Knowledge Exchange and Collaboration with Industry in the Context of Entrepreneurial Higher Education Institutions

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Abstract

Higher education institutions (HEIs) are expected not only to provide research and teaching but also to be involved in a number of other activities, such as cooperating with enterprises and interpreting and explaining scientific findings to the wider public, thus contributing to the development of society. However, little attention has been paid to the relationship between knowledge exchange and collaboration and other entrepreneurial activities of HEIs. The aim of this study is to assess the links between knowledge exchange with industry and other characteristics of entrepreneurial HEIs. The HEInnovate questionnaire is used to evaluate the various characteristics of entrepreneurial HEIs in four Estonian universities. The results of the analysis show that knowledge exchange and collaboration with industry are particularly strongly linked with providing support to prospective entrepreneurs, mentoring and facilitating access to finances and business support services. There is also a strong link with entrepreneurial teaching and learning, which involves shaping entrepreneurial attitudes and skills.

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1. Introduction

The role of higher education institutions (HEIs) has changed, with knowledge exchange and collaboration with external organisations becoming increasingly regarded as their key features (Schmitz, Urbano, Dandolini, de Souza & Guerrero, 2017). As the core creators of new knowledge, HEIs are considered main supporters of economic development and contributors to competitiveness at the enterprise, regional and state levels (D'Este & Perkmann, 2011; Huggins, Johnston & Steffenson, 2008; Huggins, Johnston & Stride, 2012). Knowledge exchange involves various activities of HEIs, such as consulting, training, cooperation agreements with private and public sector organisations, collaborative research projects, patenting and creating spin-offs, which all contribute to the wider socio-economic development (e.g. D'Este & Perkmann, 2011).

Although knowledge exchange and collaboration with industry involve a variety of activities, a number of previous studies have often addressed their impact primarily as the commercialisation of HEIs' patents (D'Este & Patel, 2007). Consequently, knowledge exchange has been studied through different stages of this process (e.g. disclosure, patenting, licensing, creating spin-offs), with a focus on the efficiency of technology transfer offices and intellectual property management (Kalantaridis & Küttim, 2019), which are therefore discussed separately from HEIs' other activities (Kochenkova, Grimaldi & Munari, 2016). However, previous studies show that in addition to controlling knowledge exchange processes, supporting different types of cooperation with external partners is necessary (D'Este & Patel, 2007); this cooperation can take a variety of forms which do not necessarily lead to a new patent but may manifest itself in some other form of cooperation. With this facet of activity left aside, a significant part of knowledge exchange activities will remain underresearched.

Research has also shown that a successful knowledge exchange is not only dependent on the foundation of knowledge transfer centres and companies' demand but also on the skills of researchers and their inclusion in collaborative projects, as well as on the companies launched by HEI employees (Bigliardi, Galati, Marolla & Verbano, 2015). Universities can support this through the development of their internal organisational culture, through entrepreneurial teaching and learning, and through fostering entrepreneurial activities in cooperation with both domestic and foreign partners, which are all included in the characteristics of an entrepreneurial HEI. An entrepreneurial HEI applies new organisational structures and arrangements aimed at enhancing internal collaborations and fostering external partnerships (Pinheiro & Stensaker, 2014). Studying all the different activities of an HEI as a whole and in synergy with one another (Schmitz et al., 2017), including how the internal environmental and organisational culture contributes to external linkages, is therefore important.

Basing on the above, this study **aims to** assess the links between knowledge exchange and collaboration with industry and other characteristics of entrepreneurial HEIs. This work poses the following **research questions**: i) How are knowledge exchange and collaboration with industry, as well as other characteristics of entrepreneurial HEIs, assessed by the employees of Estonian universities? ii) How are knowledge exchange and collaboration with industry related to other activities of entrepreneurial HEIs? Whilst knowledge exchange can take place with multiple actors (enterprises, public sector organisations, NGOs), the term 'industry' is used here as a common denominator for different external organisations.

Additionally, as knowledge exchange can cover individual- and organisational-level activities, it is used here to signify mainly inter-organisational relations.

The study uses a cross-sectional survey carried out amongst the employees of four Estonian HEIs in 2015–2016. The HEInnovate questionnaire, developed by the European Commission and the Organisation for Economic Co-operation and Development (OECD) and is aimed at the self-assessment of HEIs, was used; it was adapted and translated into Estonian. This questionnaire takes a coherent approach to entrepreneurial HEIs and addresses all the activities of HEIs, which help these HEIs transition from traditional research and teaching-focused HEIs into entrepreneurial HEIs and which create a favourable environment for the achievement of the goals set by such HEIs.

This study examines knowledge exchange and collaboration in a wider context as related to other characteristics of entrepreneurial HEIs, including collaboration with private and public sector organisations, incubators and science parks whilst interlinking research, teaching and HEI–business cooperation. The approaches to knowledge exchange and collaboration with industry and entrepreneurial HEIs are combined with one another. In addition to its theoretical novelty, this study will also contribute to HEI management practices.

The paper has been organised as follows. The subsequent section provides an overview of the relevant literature, followed by a discussion of the methodology of the study. The results are analysed in the fourth section. The final section presents the discussion of the results and the concluding remarks.

2. Literature overview

2.1 Knowledge exchange and collaboration in the context of entrepreneurial HEIs

Contributing to the development of society is pursued through cooperation between HEIs and enterprises, as knowledge-based entrepreneurship is becoming more and more important. The knowledge created at HEIs is important for businesses to improve both their processes and their products and services (Guerrero & Urbano, 2012). There are many possible ways of transferring knowledge to external organisations; for example, researchers may enter into a cooperation agreement with a public or private organisation, offer consultancy services or exchange knowledge though informal communication, patenting, licensing and spin-offs. Previous studies have shown that the pathways of knowledge exchange and collaboration with industry depend on the policies and traditions of HEIs (Guerrero & Urbano, 2012). In particular, these activities are influenced by the traditions of the structural unit of HEIs, as well as their existing contacts with public and private organisations (Lam, 2010) and the organisational culture of these HEIs (D'Este & Patel, 2007).

