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What makes an academic active in knowledge transfer process?

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Abstract

With the spread of the paradigm of the knowledge economy and information society, whereby knowledge is regarded as a key factor in development, and institutions create knowledge as a determinant of regional competitiveness and innovation, the question of the factors responsible for the involvement of universities in the processes of creating and disseminating knowledge is being addressed more and more often. The main objective of this paper is to identify factors influencing the activity of universities in the process of knowledge transfer. The research area is the Masovian Voivodeship, which, in the broad sense of innovation, research and development potential, and higher education, is the clear leader among Polish regions. The detailed analysis covered 145 basic organizational units of universities located in the Masovian Voivodeship, mostly in Warsaw. The results of the research show that the most salient factors differentiating between individual universities' activities in the process of knowledge transfer include the type of institution (public/private) and the represented field of study. However, it should be highlighted that units representing the humanities and social sciences (comparing to units representing science, technical sciences and life sciences) are not characterized by lower, but simply by different activity in the knowledge transfer process. The size of the university, in particular HR, and the financial and infrastructural potential, are also of key importance for the level of activity.

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What makes an academic active in knowledge transfer process?

1. Introduction

The results of numerous studies on the relationship between regional development and innovation clearly indicate that only regions with highly developed academic research centres have a chance for self-development and competition with other regions (Capello, Olechnicka and Gorzelak 2012). Universities are organizations that play a key role in the modern world (in contemporary societies), thanks to the implementation of the teaching mission (education of the population), the academic mission (conducting academic research), and the so-called third mission, which has been increasingly emphasized in the public debate in recent times (Perkmann et al. 2013, p. 423). One aspect that appears to be significant here is the question of the factors determining the activity of universities in the production and transmission of knowledge to their surroundings.

2. Theoretical background and hypotheses

The factors that have a potential effect on the development of a university's activity in terms of the process of knowledge transfer (both on the level and intensity of the transfer, and its character) cover a very wide range of issues related to the characteristics of the knowledge transfer participants (producers and recipients), the characteristics of the knowledge subjected to transfer, the methods of knowledge transfer (channels used) and the environment in which the process takes place (including the relationship between the participants of the transfer).

This article focuses on certain factors related to the participants in the knowledge transfer process, namely the "producers" and key broadcasters of knowledge to the surroundings, i.e. academic researchers. The determinants of the activity of academics can be dealt with at the individual, organizational and institutional levels (Perkmann et al. 2013, p. 429), and may apply to both soft factors (e.g. the level of intrinsic motivation) and hard factors (e.g. age, sex, represented academic field). This article takes as a starting point the level of the basic organizational unit of the university (overwhelmingly synonymous with the concept of the department) and limits its consideration to the following factors: represented academic discipline, unit size, and structure of employment within the unit (according to gender and position held).

2.1. Represented academic discipline

The impact of the discipline on knowledge transfer activity may be twofold. Firstly, academics representing different academic disciplines may be active in the field of knowledge transfer to **varying degrees** (addressing the question of "how much"). Secondly, researchers from different disciplines may engage in knowledge transfer **in various ways**, i.e. using different channels of knowledge transfer (answering the question of "how") (Olmos-Peñuela, Benneworth and Castro-Martínez 2014).

The widespread belief in the dominance of the sciences (over the social sciences and humanities) in the context of knowledge transfer is strongly associated with a fairly narrow interpretation of the concept of knowledge transfer, limiting it to the activities of patent licencing and the creation of spin-off companies (cf. Landry, Amara and Ouimet 2005, Molas-Gallart et al. 2002, Hofer 2006). The incorrect identification of knowledge transfer with technology transfer results in a further reduction of the field of interest for the potential "sender of knowledge" to the sciences (Hawkins, Langford and Sidhu 2007, Hughes and Kitson 2012, Nelson 2010), and for the potential “knowledge recipient" to the industry sector (Hughes and Kitson 2012). This is partly because ‘the innovations and examples of the commercialization of knowledge in the sciences are more tangible and cognitively "expressive"’ (Rudnicki 2013, p. 174), and as such are easily measured (cf. Olmos-Peñuela, Benneworth and Castro-Martínez 2014). While the automatic assumption of dominance in the context of knowledge transfer in the sciences over the social sciences and humanities is highly debatable, there is certainly a strong basis for the hypothesis of different ways of engaging representatives of both groups of academics in the process of knowledge transfer (Hughes et al. 2011, Olmos-Peñuela, Benneworth and Castro-Martínez 2014).

The present research assumes *R&D=€*. Social Sciences for the Economy showed that the social sciences engage with the surroundings and generate economic value, in particular via: advisory/ consulting services, development of expertise or analysis, conducting postgraduate studies and training (Otręba-Szklarczyk and Szklarczyk 2011, p. 42). Research conducted with Spanish academics (Olmos-Peñuela, Benneworth and Castro-Martínez 2014) showed that the social sciences and humanities (SSH) are characterized by different, but not lower, usability in the context of knowledge transfer and cooperation with the surroundings than science, technology, engineering and mathematics (STEM). Research conducted with Spanish academics (Olmos-Peñuela, Benneworth and Castro-Martínez 2014) showed that the social sciences and humanities (SSH) are characterized by **different**, but **not lower**, usability in the context of knowledge transfer and cooperation with the surroundings than science, technology, engineering and mathematics (STEM). Compared with academics representing STEM, SSH academics collaborate less with companies and more with public institutions and non-governmental organizations. In addition, compared with STEM academics, SSH academics use less formal ways of relating to their surroundings; they are more likely to engage in dissemination activities and activities for a "mass audience” (Olmos-Peñuela, Benneworth and Castro-Martínez 2014).

Differences in the manner of involvement of academics representing different disciplines in cooperation with their surroundings have also been confirmed by other studies. A very interesting piece of work in this field was produced by Schartinger et al. (2002), who conducted a simultaneous analysis of the significance of the individual channels of knowledge transfer for the various academic disciplines and different sectors of the economy. Their study included 46 specific academic fields (grouped into six areas: natural sciences, social sciences, humanities, engineering and technical sciences, agricultural sciences and medical and health sciences), as well as 49 economic sectors. Of the nine fields of study, those with the highest level of intensity of interaction with the economy were engineering and technical sciences (mining and metallurgy, general engineering, electronics, construction techniques, other technical fields), as well as the natural sciences (physics, mathematics, computer science, chemistry) and social sciences (economics and other social fields, especially those of an interdisciplinary nature). The areas of study of far less importance in the context of integration with the economy were the humanities and medical and health sciences. Meanwhile, distinct differences were observed between certain academic fields in interaction with the economy, which manifest, for example, in a different intensity of use of the channels of knowledge transfer (implementation of joint research, implementation of commissioned research, training activities and personnel transfer). While for the technical and engineering sciences, interactions involving the implementation of joint research appear to be of key importance, for the natural sciences, commissioned studies are key, and for the social sciences training is most important, which is rather less popular in the other branches of science.

Similar differences are also observed in relation to publishing activity, which is strongly dependent on the academic discipline (Błocki and Życzkowski 2013, Hoekman, Frenken and van Oort 2008 and 2009, Wolszczak-Derlacz and Parteka 2010). However, research conducted on this topic does not give a definite answer as to how the specifics of the field affects the publishing activity of academics. Research conducted with American academics showed that the highest research productivity (as well as citation rate) is characterized by representatives of earth sciences (an average of 2.2 publications per year per employee), physics (close to 2.0) and biological sciences (1.4). The other end of the classification is populated by academics from the social sciences and mathematics (0.2), and computer sciences (0.4). Slightly different conclusions can be drawn from research in Poland (Szprot 2014). The largest proportion of academics reporting four or more publications a year is found in the social sciences and humanities. Meanwhile, the least productive academics (one or fewer publications a year) are from the sciences and natural sciences.

Based on the literature, it is possible to formulate the following hypothesis:

> Hypothesis 1: Departments representing the humanities and social sciences engage in the knowledge transfer process in a different way from departments representing science and the technical sciences.

2.2. Unit size

Another factor potentially affecting engagement in the knowledge transfer process is the size of the unit. The starting point in addressing the issue of optimal unit size (from the perspective of knowledge transfer) is the economic concept of "economies of scale", according to which the unit cost of production decreases as the size of production increases (until they reach a certain critical level, where there are disadvantages of scale associated primarily with the problems of largescale management) (see e.g. Begg, Fischer and Dornbusch 2007). As noted by Grzeszczak (1999, p. 34), "economies of scale" may have internal and external dimensions. Internal economies of scale are associated with an increase in the production of a given unit, while external economies of scale are the result of an increase in the number of producers in the production group.

