengthening entrepreneurship and the regional economic activity. To carry out its responsibilities, the GAE has been developing a set of socio-economic instruments, namely:

- An information sharing platform;
- A regional portfolio of experts (either from the academy or industry);
- A regional mentoring network (connected to the national network of mentors);
- A channel to promote and spread available financial instruments, law changes, important events, etc. to the organizations within the Tâmega e Sousa Region.

The GAE is strategically located in an industrialized region. Even though the region where the School and this Center is located is one of the poorest in Portugal in many economic and social indicators, it is possible to find in this region (Tâmega e Sousa) the shoes and wood furniture industrial clusters. At the same time it is possible to find a strong presence of the textile and metal-working industry (Bessa, 2004; Castro et al., 2014)[48].

TechTransBalt Ltd. (TTB) is a special purpose vehicle established in 2014 by University of Gdansk, the largest institution of higher education in northern Poland, with approximately 30 000 graduate, doctoral and post-graduate students, over 1700 teaching and research staff, 11 faculties, Foreign Language Center and Physical Education and Sports Center, 71 courses of study, 200 specializations, 18 doctoral courses, over 100 post-graduate courses. The key advantage is its favourable geographical location. In the north, the Pomeranian Region borders with Scandinavian countries and from the east side with the Kaliningrad Region of the Russian Federation. There are two significant transit routes: the Baltic-Adriatic Corridor and the North-Sea Baltic Corridor. Both of them fulfill the role of an intermediary in the European trade path (the European Commission, 2016). Poland joined the European Union in 2004 and has improved significantly the infrastructure and developing conditions due to growing investments from EU Investment Funds and other foreign sources after 2005 (Jasiniak, 2015)[49]. The Pomeranian Region occupies 18,310 square kilometres of north-central Poland and has more than 2.3 million inhabitants that comprise 6% of the whole population in the country (the majority registered in urban

[48] Bessa, D. (2004). *PRASD – Programa de Recuperação de Áreas e Sectores Deprimidos*; Castro, A., Rodrigues, V., Vilaverde, A., Gonçalves, F., Silva, J., Sopas, L., … Costa, S. (2014). *Plano Estratégico de Desenvolvimento Intermunicipal*.

[49] Jasiniak M., *Is Poland Still Attractive for Foreign Investments?* Financial Internet Quarterly: *e-Finanse*, 2015, Vol. 11, No. 2, 10–17.

areas) (the Statistical Office in Gdansk, 2015)[50]. There are two special economic zones in the region as well as two technology parks: Gdansk Science and Technology Park and Pomeranian Science and Technology Park located in Gdynia.

TechTransBalt has a very short history of the operational activity. At present, there are good links between business, researchers and students, which creates a strong ecosystem that commercialises the inventions and research findings of the academic staff. The largest achievements that have business potential are found in the departments of biology, biotechnology and chemistry. Other departments have some successes, but at a slightly smaller scale.

TTB enjoys strong support from the Technology Transfer Office (TTO) of University of Gdansk in developing the commercialization activity. Under the current law, TTO prepares the recommendations to the rector of the university for the commercialization path. When the intention is to set up a new company, the task is undertaken by TTB.

Table 4. Self-Evaluation and Indicators for GAE and TTB

	GAE			TechTransBalt Ltd/ TTO UG		
	Yes	No	Quant	Yes	No	Quant
is the government (local or national) a relevant stakeholder involved in the Center strategy?	X		-	X		-
Does the Center support academic Spin-offs? How many products have been commercialized under the Spin-off?	X			X		20
Does there exist the Cooperation Council where the UIC strategy is discussed and approved?		X	-	X		-
Does the center provide consultancy services to the industry?	X		-	X		-
Does there exist contract research? How much is/was active in the last year?		X		X		
Is the industry employing students and/or scientists through the Center? How many during the last year?	X		2	X		10
Is the university employing industry staff?		X	-	X		-
How many as teachers?	-	-	≅40%	-	-	<10%
How many in other functions?	-	-	-	-	-	<1%