In many developed countries, the emergence of the concept of entrepreneurial HEI has been associated with a decrease in public funding and with higher education becoming a mass phenomenon, which has forced HEIs to seek additional sources of funding (Sam & van der Sijde, 2014). Changes in HEIs have involved adding knowledge building to traditional teaching and learning through scientific research, as well as the continued contributions of HEIs to the economic and social development of society (Etzkowitz, 2003a). Whilst there are numerous definitions of entrepreneurial HEIs covering different functions of these

organisations (e.g. Etzkowitz, 1984, 2003a, 2003b, 2008, 2013; Guerrero & Urbano, 2012; Jacob, Lundqvist & Hellsmark, 2003; Guenther & Wagner, 2008; Guerrero, Urbano, Cunningham & Organ, 2014; Schmitz et al., 2017; Saiz-Santos, la Mata & Hoyos-Iruarrizaga, 2017), they are often conceptualised in terms of a balance between an internal entrepreneurial culture and external linkages. Following this approach, Guerrero et al. (2014, p. 415) define an entrepreneurial HEI as 'a university that tries to provide a supportive environment, in which the university community can explore, evaluate and exploit ideas that could be transformed into social and economic entrepreneurial initiatives'. This means that an entrepreneurial HEI is characterised by the application of new organisational structures and arrangements aimed at enhancing internal collaborations and fostering external partnerships (Pinheiro & Stensaker, 2014).

An entrepreneurial HEI is characterised foremost as an environment which encourages its faculty members and students to share their knowledge through their day-to-day activities (including research, teaching and learning) beyond the HEI so that different groups of stakeholders could benefit (Guerrero et al., 2014). When HEIs become more entrepreneurial, changes in the attitude of researchers towards different forms of knowledge exchange take place (Todorovic, McNaughtonb & Guild, 2011). Previous studies have found that entrepreneurial HEIs succeed better in involving their research staff in different collaborative projects with industry, as the employees of entrepreneurial HEIs are more willing to share their research results with industry (Kalar & Antoncic, 2015). This means the greater acceptance of more entrepreneurial attitudes and behaviours by academics (Grimaldi, Kenney, Siegel & Wright, 2011), especially if they perceive that the changes in the HEI support their form of cooperation with organisations in both the private and public sectors (Hunter, Perry & Currall, 2011).

To guarantee a well-functioning system of knowledge exchange and collaboration with industry, entrepreneurial HEIs use different forms of collaboration with private and public sector organisations (Inzelt, 2004). However, knowledge exchange has not been analysed in conjunction with other activities of HEIs, as it has often been merely addressed as one of the key attributes of entrepreneurial HEIs (e.g. Kalar & Antoncic, 2014). The contribution of HEIs to the economy is one of the reasons why entrepreneurship has become ever more essential in the context of HEIs (Guerrero, Cunningham & Urbano, 2015). Studying the activities of entrepreneurial HEIs as a whole, with an emphasis on study and research (including business training), cooperation with alumni and the development of centres supporting entrepreneurship and various other extra-curricular/non-HEI entrepreneurship activities, is necessary to foster entrepreneurship (Siegel & Wright, 2015).

2.2. Assessment of the characteristics of entrepreneurial HEIs

Earlier studies have assessed entrepreneurial HEIs based on objective (existing statistics) or subjective indicators (self-assessment questionnaires) or on their combination. Guerrero and Urbano (2012) and Kirby, Guerrero and Urbano (2011) have, for example, evaluated the formal and non-formal factors contributing to the transition to entrepreneurial HEIs; activities related to knowledge exchange and collaboration with industry and the development of entrepreneurial culture were ranked the highest (Guerrero & Urbano, 2012). As a result of their study, Kirby et al. (2011) highlight three important evaluation criteria for entrepreneurial HEIs: teaching and learning, research and entrepreneurial activities. On the

other hand, Todorovic et al. (2011) have developed a self-assessment questionnaire called ENTRE-*Uscale*, which consists of four main constructs; two of these concentrate on the breadth of the scale of research and collaboration with industry. Gibb (2012) identifies the following five important activities of entrepreneurial HEIs that add value and contribute to innovation: higher education leadership and governance, involvement of target groups, entrepreneurship education, internationalisation and knowledge exchange. Every HEI is concerned with these areas to a greater or lesser extent. Each of these instruments has its theoretical underpinnings and involves a selection of dimensions of entrepreneurial HEIs.

The creation of the HEInnovate concept emerged from the need to define entrepreneurial HEIs and their characteristics, as well as from the need to create a holistic framework that will enhance the development of HEIs towards an entrepreneurial mindset. The European Commission, in cooperation with the OECD, has created the HEInnovate Assessment Tool to help understand the features of entrepreneurial HEIs, the achievement of which will contribute to the development of such HEIs (Hannon, 2013). The instrument encompasses seven dimensions of an entrepreneurial HEI; it allows these institutions to conduct an independent faculty/department/area-based self-assessment that helps them understand the essence of being an entrepreneurial HEI and assess the dimensions that are important for the development of an entrepreneurial HEI.