If economies of scale were applied in the area of science and higher education, a greater effectiveness would be expected for larger units. Due to the nature of institutions of higher education (strong autonomy of individual units) it is usually the internal benefits that are analysed. The existence of economies of scale is backed by a number of theoretical arguments: first of all, better access to financial capital and infrastructure (due to the indivisibility of certain resources), risk reduction through diversification of activities, the benefits of combining intellectual capital and greater creative possibilities (cross- fertilization among academics), the possibility of specialization, the division of labour and consequent optimizing of research output (Scherer 1980 after Jordan, Meador and Walters 1988, p. 251, Bonaccorsi, Daraio and Simar 2006, p. 393, Bukowska and Łopaciuk-Gonczaryk 2013, p. 77). Larger teams are also in a privileged position when it comes to applying for funding for a research project and have a better chance of attracting high-quality academics (Tunzelmann 2003 after Bukowska and

Łopaciuk-Gonczaryk 2013, p. 77). There are also drawbacks to larger units: excessive bureaucratization (Jordan, Meador and Walters 1988, p. 251) and reduced flexibility and adaptability to the changing conditions of the surroundings. Schartinger, Schibany and Gessler (2000, p. 13) assume, therefore, the existence of a U-shaped relationship between unit size and the susceptibility to work with the business sector (as one of the manifestations of knowledge transfer). According to this assumption, large units with more resources (personnel, infrastructure, funding, knowledge, experience) will be more likely to engage in cooperation with their surroundings, without neglecting their core responsibilities – teaching and publications. Meanwhile, small units with high operational flexibility and focused on a narrow research area will make attractive partners for small private companies.

The conclusions of the empirical research on the effects of scale in different academic fields are ambiguous. For example, studies conducted in Italy showed no positive relationship between the size of the university and the publishing activity of academics (measured by the number of publications). On the contrary, there was a weak negative correlation between the studied variables (Bonaccorsi and Daraio 2005). Similar conclusions have been formulated by researchers from Spain, who analysed 80 research teams representing the humanities and social sciences for their activity within five channels of knowledge transfer: consultative activities, realization of commissioned studies, cooperation within the R&D framework, training activities and personnel transfer (Olmos-Peñuela, Castro-Martínez and D'Este in 2014) and found no positive effects of scale. Crespi et al. (2011), who studied British academics, also found a lack of significant relationship between the size of the department and the likelihood of engaging in knowledge transfer (R&D cooperation, implementation of commissioned research, consultative activity, cooperation relating to doctoral studies, and the establishment of spin-off companies). Research on Austrian universities found different results: Schartinger, Schibany and Gessler (2000) observed a positive correlation between the size of a department (measured by the number of researchers) and their commitment to working with their surroundings. Notably, a strong correlation was found between the implementation of joint research, the transfer of personnel and joint supervision of dissertations. In analysing the activities of Canadian academics, Landry et al. (2010) noted a positive correlation between the size of a unit and five (out of six) channels of knowledge transfer: patent activity, spin-off companies, business consulting, publishing activities and informal contacts. Interestingly, the opposite trend applied only to educational activities, which the authors measured by time dedicated to teaching, and not, as in other studies, the number of students or graduates of the unit. However, Polish studies on the determinants of research productivity (as measured by the number of publications per academic teacher) shows all the approximations of university size analysed by the authors – number of students, employees and graduates – to be positively associated with research productivity (Wolszczak-Derlacz and Parteka 2010 p. 66).

Taking into account the nature of Polish higher education, it can be assumed that:

> *Hypothesis 2: "Larger" departments (in terms of human, financial and infrastructure* resources) are characterized by greater activity in the knowledge transfer process than smaller units.

2.3. Employment structure

2.3.1. Employment structure by gender

Most studies on the impact of gender on research productivity and academic engagement are conducted at the individual level, focusing on an individual academic; therefore, the presented conclusions of the literature review will be based primarily on this perspective. The consideration of this subject relates to the general discussion on the position of women in science, conducted by sociologists, psychologists and politicians, as well as feminist circles. This is due to the observed phenomenon of there being a lower proportion of women in science, a factor that is multiplied with the increasingly senior level of an academic career. Although girls generally perform better in school, and go on to university study and other forms of training more often than boys, men still predominate at professor level, and are more likely to achieve spectacular academic success. Addressing the reasons for this situation, Młodożeniec and Knapińska (2013) indicate the following phenomena, metaphorically defined as:

- **the glass ceiling** (Hymowitz and Schellhardt 1986) – invisible barriers that hinder or even prevent women from achieving a high position in the academic hierarchy;[1]
- **the leaky pipeline** (Berryman 1983) – "leaking" of women's talents and subsequent levels of academic advancement;
- **the vanish box** (Etzkovitz et al. 2009) – highly qualified women resign from the academic world and opt for different career paths, mostly in science-related fields;
- **the sticky floor** (Noble 1992) – the assignment of women to less prestigious and less well paid professions. In the academic world this manifests as the greater involvement of women in teaching (perceived as less important) than research (which is also the stepping stone for reaching higher levels in academic careers).

However, in the context of research activity, the key question is whether and how gender is a factor in determining the activity of academic staff, or a particular unit, in knowledge transfer. The answer to this question is found in the results of studies on research productivity (measured by number of publications). The thesis of women having lower research productivity than men is confirmed by the results of the majority of empirical studies in this area (Lee and Bozeman 2005, Cole and Zuckerman 1987). The natural reason for this situation is the greater burden of non-work-related obligations on women, especially in terms of family responsibilities. Accordingly, the "gender" variable should be considered in the context of family status and, more importantly, the fact of having children. Bruer (1984) came to the conclusion that the best academics are either married men or unmarried, childless women. The negative impact of parental responsibilities on the academic productivity of women has been confirmed, inter alia, by the research of Kyvik and Teigen (1996). In contrast, Cole and Zuckerman (1987) argue that neither marriage nor motherhood make a significant difference to a woman's research activity. Fox (2005) even indicates a positive correlation between having children (particularly pre-schoolers) and productivity. Women maintain the research productivity of their "pre-baby" days, which is explained by several factors: overvaluation of work priorities and preference for research over teaching (Fox 2005), better organization of work, in connection with the increased load of household duties (Cole and Zuckerman 1987), stronger motivation to work, in connection with the desire to ensure a higher standard of living for their children (Fox 2005),

[1]Opportunities for women, in comparison with men, to achieve a high position in the academic hierarchy (based on the GCI, Glass Ceiling Index, which is the ratio of the proportion of women among all academics to the proportion of female professors) were at the level of the European Union average in 2008 (EU-27). The GCI value for the Masovian voivodeship is 1.66 (the Polish average was 1.76, where 1 means no differences in access to the highest academic position, while the higher the value of the indicator, the "thicker" the glass ceiling and the stronger the so-called vertical segregation of the sexes (Młodożeniec and Knapińska 2013, p. 52).

and resignation from other activities beyond the responsibilities of home and work, in particular from social life and passions (Cole and Zuckerman 1987).

Female academics engage in knowledge transfer in a different way than male academics (e.g. through diverse activities within the individual channels of knowledge transfer – publications versus teaching). According to Bourdieu (2004, after Młodożeniec and Knapińska 2013), the labour market is regulated in an informal way by the practical rules used by women and their surroundings, one of which states that women's professions are an extension of their domestic-family roles (such as teaching and caring), which, in the academic sphere, translates into the greater involvement of women than men in teaching (Młodożeniec and Knapińska 2013, p. 50). Another principle governing the labour market, as emphasized by Bourdieu (2004, after Młodożeniec and Knapińska 2013) is the monopoly of men in the domain of the operation of machines and technical equipment, which in academia means a significantly lower proportion of women in technical and engineering fields. Meanwhile, those sciences are naturally associated with the commercialization of knowledge in the form of patents, licences and the creation of spin-off companies. While it is difficult to accept the logic that women are less likely to engage in the commercialization of knowledge than men, a major role in this case is played by the represented academic field. The arguments at the theoretical level are partly confirmed by the results of empirical research conducted by Landry et al. (2010), who observed a positive correlation between an academic being male and that academic engaging in the activities of spin-off companies (along with the absence of such a relationship between gender and patent activity).

Simultaneously, women are ascribed a more holistic vision of academic research, which is reflected in a greater research commitment in various academic disciplines and dispersion across different research areas (while men are much more likely to have a narrow specialization) (Leahey, Crockett and Hunter 2008, Zucco and Molfino 2012). On the one hand, this interdisciplinarity results in lower research productivity (as measured by number of publications), while on the other hand it brings greater opportunities to reach a wider audience (Leahey, Crockett and Hunter 2008).

Accordingly, the following hypothesis is proposed:

> *Hypothesis 3a: The greater the proportion of women in a department's employment* structure, the greater the teaching activity of the unit, and the less the publication and conference activity, and the less the activity related to the commercialization of knowledge in the form of patents or licences.

2.3.2. Employment structure by age and position

Two other factors potentially differentiating between the activity of academic research employees in knowledge transfer are age (along with the usually associated seniority and experience), and position in the academic hierarchy, designated by academic title and duties of office. Based on research conducted with British academics, D'Este and Patel (2007) observed that the knowledge transfer activity of academics is negatively correlated with age. This means that young scientists engage more often in activity within the channels of knowledge transfer, with their involvement also being more diverse than their older colleagues (i.e. including more knowledge transfer channels). A similar situation applies to those at professor level. The observation of both dependencies may come as a surprise in the Polish context, where role is usually strongly associated with age (which, assuming a negative correlation between age and involvement in knowledge transfer, would also suggest a negative correlation between position in the academic hierarchy and involvement in knowledge transfer). However, this is strongly conditioned by the specifics of the university system in Poland, and in particular the relatively slow pace of academic careers and the lack of "fast-track promotion" for the most talented academics (Thieme 2009, p. 54).