[50] Statistical Office in Gdansk, *2014 Pomorskie Voivodship. Subregions, Powiats, Gminas.*, Gdansk 2015. Retrieved from: http://gdansk.stat.gov.pl/download/gfx/gdansk/pl/defaultaktualnosci/752/5/12/1/podregiony_2014_pol_7.pdf

	GAE			TechTransBalt Ltd/ TTO UG		
	Yes	No	Quant	Yes	No	Quant
Does the Center have research projects funded by the industry? How many during the last year?		X			X	
Does the Center organize informal meetings and networking (including personal contacts)?	X		-		X	-
Are informal personal contacts between center and industry staff known and supported by the Center (e.g.: informal lunches or visits)?	X		-		X	-
How many joint publications/ research (center and industry staff) were taken up during the last year?	-	-		-	-	n/a
Is there a policy of Knowledge exchange (bidirectional)?		X	-		X	-
Is there a policy of Co-creation?		X	-		X	-
Are lectures in the university under the responsibility of industrial staff? How many courses (%) are under industry staff responsibility?	X				X	
Are Master/PhD Theses supervised by industry staff? How many supervisions (%) are under industry staff responsibility?		X			X	
Does the industry formally collaborate in curriculum development?		X	-		X	-
Does the Center have a formal procedure for Lessons Learnt?		X	-		X	-
Does the Center identify the motives for cooperation?	X		-	X		-
Does the Center support patenting and licensing agreements? How many during the last year?	X			X		5
Is it possible for the industry to use the university facilities?		X	-	X		-
Is it possible for university staff to use industrial facilities?		X	-	X		-
Does the Center promote programs to foster students' innovation and entrepreneurship skills? How many during the last year?	X		1	X		1
Is the Center a bridge for training for students in the Industry? Does the Center act as a network for internships and projects?	X		-		X	-
Does the Center/university provide training for industrial staff? How many during the last year?	X		>10	X		
Is the Center strategically located? Close to the industry?	X		-		X	-

Source: Interviews with the directors/those responsible for the evaluated entities.

From Table 4, as expected, we can observe some similarities and differences between both entities. The main objective of this paper is to identify the most relevant factors and to test the matrix in two different realities: Portugal and Poland. Once the model is tested, the next step is the establishment of an indicators board in order to compare the scores. With the indicators, the comparison will be more efficient and valuable.

In the framework of financial support instruments of the regional operational programme (ROP), entrepreneurs and startups, who see their business with the development of innovation, can use various financial instruments, such as: grants, equity funds, loan funds, guarantee funds and many others. The main condition is that their activities form a part of the implementation of the regional development strategy.

Results of scientific research are mainly commercialized by TTB in the form of spin-offs and direct services to the private sector. Until April 2016, TTB had launched two spin-offs operating in the manufacturing sector and the service sector for the chemical industry. In addition, TTB sells a range of on-demand services for domestic and foreign enterprises. TTB has not employed students in a direct way so far. However, we can point out that at present TTB participates in the finding science projects for young scientists in high schools. The participants of the project have a chance to become one of the best students at the University of Gdansk in the future. In addition, students can obtain practical experience in the spin-off companies as well.

The GAE is a recently created office that is trying to promote regional development from a triple helix perspective. In some aspects, there is a close relation between the school and industrial staff, mainly in teaching activities.

From the interviews, it was also possible to verify that among the main motives of co-operation between the higher education system and business are:

- accelerating the development of innovative products and services in enterprises;
- satisfaction of exploitation of research findings in practice;
- an additional source of revenue for scientists and the university;
- an opportunity to participate in joint research and implementation projects;
- a possibility of using practical examples shown for students during the classrooms.

5. Conclusion

From the literature it is clear that knowledge (explicit or tacit) and the way that it is managed assumes a crucial role for organizational success. Since knowledge development (namely R&D) activities are not within the strategy of many firms, in particular small ones, the collaboration between industry and university is indeed a strategy to consider. In fact, it is a strategy adopted by several firms and industries.