The HEInnovate questionnaire has previously been used by several countries to evaluate the characteristics of entrepreneurial HEIs. In Indonesia, the entrepreneurial spirit was analysed at the Bogor University of Agriculture (BOA) (Mudde, Widhian & Fauzi, 2017), and it was concluded that knowledge exchange and collaboration with industry were relatively well developed at HEIs; however, more attention should be given to entrepreneurial learning and teaching, despite the comparative statistical data of Asian universities showing that BOA students are entrepreneurial because of the businesses they have established. At Queensland University (McKenzie, Woodcroft & Cassidy, 2016), the level of innovation and entrepreneurship was analysed at the HEI level, and it was pointed out that although a variety of innovation- and entrepreneurship-related initiatives could be observed at HEIs, the activities lacked clear leadership and coordination. In Bulgaria, the HEInnovate tool was used to make a country-level overview of the obstacles, challenges and opportunities of the higher education system; as a result of this, a number of proposals were made to make traditional HEIs more innovative and entrepreneurial (OECD, 2015). In Tallinn University of Technology (TUT), different groups of respondents were compared, such as staff from the Faculty of Economics and the Faculties of Engineering (Voolaid & Ehrlich, 2016), and it was found that faculty members of the Faculty of Economics generally rated the characteristics of entrepreneurial HEIs higher.

In previous studies, the use of the HEInnovate questionnaire aims to obtain an overview of the innovative and entrepreneurial activities of HEI(s) and its/their structural units as a whole. Studies have focused on the analysis of the average rating assessments assigned to the different attributes of entrepreneurial HEIs and a comparative analysis of the answers obtained from the respondent groups (e.g. Sperrer, Soos & Müller, 2016; Jameson & O'Donell, 2015). Despite its widespread use, however, this tool has also received criticism over the choice of the target group and the period of the survey (Henry, 2015). Nevertheless, the European Commission and the OECD recommend the application of this self-assessment tool to address holistic areas in the work of HEIs and to foster their development into entrepreneurial HEIs.

In conclusion, it can be said that the development of the features and activities characteristic of an entrepreneurial HEI is oriented towards innovation and the creation of an organisational culture; this entails a supportive environment for the personal development of students and faculty members, for the implementation of their entrepreneurial ideas, for knowledge building and for the creation of new technologies and their commercialisation. Therefore, all organisational components – structure, culture and strategy – must support the development of entrepreneurial HEIs, in turn requiring that entrepreneurship- and innovation-related goals be embedded in the development plan of HEIs. Governance at different levels also needs to support bottom-up initiatives, and HEIs should set up a structural unit coordinating HEI–business relations and knowledge exchange. On the other hand, the fields of activities of HEIs are intertwined, which means that teaching, research and development activities support one another. Understanding the links between the features and activities of entrepreneurial HEIs allows us to assess the strengths and weaknesses of HEIs, as well as determine the activities that support university–business knowledge exchange and collaboration.

3. Methodology

This study incorporates a cross-sectional survey approach, whose framework was used in the HEInnovate questionnaire to assess the entrepreneurial activity and organisational culture of Estonian HEIs.

The survey was conducted in 2015–2016 at four Estonian HEIs: TUT, the University of Tartu, the Estonian University of Life Sciences and the Estonian Entrepreneurship University of Applied Sciences Mainor. These HEIs were selected for participation in the analysis because it was assumed that knowledge exchange and collaboration with industry play an important role there in the wider context of entrepreneurial HEIs.

A total of 232 HEI staff members and students replied to the HEInnovate questionnaire. Fifty percent of the respondents worked or studied at TUT, 22% at the Estonian University of Life Sciences, 19% at the University of Tartu and 9% at the Estonian Entrepreneurship University of Applied Sciences Mainor (Table 1). Most of the respondents (63%) represented a range of social science disciplines, and they worked as academics, researchers or specialists (93%). Men and women, different age groups and respondents with different work experiences were relatively equally represented.

Table 1. Overview of the sample (n=232)

		Number	Proportion
Speciality	Social sciences	144	62.9
	Natural sciences and engineering	70	37.1
	Total	229	100.0
Age	Up to 45	107	49.8
	Over 46	108	50.2
	Total	215	100
Gender	Male	93	42.9
	Female	124	57.1
	Total	217	100.0
University	Tallinn University of Technology	117	50.4
	University of Tartu	44	19.0
	Estonian University of Life Sciences	51	22.0
	Estonian Entrepreneurship University of Applied Sciences Mainor	20	8.6
	Total	232	100.0
Working experience	Up to 10 years	98	45.6
	Over 11 years	117	54.4
	Total	215	100
Position	Administration	15	6.5
	Staff	197	85.7
	Students	18	7.8
	Total	230	100.0

The HEInnovate questionnaire (www.heinnovate.eu) included questions about the seven dimensions of an entrepreneurial HEI, which are leadership and governance, organisational capacity, entrepreneurial teaching and learning, preparing and supporting entrepreneurs, knowledge exchange and collaboration with industry, internationalisation of HEIs and measuring impact. The HEInnovate questionnaire was developed by the OECD and European Commission, and it is recommended to be used by entrepreneurial universities as a tool for self-assessment. The answers to the questions are given on a five-point scale, where 5 means 'I fully agree' and 1 means 'I fully disagree'.

Both the Estonian and English versions of the questionnaire were used to assess the entrepreneurial culture at Estonian HEIs. The wording of the questionnaire was adapted to the Estonian context in such a way that the questions would be easily comprehensible to the respondents. As this was an online survey, each employee was able to choose the appropriate time to answer the questions within the specified period of time. The HEInnovate questionnaire has been updated several times, so TUT used the 2015 version, whereas the other universities used the 2016 version. For the sake of analysis, the 2015 and 2016 versions of the questionnaire were compared, and this analysis was based on the matching questions. The final questionnaire consisted of 34 questions, which covered the seven dimensions of an entrepreneurial HEI. The Cronbach's α was computed for each dimension of an entrepreneurial institution to assess the internal consistency of the measuring instrument; values in the range of 0.88–0.93 were considered high, indicating that the questions measure the same phenomenon in the same way (Table 2).