The conducted studies and empirical analyses focus in particular on the relationship of age and professional status to publishing activity (representing research productivity), leaving the other channels of knowledge transfer decidedly beyond enquiry. The second most frequently addressed issue is the role of age and professional position in relation to the tendency to engage in cooperation with the economy (determinants of university-industry linkages), and usually includes the following channels of knowledge transfer: business consulting, the implementation of commissioned research, the commercialization of intellectual property through the establishment of spin-off companies, and the implementation of joint research with industry.

In studies on the significance of these factors for the **publishing activity** of academics, two conflicting views emerge. According to the first opinion, research productivity is positively correlated with age, which is justified by cumulative advantage theory, as well as the mechanism of academic functioning known as "the Matthew effect." As age increases, there is also an increase in experience, recognition in academic circles and access to resources, and therefore the ability to conduct extensive research activity. The opposite hypothesis is that age has a negative effect on the activity of employees, as a consequence of lower adaptability and difficulty in keeping up with new technologies (obsolescence theory) (Bukowska and Łopaciuk-Gonczaryk 2013), as well as flagging motivation.

According to Kuhn's theory of academic revolutions (2001), it is young scientists – those who are not bound so strongly to the previously existing academic paradigm – who are capable of the most significant discoveries and are responsible for scientific breakthroughs. In confirmation of this theory, examples are often cited of outstanding scientists who made revolutionary discoveries at an early age: for example, Einstein (who discovered the theory of relativity at the age of 26), Newton (who began working on the theory of universal gravitation aged 24) and Darwin (who developed the theory of evolution at 29) (Zuckerman and Merton 1973, after Cole 1979). Zuckerman's (1996, after Wray 2003) analysis of the age of Nobel Prize winners did not confirm the dominance of "youth" among the most creative scientists, but indicated the age group 40-44 as containing the most outstanding scientists. It seems to be the career mid-point that is the most "prolific" period in the life of an academic. Kyvik (1990) determines the peak of research activity to fall within the age range 45-49 and highlights a sharp drop in productivity in the sixties.[2] Similarly, Cole (1979) shows that research productivity gradually increases up to the age of about 45 and then begins to decrease gradually. Gingras et al. (2008) confirm that an academic's productivity increases until around the age of 50 (the most rapid growth occurring between the beginning of the academic career and around 40 years

[2]Meanwhile, Kyvik notes that the so-called life cycle of an academic and his or her publishing activity is strongly determined by the represented academic field: 'In fields where the production of new knowledge is fast and where new scientific methods and equipment are continuously introduced, researchers may have problems coping and thus become obsolescent. In fields where knowledge production occurs at a slower pace, e. g. the social sciences and the humanities, faculty may be productive throughout their careers' (p. 37). Similar conclusions have been formulated by other authors – see e.g. Błocki and Życzkowski 2013.

old), but they also highlight another issue, which has so far been overlooked. After the age of 50, there is indeed a decline in publishing activity (or its relative stability), but an increase in the quality of publications is also observed (assuming as a measure of quality the inclusion of articles in leading journals and the average number of citations per article). However, research conducted with Norwegian academics has shown that, on average, those aged 50-59 have the highest productivity. Perhaps surprisingly, the largest number of citations relates to female academics at the beginning of their careers (under 30 years old) and men aged 40-49 (Aksnes et al. 2011). While conclusions about the relationship between the quality and recognition of published work (measured by number of citations) are not clear, analysis of the relationship between research productivity (measured by number of publications) and age seems to indicate the existence of a research activity development path, also known as the life cycle of the academic (Levin and Stephan 1991), whereby involvement in research activities increases with age, reaches a climax at a certain point, then slowly decreases (see e.g. Aksnes et al. 2011, Crespi et al. 2011). Studies also suggest that research productivity increases with advancement in the academic hierarchy. On average, a female professor publishes double what a PhD student publishes; for men, the difference is threefold.

These conclusions are confirmed by research conducted with Polish academics. The percentage of the most productive academics (publishing more than six articles per year) is the highest among professors (25.3%) and associate professors (19.1%), with 11.4% among doctors, and just 6.7% among respondents with no academic title. The opposite trend is observed for the least productive scientists (publishing one or fewer articles per year) – the percentage decreases going up the academic hierarchy, with the highest rates among respondents with no academic title (23.4%), followed by doctors (13.7%), associate professors (4.1%) and professors (6.2%) (Szprot 2014, p. 82).[3]

In addition, a more detailed analysis showed that the prospect of promotion is responsible to a large extent for fluctuations in research productivity over time (Tien and Blackburn 1996). In the first period after promotion, when motivation to get promoted disappears, there follows a decrease in productivity; in the following years, when the vision of the next promotion becomes more real, an increase in publishing activity is observed.[4] Meanwhile, those who do not receive promotions within the academic hierarchy at the expected time note a significantly lower level of research productivity than their colleagues who are "following the academic path on time."

The topic of promotions in the context of research productivity is part of the broader discussion on motivation to undertake academic research. Two types of motivation are commonly mentioned in the literature: intrinsic motivation, which results from the researcher’s curiosity and desire to discover the truth, and extrinsic motivation, also referred to as instrumental

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[3] According to data contained in *Strategii rozwoju szkolnictwa wyższego w Polsce do 2020 roku* [the Strategy for the development of higher education in Poland by 2020], produced by Ernst & Young Business Advisory and the Institute of Market Economics Research, the average number of academic publications in Poland is almost five times less than the number of FTE academic staff, which translates to approx. 0.2 publications per year per academic (2010, p. 31).

[4] The authors (following Bayer and Smart 1991) found the average time taken to obtain a promotion for an assistant professor or associate professor to be six years. It should be noted that this situation is somewhat different in Poland. Studies conducted with subjects who reached doctoral level between 1990 and 2007 showed that the rate of achieving habilitation after receiving a PhD varies between different academic fields, ranging from 10.5 years for representatives of the medical sciences to an average of 15 years for representatives of the technical sciences. Furthermore, in all disciplines, the time between PhD and habilitation is significantly shorter for men than for women (Batorski, Bojanowski and Czerniawska 2010, pp. 35-36).

motivation. Levin and Stephan (1991) argue that young academics are initially focused on building their reputation at the university (through academic achievements – publications, research etc.), and later in their careers they use their expertise to reach out to industry and reap its tangible (including financial) benefits. According to this assumption, it could be expected that, along with increasing age and achievements in one's academic career, there is also an increase in involvement in activities related to cooperation with one's surroundings: business consulting, implementation of commissioned research, the commercialization of intellectual property in the form of patent sales, licencing and the establishment of spin-off companies. D'Este and Perkmann (2010) observed among a sample of British academics that age is negatively correlated with involvement in joint research and consultative work.[5] Interestingly, Crespi et al. (2011) did not confirm the relationship between age and knowledge transfer activity, with two exceptions: the foundation of spin-off companies, and cooperation in doctoral studies, where a positive relationship was observed. However, studies of Danish academics showed that younger workers, much more often than their older colleagues, recognise the transfer of personnel as an important channel for knowledge transfer, which should be associated with the increased mobility of younger people (Bekkers and Bodas Freitas 2008, p. 1845). Much firmer conclusions were made in relation to the associations between professor status and the activity of academics. In both studies there was a fairly strong positive relationship for joint research, consultancy, the implementation of commissioned research (D'Este and Perkmann 2010, Crespi et al. 2011), cooperation in doctoral studies and the establishment of spin-off companies (Crespi et al. 2011).

Although the "age" and "position in the academic hierarchy" variables are usually analysed on an individual level, it is also interesting to examine the "age structure" and "academic/ professional structure" of a unit in the context of its achievements in knowledge transfer. One of the few studies on this topic is that of Bonaccorsi and Daraio (2003), who observed a negative relationship between the average age of academics in a given unit and that unit's research productivity. This correlation was much stronger (and always statistically significant) in the case of geology, chemistry and physics, while in the case of engineering, medical sciences and agriculture, the correlation was weak (negative) and was not statistically significant. According to the authors, academics representing the more applicable sciences (engineering, medicine and agriculture), oriented towards the external surroundings (industry, patients), and in which practical experience plays an important role, are able to maintain their research productivity at a more constant level in contrast to the other sciences. Bonaccorsi and Daraio also highlight the fact that the negative correlation observed between the average age of a unit's employees and research productivity does not necessarily mean that older academics are generally less productive. Units with a high average age of employees are generally departments with a low proportion of young scientists, a stable personnel system and "low turnover" of employees. The

[5] D'Este and Perkmann (2010) conducted a study on a group of 1,528 British academics (a sample of 4,337 people, with a 35% questionnaire return rate) who won grants from the UK Engineering and Physical Research Council (EPSRC) between 1999 and 2003. The academics represented the sciences and technical sciences: chemistry, computer science, physics, mathematics, mechanical engineering, aviation and manufacturing, chemical engineering, civil engineering, electrical and electronic engineering, and general metallurgy and materials engineering. From the group of 1,528 academics examined by D'Este and Perkmann, Crespi et al. (2011) took 660 academics (representing only four areas of science: chemistry, computer science, physics, and mechanical engineering, aviation and production engineering) and conducted an in-depth study. They analysed the relationship between patent activity and other knowledge transfer activities for a group of 157 academics (questionnaire return rate of 26%, final sample limited to 157 people).

authors treat the average age of a unit's employees as a sign of its appeal to potential job candidates, a measure of "academic vitality" and the ability to attract new staff.