The university-industry collaboration allows not only the transfer of knowledge, but also its exchange. It means that universities share the knowledge with industry, but at the same time get the inputs to generate new knowledge.

Knowledge is an important output for universities, it is also important for industries in order to supply innovative products (or processes) thereby gaining competitive advantages, and it is also important for a region since it will bring growth and development at economic and social levels.

In order to promote the most efficient innovations, knowledge should be generated from a triple helix perspective. This means that universities should not create knowledge just because it is their mission, but they should conduct their research through an integrated strategy between universities, industry and government.

The University-Industry Collaboration is a strategy adopted by many firms and industries. This paper has identified many different types of links between universities and industry. In fact, these links are growing from a knowledge transfer perspective (university to industry) to a knowledge exchange (bidirectional knowledge transfer).

The most relevant links identified within the literature review were presented in Table 2 and those links are: Academic Spin-offs; The existence of the Cooperation Council; Consultancy Relations; The Existence of Research Contracts and Funded Research; Industry Employing Students or Scientists; The Existence of Informal Meetings; Joint Research Publications; Co-creation of Value; Lectures by Industry Staff; Patenting and Licensing Agreements; Facilities Usage Available for both Stakeholders and Training.

The links previously presented lead to a matrix that can work either as a self-evaluation model and a proposal of indicators to evaluate the Centers' effectiveness in knowledge transfer.

Finally, the matrix was applied in an interview style to each center director/responsible and it was possible to compare the links that both institutions are establishing with the industry in their surroundings.

In the future it might be interesting to apply this matrix to different research/knowledge transfer units, in order to compare the strategies adopted as well as request some indicators in order to compare the effectiveness of each analyzed center. Furthermore, in future research it might be interesting to establish an indicators board in order to compare quantitative results among different institutions. Those indicators might be suggested from the matrix that was previously presented and tested.

Both Centers are quite recent but form the basis for the development of an innovation ecosystem at their "mother" universities. A survey conducted with the help of the model presented in this paper, allowed us to identify the areas in which action should be taken to integrate university scientists, students and business. Only well-prepared and coordinated co-operation can bring the desired results.

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Model transferu wiedzy z uczelni wyższych do biznesu

Streszczenie

System szkolnictwa wyższego, w szczególności uniwersytety i politechniki, ma ogromny potencjał w zakresie wspierania innowacji oraz przedsiębiorczości wśród swoich pracowników i studentów. Pomimo faktu, że innowacyjność i przedsiębiorczość są w ostatnich latach wskazywane jako kluczowe elementy wielu programów oraz projektów, nie sformułowano dotychczas jednolitej i unikalnej definicji służącej określeniu charakteru oraz zasad współpracy w relacji uczelnia wyższa–biznes. Celem artykułu jest przeprowadzenie analizy porównawczej modeli transferu wiedzy z uczelni wyższych do biznesu na podstawie doświadczeń Portugalii i Polski. Wykorzystując jako metodę badawczą studium przypadku, w niniejszym artykule po raz pierwszy porównano systemy wsparcia transferu technologii do biznesu na dwóch uczelniach: Politechnice w Porto, Szkole Technologii i Zarządzania (Portugalia) i Uniwersytecie Gdańskim, komercjalizującym wiedzę poprzez Centrum Transferu Technologii oraz spółkę celową TechTransBalt Sp. z o.o. (Polska). Na podstawie dokonanego przeglądu literatury zaproponowano ponadto model umożliwiający przeprowadzenie analizy tego, w jaki sposób obie te instytucje wspierają swoje wydziały oraz studentów we wdrażaniu innowacji. Na zakończenie, wykorzystując zaproponowany model, autorzy przeprowadzili badania porównawcze oraz wyjaśnili, jak te dwie instytucje odkrywają potencjał swoich pracowników i studentów oraz wpierają tworzenie akademickich start-upów, jak również przedstawili sposoby rozwoju technologii i transferu wiedzy z uczelni wyższych do biznesu.

Słowa kluczowe: transfer wiedzy, przedsiębiorczość, spin-off, TTO, CTT, start-up