Table 2. Internal consistency of the questionnaire

No	Dimension	No. of questions	Cronbach's α
1	Leadership and governance	5	0.88
2	Organisational capacity	5	0.90
3	Entrepreneurial teaching and learning	4	0.90
4	Preparing and supporting entrepreneurs	6	0.90
5	Knowledge exchange and collaboration with industry	5	0.91
6	Internationalisation of higher education	5	0.89
7	Impact assessment	4	0.93

The data are analysed by calculating the respondents' average rating (M), the standard deviation (SD) and the confidence intervals for the mean (95% confidence level) for the overall seven dimensions of entrepreneurial HEIs. Furthermore, each question in the knowledge exchange and collaboration with industry section is separately analysed to determine which of the entrepreneurial HEI characteristics are ranked higher and which are ranked lower.

Unlike prior surveys which focused on comparing the mean values of variables (Sperrer et al., 2016; Mudde et al., 2017; Voolaid & Ehrlich, 2016; McKenzie et al., 2016; OECD, 2015), the present study also examined the inter-linkages between the characteristics of entrepreneurial HEIs. First, Spearman correlation analysis was used to determine the strength of relationship between the values of different variables.

Second, binary logistic regression was utilised to estimate the effect of other entrepreneurial HEI characteristics on knowledge exchange and collaboration with industry. The dependent variable was knowledge exchange and collaboration with industry, in which case 1=HEI means less engaged in knowledge exchange and collaboration with industry and 2=HEI means highly engaged in knowledge exchange and collaboration with industry.

The independent variables included the following characteristics of entrepreneurial HEIs: i) leadership and governance, ii) organisational capacity, iii) entrepreneurial teaching and learning, iv) preparing and supporting entrepreneurs, v) internationalisation of higher education and vi) impact assessment, where 1=HEI means less engaged in these areas and 5=HEI means highly engaged in these areas.

The control variables were as follows: i) position (1=administration, 2=staff, 3=students), ii) field (1=natural sciences, 2=social sciences), iii) HEI (1=Tallinn HEI of Technology, TUT, 2=other universities), iv) age (1=up to 45, 2=over 46), v) gender (1=male, 2=female) and vi) working experience (1=up to 10, 2=over 11).

4. Results

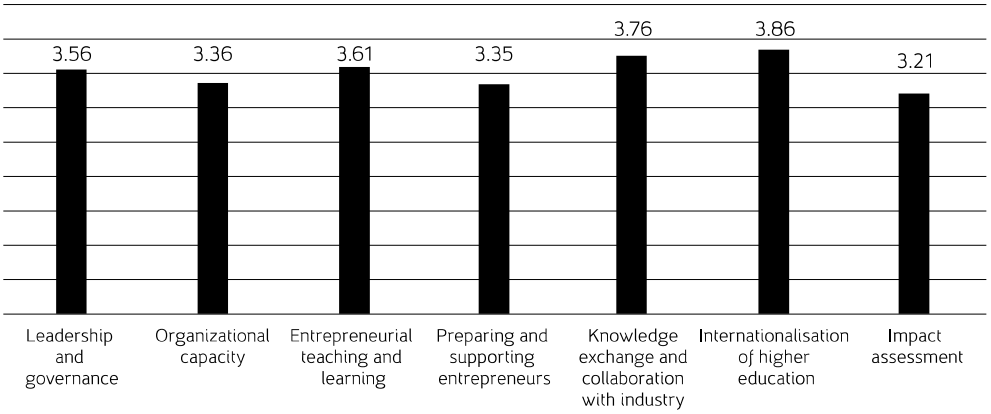
4.1 Assessments of knowledge exchange and collaboration

Knowledge exchange and collaboration with industry are among the seven characteristics that the respondents assessed, and these are among the most highly valued characteristics (M=3.76, SD=0.95) (Figure 1). Such dimensions as leadership and governance (M=3.56, SD=1.00), organisational capacity, funding, people and incentives (M=3.36, SD=1.06), entrepreneurial teaching and learning (M=3.61, SD=1.03) and internationalisation (M=3.86,

SD=0.92) were also highly valued, as the average values of the confidence intervals of these characteristics overlap. Knowledge exchange and collaboration with industry were valued more than the two other characteristics of preparing and supporting entrepreneurs (M=3.35, SD=1.03) and impact measurement (M=3.21, SD=1.15).

One of the interpretations is that such dimensions as knowledge exchange and collaboration with industry, internationalisation, entrepreneurship training and organisational capacity outranked others because these are areas that are regularly monitored by the universities as a part of their educational and research evaluation and accreditation. Thus, these dimensions are more familiar to the HEI staff. It can be assumed, however, that the results are also influenced by the position of the respondent because the scores were higher for the characteristics that the respondents were well aware of and were more involved with in their daily activities (e.g. scores from the respondents in administration). Only 7% of the respondents held key management positions at the HEI (i.e. Vice-Rector, Director, Dean), which reflects the actual organisational structure of HEIs, but their average scores in many dimensions were higher. So, it may be assumed that most respondents were not adequately informed about the activities related to the assessment of organisational capacity and impact measurement, as these activities were not directly related to their day-to-day tasks. At the same time, a strong organisational culture of an entrepreneurial HEI is based on the development of entrepreneurial values, which are borne by both the HEI staff at different levels and by students; therefore, the general awareness of organisational capacity could be higher. As more than half of the respondents come from a social science (including economics) background, they scored relatively high in entrepreneurial teaching and learning. Previous studies have also highlighted higher scores for the characteristics of entrepreneurial HEIs given by those respondents with a background in economics compared with those with an engineering background (Voolaid & Ehrlich, 2016). On the other hand, support for prospective entrepreneurs is an area to which most of the academics and researchers are not exposed; therefore, they are not necessarily aware of the specific activities carried out at the respective HEIs.