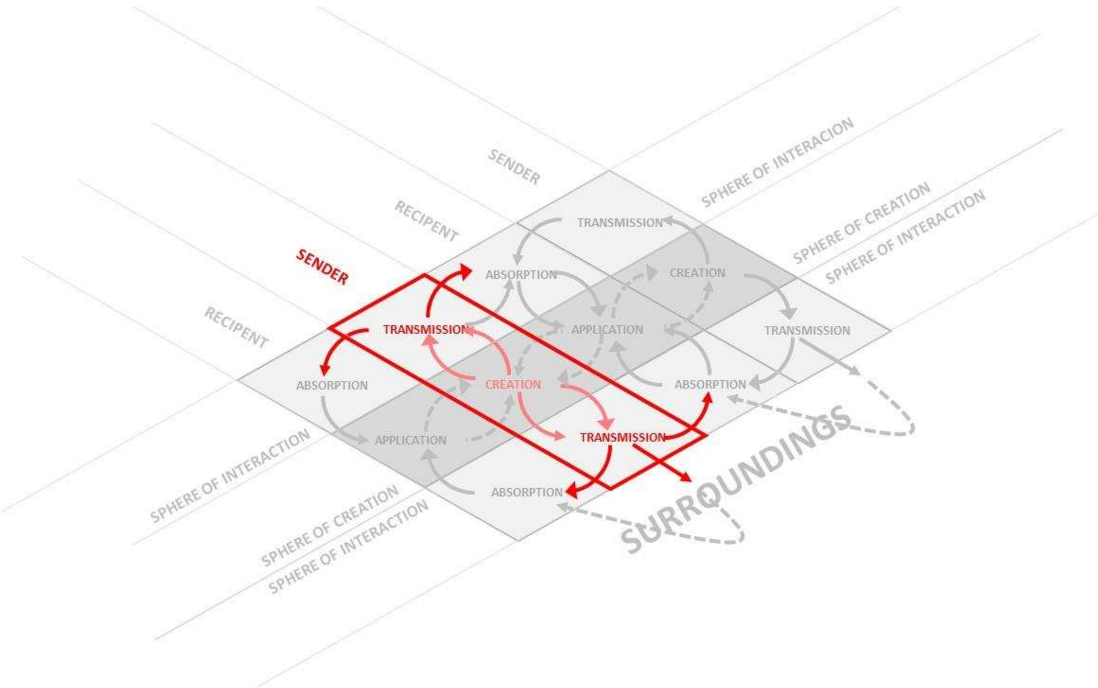
Accordingly, the following hypothesis is proposed:

> *Hypothesis 3b: The greater the proportion of professors in a department's employment* structure, the greater the publication and conference activity of the unit, and the lower the range of activities within the channels associated with the commercialization of knowledge (in the form of patents and licences).

3. Method

The term **knowledge transfer activity** is understood here as the activity of a unit in the production and transmission of knowledge to the surroundings (Figure 1).

Figure 1 Aspects of knowledge transfer analysed in the paper



Source: Dąbrowska 2015, p. 66.

It is assumed that this process includes the following channels of knowledge transfer:

- **education** (the didactic process implemented through higher education),
- **training** (postgraduate studies),
- **publishing** academic papers,
- **conferences** (organization and participation),
- participation in **networks** (research and scientific),
- **commercialization of intellectual property** (through the sale of patents, licences, implementations),
- conducting **joint research, commissioned research and consultancy**,
- **personnel transfer** (exchange of employees, internships, personnel mobility programmes),
- **spin-off company activities**,

- **informal contacts** (Dąbrowska 2015).

Due to the lack of relevant data in the final analysis, three channels of knowledge transfer were not included: personnel transfer, spin-off companies and informal contacts; commissioned research and consultancy were treated as one channel, and joint research was included indirectly in the commissioned research and consultancy channel, as well as the networks channel.

In the analysis, the division of the relevant channels was made on the basis of the legitimacy of the criterion in the academic tradition (traditional and "new" channels) and the relationship to the mission of the university (channels associated with a research mission as opposed to a teaching mission) (**Błąd! Nie można odnaleźć źródła odwołania.**).

Table 1 Typology of knowledge transfer channels

PLACE IN ACADEMIC TRADITION	traditional channels	CONFERENCES PUBLICATIONS NETWORKS	EDUCATION
	“new” channels	COMMERCIALIZATION OF INTELLECTUAL PROPERTY AND IMPLEMENTATIONS COMMISSIONED RESEARCH AND CONSULTANCY	TRAINING
		research mission	teaching mission
		RELATIONSHIP TO THE UNIVERSITY’S MISSION	

Source: own research.

The basic organizational unit of the university was taken as the unit of analysis. In accordance with the Act of 27 July 2005 of the Law on Higher Education, this term should be understood as the ‘faculty or other organizational unit of the university specified in the statutes, leading at least one field of study, doctoral studies or research in at least one academic discipline’ (Journal of Laws 2005 No. 164, item 1365, art. 2, para. 1, point 29).

The **Masovian voivodeship** was taken as the research area. In the broad sense of innovation, research and development potential, and higher education, Masovia is the clear leader of all the Polish regions (Płoszaj 2012). In 2012, the Masovian voivodeship dedicated almost 40% of its expenditure to research and development activity in Poland, 30% of employees to R&D; over 25% of all units were research active, as were nearly 40% of all academic and research and development units (Nauka i Technika [Science and Technology] in 2012, Local Data Bank, Central Statistical Office). In the context of the current analysis, this leads to the belief that **the scale of the analysed phenomenon of the activity of a university in the knowledge transfer process will be greatest in the Masovian voivodeship**. The analysed group of the basic organizational units of universities includes 145 basic organizational units belonging to 29 universities, mostly located in Warsaw (90%), representing both public (80%) and private (20%) universities, and three broad academic groups: science, technical sciences and life sciences (46%), humanities and social sciences (44%) and the arts (10%).

The sources of data on the activity of the units were:

- academic surveys from individual units covering the period 2005-2009, obtained from the Information Processing Centre with the permission of the Ministry of Science and Higher Education (a prerequisite when applying for a grant based on statutory activity),
- data obtained directly from the organizational units of the universities and from the relevant ministries managing the universities,
- publicly available data from the POL-on database, the Polish Accreditation Committee and the official websites of individual units.

To assess the level of activity of a university in the knowledge transfer process, synthetic measures were used, constructed according to an unmodelled method, on the basis of the average of the normalized values of the input variables (Strahl 2006, p. 161). The synthetic index was constructed based on the arithmetic mean, assuming equal weighting for each knowledge transfer channel. The detailed indicators used for the construction of the synthetic indicators of a unit's activity within the individual knowledge transfer channels are presented in Appendix 1.

The factors potentially differentiating between the activity of university's in the knowledge transfer process were selected based on the analysis of the literature. These included:

Table 2 Factors selected for the analysis of the activity of universities in the knowledge transfer process and their operationalization

FACTORS and their operationalization	
type of university	two types of university: public and private
academic field	three academic groups: sciences, technical sciences and life sciences; humanities and social sciences; the arts 22 specific academic fields according to the classification used in the parametric evaluation system (Appendix 2)
human potential	employment in R&D four sizes: small units (fewer than 30 FTE employees), average units (30-70), large units (70-120), and very large units (above 120).[6]
infrastructural potential	gross value of fixed assets
financial potential	internal expenditure actually incurred for R&D revenues from R&D
employment structure	proportion of women on the staff proportion of professors on the staff proportion of assistant professors on the staff

Source: own research.

In order to identify the factors determining a university's activity in the knowledge transfer process, the following statistical methods were used: t test for independent samples, one-way ANOVA and Pearson's correlation (pair and partial correlations).

4. Analysis, results and discussion

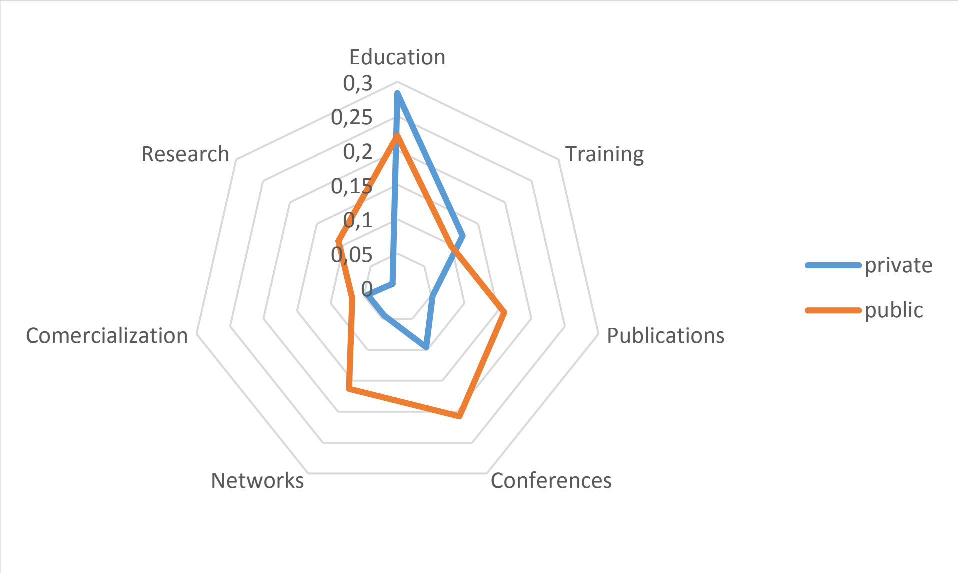
The evaluation of the importance of individual factors in a university's activity in the knowledge transfer process comes down to two main questions: manner of involvement in the knowledge transfer process (HOW?) and intensiveness of this activity (HOW MUCH?).

4.1.Type of university

[6] Division into size groups was done using natural breaks while striving for the closest possible group sizes.

On average, public universities have a higher level of activity in all knowledge transfer channels apart from those channels associated with educational activity – EDUCATION AND TRAINING (Chart), which are the domain of private universities. The expected higher activity of private universities in the so-called "new" channels (COMMISSIONED RESEARCH AND CONSULTING, and COMMERCIALIZATION OF INTELLECTUAL PROPERTY AND IMPLEMENTATIONS), which results from the often highlighted market orientation and business strategy (Thieme 2009), is not confirmed in the current research.

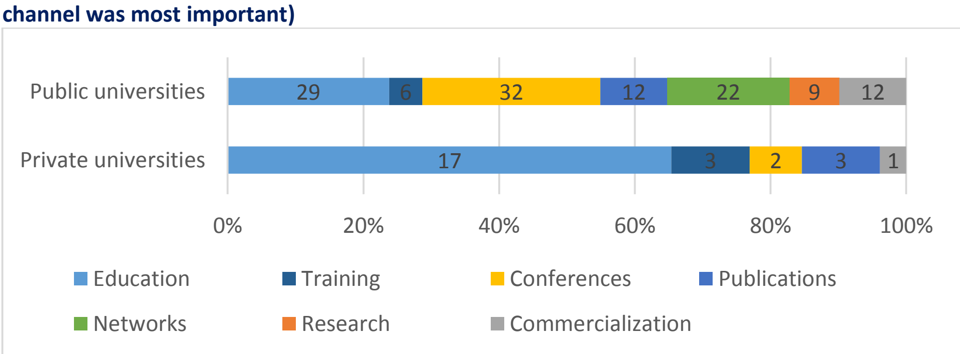
Chart 1 Activity in knowledge transfer (average values of sub-synthetic indicators) by type of university



Source: own research.

The specific activity of private universities is based mainly on the concentration of activity in educational channels. At 65%, the channel dominating general activity is EDUCATION, with the next 12% representing TRAINING (Chart).[7] For public universities, the most frequently dominating knowledge transfer channels were CONFERENCES (26.9%) and EDUCATION (24.4%), while the least frequent was TRAINING (5.0%).

Chart 2 Most important knowledge transfer channels by type of university (share and number of units for which the given channel was most important)



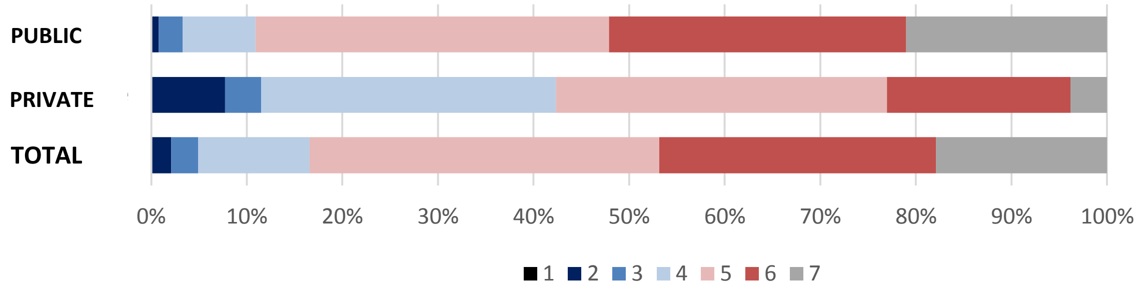
Source: own research.

Furthermore, public universities undertake more diverse activity in the knowledge transfer process, i.e. on average, they are involved in more knowledge transfer channels than private

[7] It was decided that the dominating knowledge transfer channel is the one with highest value of the sub-synthetic indicator, out of the seven values constituting the synthetic indicator of knowledge transfer. For this purpose, the sub-synthetic indicators have been normalized to allow the assumption of a value in the range 0-1.

universities. Almost 90% of public universities are active in at least five knowledge transfer channels, while the number of private universities for which this is the case is below 60% (Chart).

Chart 3 Involvement of universities in activity according to number of knowledge transfer channels used, divided into public and private universities (N=145, unit share)

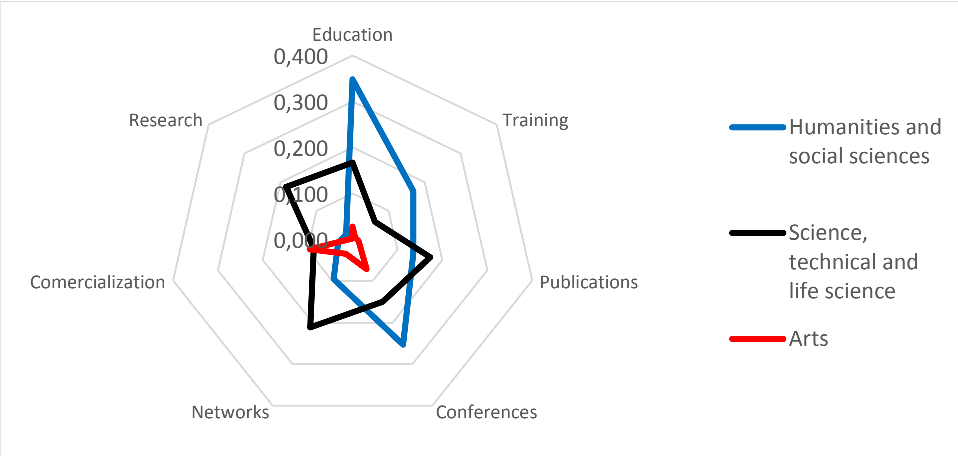


Source: own research.

4.2.Academic discipline

Another factor strongly differentiating between the activities of different units in terms of knowledge transfer is the represented academic field. While the different types of universities presented strong differences in the **level of activity** (on average, public universities were more active in all knowledge transfer channels, with the exception of EDUCATION and TRAINING), the main difference between units representing various academic groups and fields is in the **manner of involvement** in the knowledge transfer process. Specifically, this concerns the two main academic groups: humanities and social sciences (HS) and science, technical sciences and life sciences (ST+L). The most important channels in the HS group are EDUCATION, TRAINING, and CONFERENCES, whereas the activity of the ST+L group focuses on COMMISSIONED RESEARCH and NETWORKS (Chart). The greater activity of units in the ST+L group in the PUBLICATIONS channel is also noteworthy. The causes of this situation include the higher internationalisation of the sciences (and consequentially greater potential for publishing activity) (Diagnoza obszaru metropolitalnego Warszawy [Diagnosis of the Warsaw Metropolitan Area] 2014, p. 358). The activity of units representing art fields clearly departs from that of the HS and ST+L groups, but this does not necessarily mean that these units are less involved in the knowledge transfer process. It must be remembered that artistic units have a completely different operating profile than units operating in other groups of sciences and that the criteria applied to the evaluation of a university's activity would not take the specifics of its operations under much consideration. Nevertheless, it is noteworthy that there is relatively high activity of artistic units in the COMMERCIALIZATION channel, which may stem from the fact that activity in the field of copyrights is beneficial in charging for access to these copyrights.