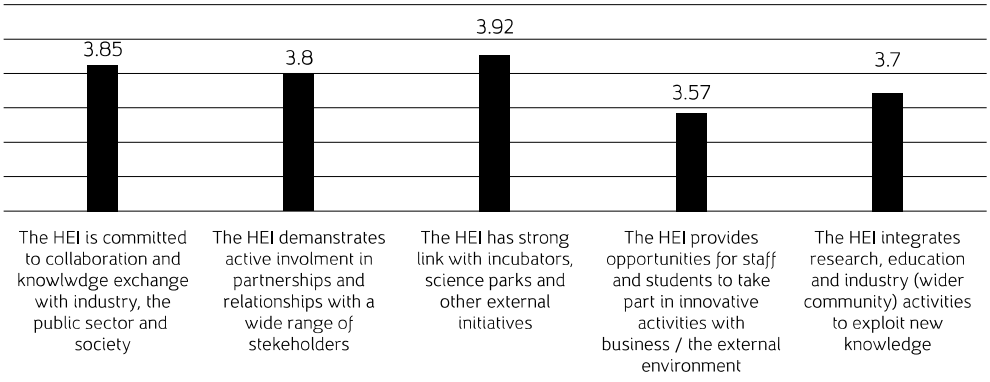
Figure 1. Average rating given by the HEI staff for the dimensions of an entrepreneurial HEI



Note: Average confidence intervals are found at the 95% confidence level.

Knowledge exchange and collaboration with industry are among the main features of entrepreneurial HEIs, and these have also obtained relatively high scores in the study (Figure 2). A statistically significant difference can be observed in the case of only two statements. The respondents have given the highest scores to the statement that HEIs have strong links with incubators, science parks and other organisations (M=3.92, SD=1.03). Considering that half of the respondents work at TUT (where engineering sciences have close relations with industry), this result could be expected. The statement that 'the HEI offers its staff and students a good opportunity to participate in innovative activities involving companies/ external environment' had the lowest scores (M=3.57, SD=1.19). At the same time, however, the content of the collaboration is important, as different partners are involved in different forms of cooperation. In comparison with a similar study across Bulgarian universities, for example, universities collaborated with other universities in the form of research projects and staff mobility, whereas cooperation with businesses was primarily evident in being offered opportunities for placements, traineeships and further training (OECD, 2015).

Figures 2. Average rating given by HEI staff on knowledge exchange and collaboration



Note: Average confidence intervals are found at the 95% confidence level.

4.2. Relationship between knowledge exchange and collaboration with industry and other characteristics of entrepreneurial HEIs

Knowledge exchange and collaboration with industry are strongly linked with other features of entrepreneurial HEIs (Table 4). This may be attributed to the fact that in an entrepreneurial HEI, business and entrepreneurship are not only embedded in subjects in the curricula, but they also find expression in all the activities of the HEIs (Mets, 2010). Successful entrepreneurial universities, such as Stanford University, Massachusetts Institute of Technology, Cambridge University, Technion, Aalto University, University of Michigan, KAIST and Auckland University, are characterised by strong governance and leadership, a corporate culture fostering entrepreneurship and innovation, as well as by the fact that entrepreneurship support and innovation activities take place in different units of the HEI. Support for student entrepreneurship is well thought out and provides students with mentoring and limited funding, and the HEI constitutes a part of the local entrepreneurial ecosystem (McKenzie et al., 2016).

The results of the correlation analysis showed that the dimension of knowledge exchange and collaboration with industry is strongly positively correlated with the pathways for the preparation and support of entrepreneurs (ρ=0.80). It can be assumed that enhancing entrepreneurial incentives and business awareness, supporting the launch of business enterprises, mentoring and providing access to financing and incubation services have a positive effect on the cooperation with business enterprises and facilitate the creation of start-ups (for example, in the case of universities, the launch of spin-off companies). Knowledge exchange and collaboration with industry are also strongly correlated with entrepreneurship education (ρ=0.77), the capacity and resources of HEIs (ρ=0.72) and their impact assessment (ρ=0.74). Knowledge exchange needs resources, such as funding and labour resources, as well as an organisational culture that values entrepreneurship. It is also important to link the results of research and applied research with teaching and learning, as well as with mapping the situation (i.e. measuring the impact of the performed activities). Knowledge exchange likewise contributes to the implementation of other entrepreneurial activities; for example, the results of knowledge exchange and collaboration with industry can be used in teaching, including the development of new courses (Wynn - Jones, 2017). Additionally, knowledge exchange and collaboration with industry and the internationalisation of HEIs have a strong positive correlation (ρ=0.71). Previous studies have also found that staff members with some international experience are more likely to cooperate with businesses, such as enterprises located close to the HEIs where they obtained their doctorate degree (Slavtchev, 2013). There is a medium to strong relationship between knowledge exchange and collaboration and governance and leadership (ρ=0.69).

Table 4. Correlation between the different dimensions of entrepreneurial HEIs

		1. Leadership and governance	2. Organisational capacity	3. Entrepreneurial teaching and learning	4. Preparing and supporting entrepreneurs	5. Knowledge exchange and collaboration with industry	6. Internationalisation of higher education	7. Impact assessment
1. Leadership and governance	ρ	1						
	N	232						
2. Organisational capacity	ρ	0.73**	1					
	N	232	232					
3. Entrepreneurial teaching and learning	ρ	0.72**	08**	1				
	N	232	232	232				
4. Preparing and supporting entrepreneurs	ρ	0.71**	0,77**	0,81**	1			
	N	230	230	230	230			
5. Knowledge exchange and collaboration with industry	ρ	**0.69****	**0,72****	**0,77****	**0,80****	1		
	N	232	232	232	230	232		
6. Internationalisation of higher education	ρ	0.61**	0,65**	0,63**	0,64**	**0,71****	1	
	N	231	231	231	229	231	231	
7. Impact assessment	ρ	0.71**	0,79**	0,76**	0,76**	**0,74****	0,71**	1
	N	221	221	221	220	221	221	221

**p< 0.05

The following is an examination of the effect of other entrepreneurial HEI characteristics on knowledge exchange and collaboration with industry when demographic variables are controlled for. The regression model indicates that the probability of assessing knowledge exchange and collaboration with industry substantially depends mainly upon highly assessing also entrepreneurial teaching and learning, preparing and supporting entrepreneurs and the internationalisation of higher education (Table 5). The results also indicate that the probability of assessing knowledge exchange and collaboration with industry at a high level is lower in the case of respondents from the natural sciences and engineering.