Chart 4 Knowledge transfer activity (average values of sub-synthetic indicators) and affiliation to academic groups

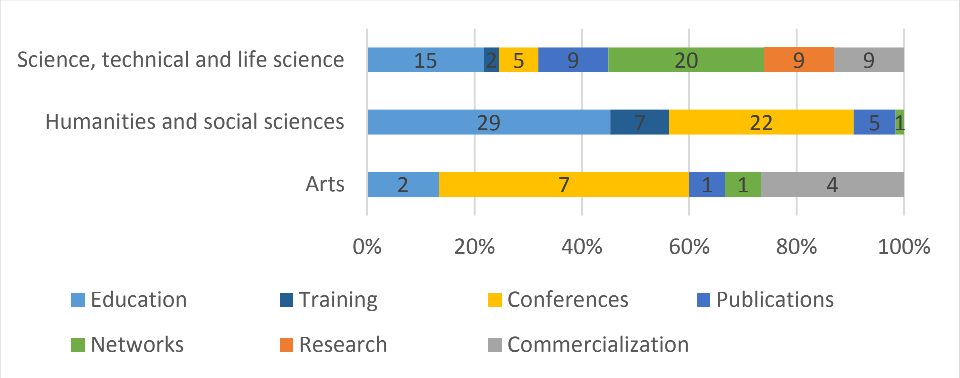


Source: own research.

The different specifics of the operations of units representing various academic groups are confirmed in the results of the analysis of the dominating knowledge transfer channels. EDUCATION was most frequently the main transfer channel for the humanities and social sciences (in 45.3% of cases), followed by CONFERENCES (in 34.3% of cases) (Chart). It should also be noted that, in the case of units for which the most important channel was TRAINING, the value of this indicator is very high (0.74). The values of average indicators in the EDUCATION and CONFERENCES channels are also relatively high, while units with different dominating knowledge transfer channels achieved very low values of the indicator (0.15), so as a rule they were not active in the field of knowledge transfer. The units in the group of science, technical sciences and life sciences presented the greatest diversity in dominating channels. The most frequent were NETWORKS (in 30.3% of cases) and EDUCATION (in 22.7% of cases). It should be noted that, as a rule, units from this academic group show high activity in the knowledge transfer process. Furthermore, all nine units for which the most important channel was COMMISSIONED RESEARCH AND CONSULTING ACTIVITY, were public universities in the science, technical sciences and life sciences group. The relatively minimal role of the COMMERCIALIZATION channel in the arts should also be noted, which is confirmed by the number of units for which this channel was dominant (4/15, which is a high result in comparison with other academic groups), the average value of the indicator (0.32), and the popularity of the channel's use (60% of active units).[8] In the case of arts universities, the commercialization of intellectual property is mainly visible in the sales of copyrights for creative products.

[8] The rating of the channels' popularity aimed to address the question of which knowledge transfer channels are used by all or most of the analysed entities, and which have a more selective nature.

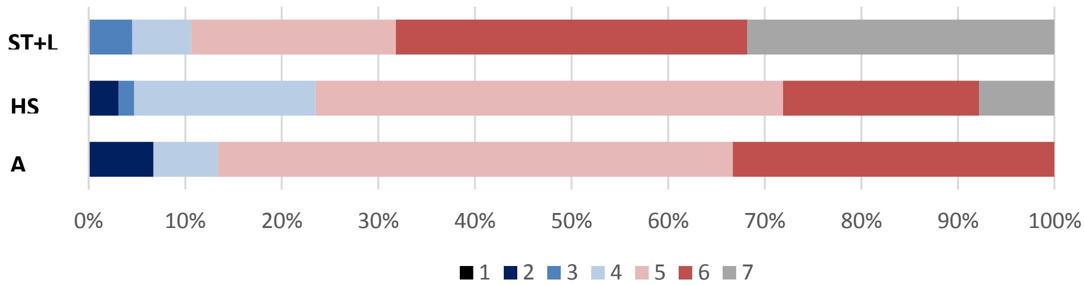
Chart 5 Most important knowledge transfer channels and academic fields (share and number of units for which the given channel was most important)



Source: own research.

Units from the science, technical sciences and life sciences group also undertake more diverse activity. Almost 70% of these units are active in at least six channels, while the proportion of units in the humanities and social sciences group is below 30% (Chart).

Chart 6 Involvement of the university in activity according to number of knowledge transfer channels used, divided into academic groups (N=145, unit share)



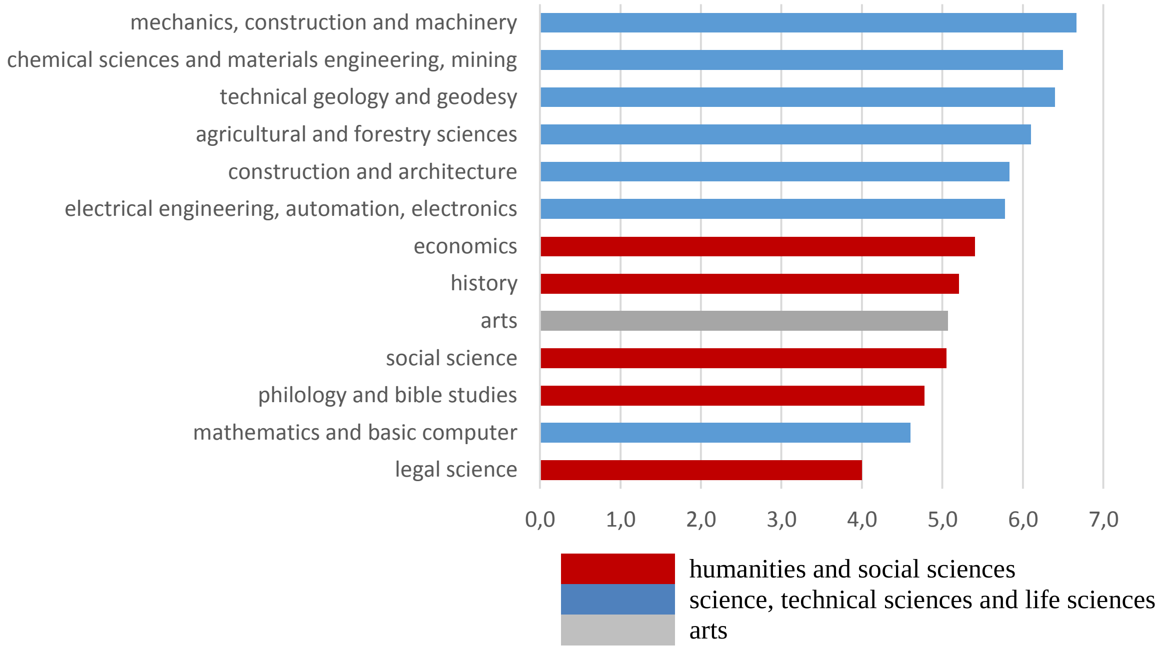
where:

ST+L – science, technical sciences and life sciences
HS – humanities and social sciences
A – arts

Source: own research.

The most "versatile" units are dominated by those representing narrow fields of science: mechanics, construction and machinery (activity in 6.7 channels), chemical sciences and materials engineering (6.5), and mining, technical geology and geodesy (6.4), which are in the group of science, technical sciences and life sciences (Chart). In the group of humanities and social sciences, the greatest diversity of undertaken activity is presented by economic (5.4) and historical (5.2) units.

Chart 7 Average number of knowledge transfer channels used according to narrow fields

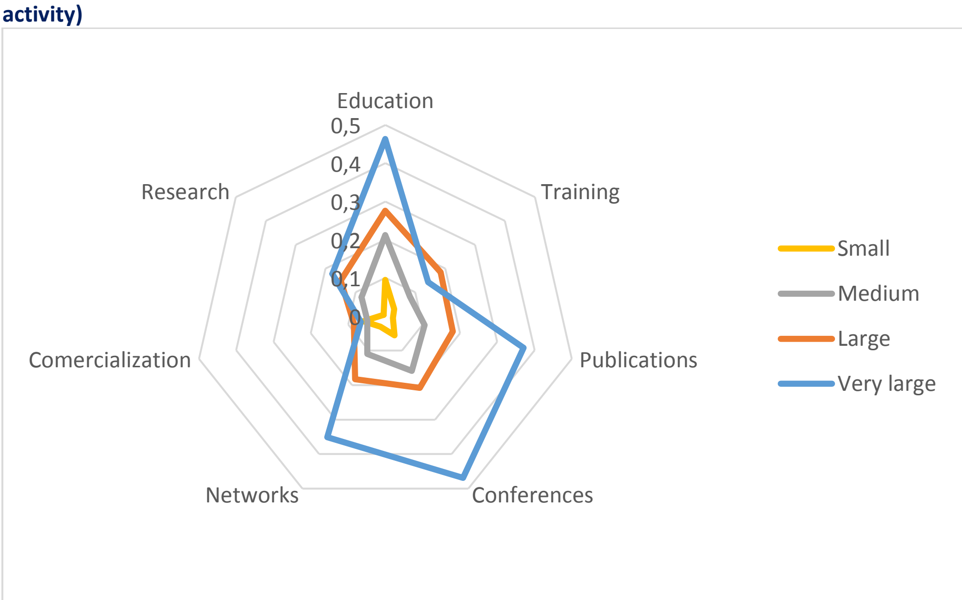


Source: own research.

4.3.Unit size (human, financial, and infrastructural potential)

Larger units generally show greater activity in all channels, which seems natural. This trend is broken by very large units, which were found to be less active than large units in the TRAINING and COMMERCIALIZATION channels (Chart).