Table 5. Effect of entrepreneurial HEI characteristics on knowledge exchange and collaboration with industry: results of the binary logistic regression

	B	S.E.	Wald	Sig.	Exp(B)
Leadership and governance	–0.72	0.82	0.78	0.378	0.49
Organisational capacity	1.64	1.07	2.34	0.126	5.17
Entrepreneurial teaching and learning	**1.88**	**0.85**	**4.86**	**0.028**	**6.53**
Preparing and supporting entrepreneurs	**2.01**	**0.91**	**4.85**	**0.028**	**7.45**
Internationalisation of higher education	**1.22**	**0.73**	**2.82**	**0.093**	**3.40**
Impact assessment	–1.18	0.81	2.11	0.147	0.31
Position (1=administration)	–2.47	1.80	1.88	0.170	0.08
Area (1=natural sciences and engineering)	**–2.03**	**1.14**	**3.16**	**0.075**	**0.13**
HEI (1=TTU)	1.01	1.03	0.97	0.325	2.75
Age (1=up to 45 yrs)	0.61	1.12	0.29	0.589	1.83
Working experience (1=up to 10 yrs)	–0.98	1.15	0.72	0.396	0.38
Gender (1=male)	0.00	1.08	0.00	1.000	1.00
Constant	–3.84	5.29	0.53	0.470	0.02

Note: Nagelkerke r^2=.76

Entrepreneurial teaching and learning are understood in the present study as entrepreneurship education that is a part of the official curricula and also of extra-curricular activities, the involvement of target groups in the planning of the curricula and the connectedness of the research results with entrepreneurship education. It follows that knowledge exchange and collaboration with industry are likely to be more widespread when an HEI offers different possibilities for entrepreneurial learning, both formally and informally. To develop students' entrepreneurial attitudes and skills, an HEI plans and implements its teaching activities together with external interest groups (from industry and the public sector) and makes use of the latest entrepreneurship research results whilst teaching.

Preparing and supporting entrepreneurs entail supporting entrepreneurial intentions and attitudes, providing assistance and enabling mentoring at various stages, such as finding business ideas, establishing a company, growing the company and facilitating access to financial and incubation services. Knowledge exchange and collaboration with industry are likely to be more frequent if an HEI chooses to support positive attitudes regarding entrepreneurship and the entrepreneurial intentions of students, alumni and employees by offering mentoring and other support services either by using the HEI's resources or by facilitating access to external ones.

The internationalisation of higher education involves prioritising and assessing international cooperation at the level of an HEI's management, supporting the mobility of students and employees, hiring staff from abroad, implementing international and joint curricula and conducting international research activities. Knowledge exchange and collaboration with industry are likely to be more developed when an HEI has included the international dimension into its various activities, including teaching. Knowledge exchange and collaboration with industry can be said to partly overlap with internationalisation; both involve partners located abroad, although internationalisation takes place more frequently between universities, whereas knowledge transfer also involves enterprises. It follows that international research cooperation, such as participation in research projects, can boost other forms of university–industry cooperation, such as contract research or the commercialisation of technologies.

It can be summarised that knowledge exchange and collaboration with industry are linked with other characteristics of entrepreneurial HEIs. In this study, knowledge exchange and collaboration with industry were found to be connected the most with preparing and supporting entrepreneurs, which involved mentoring and facilitating access to finances and entrepreneurship support services. There was also a connection with entrepreneurial teaching and learning, which aims to support the development of entrepreneurial attitudes, knowledge and skills. HEIs' knowledge exchange and collaboration with industry can be boosted when HEIs organise different events to create an entrepreneurial culture that values the entrepreneurial attitudes and intentions of students and staff. Another important factor was the internationalisation of higher education and when this is set as a strategic objective accompanied by regular assessment.

5. Discussion and conclusion

This study aimed to explore the links between knowledge exchange and collaboration with industry and other characteristics of entrepreneurial HEIs. The results of the study indicated that the employees of Estonian HEIs highly assessed knowledge exchange and collaboration with industry. Amongst the seven characteristics of entrepreneurial HEIs, knowledge exchange and collaboration with industry, leadership and governance, organisational capacity, entrepreneurial teaching and learning and the internationalisation of higher education were assessed the highest. One possible explanation is that higher assessments were given to areas which the HEIs have prioritised the most in the past and which are regularly assessed, such as through regular research and teaching quality assessments, and those whose development the respondents have first-hand knowledge of.

Knowledge exchange and collaboration with industry are strongly linked with the other characteristics of entrepreneurial HEIs. They are related to the internal factors of HEIs, such as the activities of technology transfer offices, as well as to external factors, such as the demand from enterprises, awareness of the staff on entrepreneurial activities of HEIs and their willingness to cooperate with other organisations and establish start-ups (Bigliardi et al., 2015). In this study, knowledge exchange and collaboration with industry were found to be higher when an HEI prepares and supports entrepreneurs, including providing mentoring and facilitating access to finances and entrepreneurship support services. They were also found to be contingent upon entrepreneurial teaching and learning involving the development of entrepreneurial attitudes and skills. Knowledge exchange and collaboration

with industry can be said to be more widespread if an HEI organises different formal and informal activities to support the development of an entrepreneurial mindset and intentions amongst its staff and students. Another important aspect was the internationalisation of HEIs and the regular assessment of internationalisation outcomes. Furthermore, previous studies have shown that university–industry cooperation is linked with international mobility and international cooperation (Slavtchev, 2013).

The theoretical contribution of this study is that it explores the links between knowledge exchange and collaboration with industry and other characteristics of entrepreneurial HEIs. Earlier studies on entrepreneurial HEIs have focused mainly on their different dimensions whilst comparing such dimensions and identifying areas of weaknesses. Knowledge exchange and collaboration with industry have been studied from the perspective of their narrower aspects, such as the commercialisation of research results, their organisation and their effectiveness. The present study approaches knowledge exchange and collaboration with industry from a wider perspective, which is connected to other characteristics of entrepreneurial HEIs involving cooperation with enterprises, public sector and third sector organisations, incubators and science parks, as well as relating research, teaching and cooperation with industry. The study therefore combines two approaches: knowledge exchange and entrepreneurial HEIs.

In addition to theoretical novelty, the study contributes to the practice of HEI management. First, the assessments and awareness of staff holding different positions at HEIs vary in terms of the characteristics of entrepreneurial HEIs. In the study, the management members of HEIs were somewhat more likely to assess knowledge exchange and collaboration with industry more highly in their organisations (although the results were not statistically significant). This finding could indicate a lack of awareness of different possibilities for support when engaging in entrepreneurial activities on the part of employees and students. Second, the assessments of respondents seem to depend on the area of study they represent. Having a background in the social sciences is more likely to yield higher assessments of knowledge exchange and collaboration with industry. This might reflect the different nature of cooperation with industry in this field because in the social sciences, collaborative and contract-based research is perceived as adequately developed and supported, whereas commercialisation-related activities in the natural sciences and in engineering are less frequent and in need of more specialised support. But the results also indicate a considerable weakness in Estonian HEIs: the natural sciences and engineering fields have failed to be in the forefront of research commercialisation and spin-off activities, which can be observed in the top universities of the world. Finally, knowledge exchange and collaboration with industry should be developed in conjunction with other characteristics of entrepreneurial HEIs. Cooperation with external partners cannot progress in isolation from developing an entrepreneurial mindset and intentions, acknowledging external cooperation, implementing research results in teaching and internationalising HEIs.

This study is not without limitations. The main constraint is its relatively small sample. Further studies should involve more HEIs with different focuses and characteristics. This would also contribute to adapting the survey instrument further in order to meet local conditions. Another path of further research involves combining objective statistical data with subjective evaluations on the characteristics of entrepreneurial HEIs. Doing so would allow obtaining a more thorough overview of the actual situation on the entrepreneurial culture and activities of HEIs.

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References

Bigliardi, B., Galati, F., Marolla, G., & Verbano, C. (2015). Factors affecting technology transfer offices' performance in the Italian food context. *Technology Analysis & Strategic Management*, *27*(4), 361-384.

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.

D'Este, P., & Perkmann, M. (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations. *Journal of Technology Transfer*, *36*(3), 316–339.

Etzkowitz, H. (1984). Entrepreneurial scientists and entrepreneurial universities in American academic science. *Minerva*, *21*(2-3), 198-233.

Etzkowitz, H. (2003a). Innovation in innovation: The triple helix of university-industry-government relations. *Social Science Information*, *42*(3), 293-337.

Etzkowitz, H. (2003b). Research groups as Bquasi-firms: The invention of the entrepreneurial university. *Research Policy*, *32*(1), 109-121.

Etzkowitz, H. (2008). *The triple helix: University-industry-government innovation in action*. New York: Routledge.

Etzkowitz, H. (2013). Anatomy of the entrepreneurial university. *Social Science Information*, *52*(3), 486-511.

Gibb, A. (2012). Exploring the synergistic potential in entrepreneurial university development: Towards the building of a strategic framework. *Annals of Innovation & Entrepreneurship*, *3*(1), 16742.

Grimaldi, R., Kenney, M., Siegel, D. S., & Wright, M. (2011). 30 years after Bayh–Dole: Reassessing academic entrepreneurship. *Research Policy*, *40*(8), 1045-1057.

Guenther, J., & Wagner, K. (2008). Getting out of the ivory tower: New perspectives on the entrepreneurial university. *European Journal of International Management*, *2*(4), 400-417.

Guerrero, M., Cunningham, J. A., & Urbano, D. (2015). Economic impact of entrepreneurial universities' activities: An exploratory study of the United Kingdom. *Research Policy*, *44*(3), 748-764.

Guerrero, M., & Urbano, D. (2012). The development of an entrepreneurial university. *The Journal of Technology Transfer*, *37*(1), 43-74.

Guerrero, M., Urbano, D., Cunningham, J., & Organ, D. (2014). Entrepreneurial universities in two European regions: A case study comparison. *The Journal of Technology Transfer*, *39*(3), 415-434.

Hannon, P. D. (2013). Why is the Entrepreneurial University Important? *Journal of Innovation Management*, *1*(2), 10-17.

Henry, C. (2015). Entrepreneurship education evaluation: Revisiting Storey to hunt for the heffalump. *Education + Training*, *57*(8/9), 816-833.

Huggins, R., Johnston, A., & Steffenson, R. (2008). Universities, knowledge networks and regional policy. *Cambridge Journal of Regions, Economy and Society*, *1*(2), 321-340.