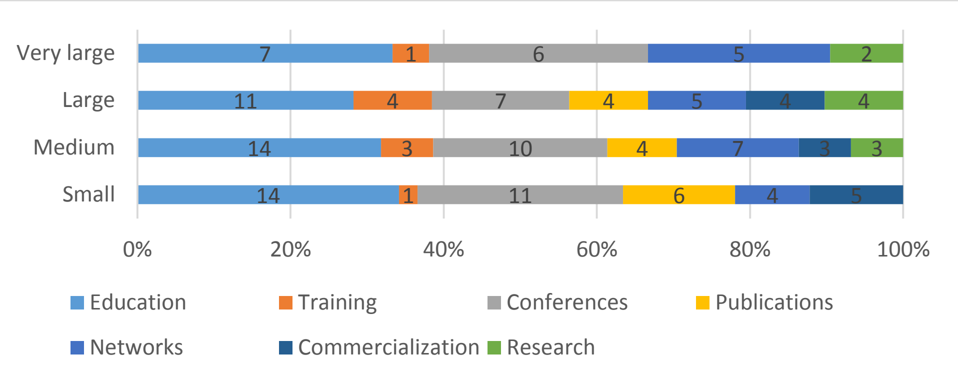
Chart 8 Knowledge transfer activity (average values of sub-synthetic indicators) and size of units (employment in R&D activity)



Source: own research.

Meanwhile, there are no significant differences observed between the size of the unit and the knowledge transfer channel dominating its activity. The analyses of four unit size groups (small, medium, large, and very large) did not reveal any considerable differences in this variable (Chart). EDUCATION was found to be the most important channel for roughly 30-35% of the units, regardless of size. On the other hand, approximately 10% of units are dominated by activity associated with commercial knowledge application, i.e. COMMISSIONED RESEARCH AND CONSULTING ACTIVITY and COMMERCIALIZATION AND IMPLEMENTATIONS. Large units are an exception in this case as their share is 20%.

Chart 9 Most important knowledge transfer channels and size of units for which the given channel was most important)



Source: own research.

Extensive analysis of the unit size relationship (understood as human potential and measured by number of R&D employees) showed a strong correlation with general activity in the knowledge transfer process and with activity in individual channels (from 0.21** in COMMISSIONED RESEARCH AND CONSULTING ACTIVITY to 0.85** in PUBLICATIONS) (Table). The only exception here is activity in COMMERCIALIZATION. There are no observed relationships between employment volume and the effectiveness of the activity of individual units (Table).[9] The undisputable advantage of larger units over smaller ones in relation to knowledge transfer is a natural consequence of their size, and is not necessarily the result of more effective operations.

A unit's financial potential is determined on the one hand by INPUT statistics (expenses for R&D activity) and on the other by OUTPUT statistics (revenue from R&D activity). The differences between the obtained results are minimal. A unit's financial potential is positively correlated with the general activity indicator (0.28**) and sub-synthetic indicators for the following channels: NETWORKS (0.53**), COMMISSIONED RESEARCH (0.42**), and PUBLICATIONS (0.35**). One seemingly interesting aspect, especially in the context of the state policy on science, is the question of whether the increased expenses for research and development activity go hand in hand with increased effectiveness of a unit's activity. The current research only confirms this dependency for the NETWORKS (and COMMISSIONED RESEARCH channels (0.25** and 0.33**, respectively). Meanwhile, there is a negative correlation between effectiveness in EDUCATION (-0.21*) and expenses for R&D activity. It should be noted that effectiveness in the education channel means de facto educational burden on the employees, which means that higher expenses for R&D activity do not go hand in hand with a lower educational burden. It is difficult to interpret the obtained results in an unambiguous way. This observation could be explained by the fact the additional expenses for R&D activity allow an increase in the number of people employed at the unit and consequentially reduce the educational burden.

However, the unit size is also determined by the infrastructural potential, measured by the value of fixed assets. The general activity of a university in the knowledge transfer process is

[9] Effectiveness of activity is measured as activity per employee.

positively correlated with the infrastructural potential, as measured in this way (0.24**). Assuming that the volume of fixed assets is the value of expenses made mainly for the purchase or production of scientific apparatus for research and development, a positive relationship can be expected between the units' infrastructural potential and their activity in the so-called new channels, which are mainly associated with the commercial use of knowledge relating to COMMERCIALIZATION OF INTELLECTUAL PROPERTY AND IMPLEMENTATIONS and COMMISSIONED RESEARCH. The current analysis does not confirm this dependency; in fact, it suggests positive relationships with activeness in the PUBLICATIONS (0.43**), NETWORKS (0.38**) and CONFERENCES (0.25**) channels (Table). Simultaneously, there is no observation of dependency between the infrastructural potential and effective activity of the units (Table).

Table 3 Factors differentiating between the activity of units in the knowledge transfer process – unit size

		TOTAL ACTIVITY	EDUCATION	TRAINING	CONFERENCES	PUBLICATIONS	NETWORKS	COMMERCIALIZATION	RESEARCH
unit size	**Human potential** employment in R&D activity (zatrBR)	+ **0.73**	+ **0.36**	+ **0.22**	+ **0.63**	+ **0.85**	+ **0.69**		+ **0.21**
	Financial potential expenses for R&D activity (nak_BR)	+ **0.28**				+ **0.35**	+ **0.53**		+ **0.42**
	Financial potential expenses for R&D activity (nak_zatr)		- 0.17						
	Financial potential revenue from R&D activity (przych_BR)	+ **0.32**				+ **0.36**	+ **0.50**		+ **0.40**
	Financial potential revenue from R&D activity (przych_zatr)								
	Infrastructural potential fixed asset value (srodk_trw)	+ **0.24**			+ **0.25**	+ **0.43**	+ **0.38**		
	Infrastructural potential fixed asset value (srodktrw_zatr)								

Significant correlation at 0.01 Significant correlation at 0.05

Source: own research.

Table 4 Factors differentiating between the effectiveness of units in the knowledge transfer process – unit size

		TOTAL ACTIVITY	EDUCATION	TRAINING	CONFERENCES	PUBLICATIONS	NETWORKS	COMMERCIALIZATION	RESEARCH
unit size	**Human potential** employment in R&D activity (zatrBR)				- 0.19				
	Financial potential expenses for R&D activity (nak_BR)		- 0.21				+ **0.25**		+ **0.33**
	Financial potential revenue from R&D activity (przych_BR)						+ **0.24**		+ **0.29**
	Infrastructural potential fixed asset value (srodk_trw)								

Significant correlation at 0.01 Significant correlation at 0.05
Source: own research.

In conclusion, the results of the analysis of the importance of a unit's size show that the strongest relationship for activity in the knowledge transfer process is with human potential, while the relationship is weaker with financial and infrastructural potential. Simultaneously, the suggested scale effect, i.e. the effective activity of a unit increasing with its size, is unconfirmed. The only exception here is activity in NETWORKS and COMMISSIONED RESEARCH.

4.4.Employment structure (gender/job)

The current analysis indicates that there is a relationship between employment structure and the synthetic indicator of the unit's general activity in the knowledge transfer process (Table) and between employment structure and the sub-synthetic activity indicators of the individual knowledge transfer channels. Firstly, a positive relationship is observed between the proportion of women on the staff and activity in EDUCATION and CONFERENCES, while a negative relationship is found between the proportion of women on the staff and involvement in COMMISSIONED RESEARCH AND CONSULTING ACTIVITY. Staffs dominated by women are also more effective in CONFERENCES and less effective in COMMERCIALIZATION OF INTELLECTUAL PROPERTY and COMMISSIONED RESEARCH AND CONSULTING ACTIVITY. However, the presented results fail to provide grounds for declaring that women are either superior or inferior in research and development productivity (for example that, on average, a female scientist produces more/fewer publications or creates more/fewer patents). In this case, the determinant is the represented field of science and the willingness of both women and men to take academic paths in relation to certain academic disciplines. In science, there is a lower proportion of women in technical and engineering fields (see Bourdieu 2004, after Młodożeniec and Knapińska 2013), which are clearly more active than humanities and social science units in knowledge transfer channels such as COMMISSIONED RESEARCH AND CONSULTING ACTIVITY and COMMERCIALIZATION OF INTELLECTUAL PROPERTY AND IMPLEMENTATIONS, but less active than humanities and social science units in EDUCATION, TRAINING or CONFERENCES.