Huggins, R., Johnston, A., & Stride, C. (2012). Knowledge networks and universities: Locational and organisational aspects of knowledge transfer interactions. *Entrepreneurship and Regional Development*, *24*(7-8), 475-502.

Hunter, E. M., Perry, S. J., & Currall, S. C. (2011). Inside multi-disciplinary science and engineering research centers: The impact of organizational climate on invention disclosures and patents. *Research Policy*, *40*(9), 1226-1239.

Inzelt, A. (2004). The evolution of university–industry–government relationships during transition. *Research Policy*, *33*(6-7), 975-995.

Jacob, M., Lundqvist, M., & Hellsmark, H. (2003). Entrepreneurial transformations in the Swedish university system: The case of Chalmers University of Technology. *Research Policy*, *32*(9), 1555-1568.

Jameson, J., & O'Donnell, P. (2015). *The entrepreneurial university: A unifying theme for TU4Dublin*. Dublin: Dublin Institute of Technology.

Kalantaridis, K., & Küttim, M. (2019). University ownership and information about the entrepreneurial opportunity in commercialisation: A systematic review and realist synthesis of the literature. *Journal of Technology Transfer* (forthcoming).

Kalar, B., & Antoncic, B. (2015). The entrepreneurial university, academic activities and technology and knowledge transfer in four European countries. *Technovation*, *36*(1), 1-11.

Kirby, D. A., Guerrero, M., & Urbano, D. (2011). Making universities more entrepreneurial: Development of a model. *Canadian Journal of Administrative Sciences*, *28*(3), 302-316.

Kochenkova, A., Grimaldi, R., & Munari, F. (2016). Public policy measures in support of knowledge transfer activities: A review of academic literature. *The Journal of Technology Transfer*, *41*(3), 407-429.

Lam, A. (2010). From 'ivory tower traditionalists' to 'entrepreneurial scientists'? Academic scientists in fuzzy university - industry boundaries. *Social Studies of Science*, *40*(2), 307-340.

Mainardes, E. W., Alves, H., & Raposo, M. (2011). The process of change in university management: from the Bivory tower to entrepreneurialism. *Transylvanian Review of Administrative Sciences*, *33*, 124-149.

McKenzie, S., Woodcroft, T., & Cassidy, M. (2016). Entrepreneurship and innovation: The state of play at UQ. The University of Queensland: Institute for Teaching and Learning Innovation.

Mets, T. (2010). Entrepreneurial business model for classical research university. *Engineering Economics*, *66*(1), 80-88.

Mudde, H. L. M., Widhiani, A. P., & Fauzi, A. M. (2017). Entrepreneurial university transformation in Indonesia: A comprehensive assessment of IPB. *GSTF Journal on Business Review (GBR)*, *5*(1), 46-61.

OECD (2015). *HEInnovate reviews. Universities, entrepreneurship and local development. Bulgaria 2014. Country level review Bulgaria*. Paris. Retrieved in April 2018 from https://www.oecd.org/cfe/leed/OECD-LEED-2015-Bulgaria-report.pdf.

Pinheiro, R., & Stensaker, B. (2014). Designing the entrepreneurial university: The interpretation of a global idea. *Public Organization Review*, *14*(4), 497-516.

Rothaermel, F. T., Agung, S. D., & Jiang, L. (2007). University entrepreneurship: A taxonomy of the literature. *Industrial and Corporate Change*, *16*(4), 691-791.

Saiz-Santos M., la Mata A. AD., & Hoyos-Iruarrizaga J. (2017). Entrepreneurial University: Educational Innovation and Technology Transfer. In M. Peris-Ortiz, J. Gómez, J. Merigó-Lindahl, C. Rueda-Armengot (Eds.), *Entrepreneurial Universities. Innovation, Technology, and Knowledge Management* (pp. 105-121). Cham, Springer.

Sam, C., & Van Der Sijde, P. (2014). Understanding the concept of the entrepreneurial university from the perspective of higher education models. *Higher Education*, *68*(6), 891-908.

Schmitz, A., Urbano, D., Dandolini, G. A., de Souza, J. A., & Guerrero, M. (2017). Innovation and entrepreneurship in the academic setting: A systematic literature review. *International Entrepreneurship and Management Journal*, *13*(2), 369-395.

Siegel, D. S., & Wright, M. (2015). Academic entrepreneurship: Time for a rethink? *British Journal of Management*, 26(4), 582-595.

Slavtchev, V. (2013). Proximity and the transfer of academic knowledge: Evidence from the spatial pattern of industry collaborations of East German professors. *Regional Studies*, *47*, 686-702.

Sperrer, M., Soos, J., & Müller, C. (2016). The concept of "entrepreneurial university" applied to universities of technology in Austria-Already reality or a blink to the future? Proceedings from ISPIM Conference. *The International Society for Professional Innovation Management* (ISPIM).

Todorovic, Z. W., McNaughton, R. B., & Guild, P. (2011). ENTRE-U: An entrepreneurial orientation scale for universities. *Technovation*, *31*(2-3), 128-137.

Voolaid, K., & Ehrlich, Ü. (2016). Learning university versus entrepreneurial university: The case of Tallinn University of Technology, Estonia. In International Conference on Intellectual Capital and Knowledge Management and Organisational Learning (pp. 259-265). Kidmore End: Academic Conferences International Limited.

Wersun, A. (2010). Triple translation: Academic and managerial discourses of knowledge transfer policy in a new university in Scotland. *Discourse: Studies in the Cultural Politics of Education*, *31*(5), 665-682.

Wynn-Jones, J. (2017). Continuing professional development. In J. Cox & I. Mungall (Eds), *Rural Healthcare* (pp. 121-134). London, CRC Press.

Yusof, M., & Jain, K. K. (2010). Categories of university-level entrepreneurship: A literature survey. *International Entrepreneurship and Management Journal*, *6*(1), 81-96.