A negative correlation is also observed between the proportion of professors among all employees and the unit's activity level (as well as activity in PUBLICATIONS, NETWORKS and COMMISSIONED RESEARCH AND CONSULTING ACTIVITY). This dependency is associated with a positive correlation between the proportion of assistant professors among all employees and the unit's activity in the knowledge transfer process (including activity in the following individual knowledge transfer channels: CONFERENCES, PUBLICATIONS, NETWORKS, and COMMISSIONED RESEARCH AND CONSULTING ACTIVITY). The analysis of the effectiveness of the activity undertaken (e.g. for PUBLICATIONS – research productivity) provides almost the opposite conclusions. The units with a higher proportion of assistant professors among all employees are less effective (with the exception of effectiveness in PUBLICATIONS and COMMISSIONED RESEARCH AND CONSULTING ACTIVITY) (Table). It seems that these conclusions contradict each other only on the surface, as the most important thing in this case is the dependence between the employment structure and the unit's size. A negative correlation is observed between the proportion of professors among all employees and the size of the unit, as measured by the number of employees (-0.31**), while a similarly positive correlation is observed in the case of assistant professors (0.32**). This means that smaller units (with a greater proportion of professors and smaller proportion of assistant professors than larger units) will be less active in the field of knowledge transfer, because the level of activity is determined mainly by the unit's size (correlation of 0.73**). Simultaneously, said smaller units will likely be more effective in their activity, since a smaller proportion of assistant professors is accompanied by activity that is more effective. The explanation for this phenomenon may lie in the theory of accumulated resources, or once again in the "Matthew effect", according to which experience, esteem among scientists and access to required resources increases with age, resulting in increased research and development productivity.

Table 5 Factors differentiating between the activity of units in the knowledge transfer process – employment structure

		TOTAL ACTIVITY	EDUCATION	TRAINING	CONFERENCES	PUBLICATIONS	NETWORKS	COMMERCIALIZATION	RESEARCH
employment structure	Proportion of females on the staff (fem)		+ 0.20		+ 0.17				**- 0.24**
	Proportion of professors on the staff (str_prof)	**- 0.22**				**- 0.24**	**- 0.25**		**- 0.22**
	Proportion of assistant professors on the staff (str_adiunkt)	**+ 0.33**			+ 0.20	**+ 0.39**	**+ 0.34**		**+ 0.33**

Significant correlation at 0.01 Significant correlation at 0.05

Source: own research.

Table 6 Factors differentiating between the effectiveness of units in the knowledge transfer process – employment structure

		TOTAL ACTIVITY	EDUCATION	TRAINING	CONFERENCES	PUBLICATIONS	NETWORKS	COMMERCIALIZATION	RESEARCH
employment structure	Proportion of females on the staff (fem)				+ 0.17			**- 0.25**	- 0.21
	Proportion of professors on the staff (str_prof)		+ 0.38						
	Proportion of assistant professors on the staff (str_adiunkt)		**- 0.29**	- 0.16	- 0.20	+ 0.17		- 0.18	**+ 0.25**

Significant correlation at 0.01 Significant correlation at 0.05

Source: own research.

5. Conclusions

The expectations addressed towards universities in the public debate are largely focused on the role of universities as a source of technology and innovation. The instruments of regional policy in Poland relate mainly to strengthening the cooperation between academia and business; the commercialization of research in the form of the sale of patents, licencing and spin-off companies is synonymous with this cooperation. Meanwhile, the results of numerous studies show that, in the opinion of entrepreneurs, the commercialization of intellectual property is not the most important channel for the transfer of knowledge from universities (cf. Agrawal and

Henderson 2002, Arundel and Geuna 2004, Bekkers and Bodas Freitas 2008, Cohen et al. 2002, Colyvas and al. 2002, D'Este and Patel 2007). Of much greater importance are publications, conferences, meetings and informal contacts, which are often the starting points for more formalized cooperation.

The result of the emphasis on the importance of the commercialization of intellectual property in the public debate is the gradual depreciation in the value of basic research (with no direct practical application). The importance of the humanities and social sciences (which function in the universal consciousness as "detached from practice") is also brought into question. The strengthening of such thought patterns may ultimately contribute to an actual reduction in the activity of these "potentially useless" disciplines (including through the reduction of funding sources), resulting in a reduction of the real impact of universities on the development of the region.

Decision makers should focus on supporting not only the science and technology units, which are generally regarded as being naturally suited to strong relationships with their surroundings, but also units representing the humanities and social sciences, since, as shown by the current analysis, they are **not** characterized by **lower**, but simply by **different activity** in the knowledge transfer process.

The assumption that both humanities and social science units and science and technical units are important in the diffusion of knowledge and regional development, as well as the observation that both types of units are characterized by different operational specifics, implies the need for differentiated methods of support for these units (cf. Perkmann et al. 2013). This will allow the full usage of the potential offered by the different types of units.

6. Appendix

Appendix 1 Indicators used to build the synthetic structure of a university's activeness in the knowledge transfer process (for the period 2005-2009)*

<table>
<tr><th rowspan="2">KNOWLEDGE TRANSFER CHANNEL</th><th colspan="4">VARIABLES AND INDICATORS</th></tr>
<tr><th>VARIABLE</th><th>INDICATOR</th><th>SOURCE</th><th>DATA TIME FRAME</th></tr>
<tr><td>EDUCATION</td><td>Graduates of first and second degree studies</td><td>Number of graduates of first and second degree full time and part time studies in the 2009/2010 academic year</td><td rowspan="2">Data obtained directly from the appropriate governing ministries (MNiSW, MKiDN) and main organisational units of universities</td><td rowspan="2">2009/2010 academic year</td></tr>
<tr><td>TRAINING</td><td>Graduate students</td><td>Number of graduate students in the 2009/2010 academic year</td></tr>
<tr><td rowspan="3">CONFERENCES</td><td rowspan="2">Organisation of conferences</td><td>Number of international conferences organised by the unit</td><td rowspan="16">2005-2009 research survey of the unit</td><td rowspan="16">2005-2009 average (or respective average for the years in which the unit submitted the research survey)</td></tr>
<tr><td>Number of domestic conferences organised by the unit</td></tr>
<tr><td>Presented reports</td><td>Number of plenary reports presented at international conferences by invited employees of the unit</td></tr>
<tr><td rowspan="4">PUBLICATIONS</td><td>Publications in international magazines with IF</td><td>Number of publications in magazines distinguished by Journal Citation Reports (JCR) and European Reference Index for Humanities (ERIH)</td></tr>
<tr><td>Publications in other foreign magazines and Polish magazines</td><td>Number of publications in reviewed magazines included in the ministry list</td></tr>
<tr><td rowspan="2">Monographs</td><td>Number of monographs and original textbooks in English or the main language for the given discipline</td></tr>
<tr><td>Number of monographs and original textbooks in languages other than English or the main language for the given discipline</td></tr>
<tr><td rowspan="3">NETWORKS +
collective research</td><td rowspan="2">Scientific networks and consortia</td><td>Number of scientific networks in which the unit participates</td></tr>
<tr><td>Number of scientific and industrial consortia in which the unit participates</td></tr>
<tr><td>Scientific organisations and editorial committees</td><td>Voluntary membership in scientific organisations and editorial committees of scientific magazines with global reach (including PAN, PAU)</td></tr>
<tr><td rowspan="5">COMMERCIALIZATION OF INTELLECTUAL PROPERTY AND IMPLEMENTATIONS</td><td rowspan="3">Patents</td><td>Number of patents granted to the academic unit by the Polish Patent Office for applied inventions</td></tr>
<tr><td>Number of patents granted to the academic unit abroad for applied inventions</td></tr>
<tr><td>Number of patents granted to a business unit for applied inventions created by employees of the academic unit</td></tr>
<tr><td rowspan="2">Utility models and industrial models</td><td>Number of protective rights obtained for applied utility models</td></tr>
<tr><td>Number of rights from registration of applied industrial models</td></tr>
</table>

KNOWLEDGE TRANSFER CHANNEL	VARIABLES AND INDICATORS			
	VARIABLE	**INDICATOR**	**SOURCE**	**DATA TIME FRAME**
	Implementations	Number of **implementations** of documented results of academic research and development performed by the unit and applied outside the unit		
	Licences	Number of sold **licences** and know-how		
	Copyrights	Number of entitled copyrights to creative products of an individual nature (specifically relating to architecture, urban planning, industrial design, and the arts)		
COMMISSIONED RESEARCH, CONSULTING ACTIVITY + collective research	**Realised agreements**	Number of realised **agreements** concluded with other units which reached their objective, with a value exceeding PLN 5,000, for the development of new technologies, materials, products, systems, and services		
	Targeted projects	Number of realised **targeted projects**		

Source: own research.

Appendix 2 Science groups and constituent disciplines

HS	**humanities and social sciences**	
	N1	philology and bible studies
	N2	history
	N3	culture, philosophy and theology
	N4	social sciences
	N5	economics
	N6	legal sciences
A	**arts**	
	N14	arts

ST+L	**science, technical sciences and life sciences**	
	G1/N12	chemical sciences and materials engineering
	G2	mechanics, construction and machinery
	G4	construction and architecture
	G5	electrical engineering, automation, electronics and IT
	G6	mining, technical geology, geodesy, energy and transport
	G7	engineering and environmental protection, environmental technologies, agriculture and forestry
	G8	security and other general technical fields
	N7a	clinical research units
	N7b	non-clinical research units
	N8	healthcare and physical education
	N9	biological sciences
	N10	earth sciences
	N11	agriculture and forestry
	N13	mathematics and basic computer studies
	N15	physics and astronomy

Source: own research.

7. References

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