

## THE ASPECTS OF KNOWLEDGE LOGISTICS IN THE PROCESS OF CREATING UNIVERSITY HIGH-GROWTH TECHNOLOGY BUSINESSES. THE CASE OF THE AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

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### Abstract

This paper is about knowledge logistics, the transfer of tangible and intellectual property, expertise, learning and skills between academia and the non-academic community. Innovations are essential for economic growth and development and are major determinants of long-term improvements in income and living standards. Innovation is one of the three elements of the Knowledge Triangle: education, research and innovation. The Knowledge Triangle aims to create an interaction between education, research and innovation thereby creating the conditions for increased relevance and utilization of the universities' activities - the results of their research and developmental work.

Today, no one can imagine building a competitive economy without focusing on the academic community, the achievements of its researchers and PhD students as a basic potential source of new knowledge.

Technology transfer and the commercialization process provide a significant driving force for enhancing economic growth and societal well-being. The transfer of technology and the knowledge passed from academic institutions to businesses and the society in general can take place through various channels, such as education, publications, commissioned research, the flow of personnel, co-operation, licensing and the establishment of new business entities based on academic technology and knowledge, known as university spin-offs.

Such spin-offs are one of the ways of implementing the latest scientific discoveries into industrial practice, and thus building an innovative economy. The goal of universities is to establish efficiently managed, continually developing spin-offs.

The AGH University of Science and Technology is one of the best and most renowned modern Polish universities. The University is an important centre for the development and transfer of innovative technologies. The AGH UST is the leader among institutions submitting the largest number of inventions and utility models (confirmed by annual reports published by the Polish Patent Office).

**Keywords:** Knowledge logistic, knowledge transfer, innovation, technology transfer, spin-off, university of technology, academic entrepreneurship, technology commercialization

### 1. INTRODUCTION

The literature relevant to these issues, in the form of articles and discussions published in periodicals, dedicates much attention to today's economy, and consequently to the conditions that accompany the manufacturing of goods and rendering services in response to the public demand. The term science-based economy, which describes the present stage of economic development, was first used in mid-1980s in OECD publications in the context of a breakthrough within civilisation which meant the substitution of the industrial era for the post-industrial civilisation (at that time only vaguely defined) for. Today we participate in an economy in which the development of countries, regions or organisations depends on the intellectual potential and

knowledge associated with the modern achievements of learning, in particular science and engineering. According to the Austrian economist J.A. Schumpeter in the first half of the 20<sup>th</sup> century, the main links of the contemporary economy are [1]:

- innovations and innovative processes,
- innovative entrepreneurs and the role of new companies in the transfer and commercialisation of technology,
- creative destruction and its economic, structural and social consequences,
- time regularities in technological changes (long prosperity waves - also known as Kondratieff cycles),

The foundation for the development of today's economy is knowledge, and primarily its conversion into new market application relating to products, processes, organisation or marketing (innovations). Innovation is of key importance to economic growth, societal well-being and the development and survival of companies. Innovativeness is one of the most important factors allowing us to achieve a high level of development and competitiveness.

If companies want to develop and survive on an increasingly competitive and demanding market, companies must increase the competitiveness of both their organisation and their offer. The best way to do so is to introduce innovation that is inspired by new knowledge, new technologies or research methods.

At this point it should be noted that an important way of transferring state-of-the-art technology to economic practice is to establish efficiently managed and constantly developed small businesses. Start-ups are businesses established to find a business model that would guarantee their development. S. Blank defines start-ups as experiments, temporary organisations established to search for a reproducible and scalable business model [2]. These businesses also build on new knowledge, advanced technologies and the results of research and development work. Innovativeness of large businesses is no match to that of start-ups. Innovation is created by duly motivated people focused on market success. Fast, entrepreneurial, creative, well-educated and fully committed enthusiasts become leaders of innovative business initiatives: undertakings characterised by great flexibility and acceptance of high risk. It is technological start-ups - often supported by what is known as business angels, i.e., seed funds or venture capital - that introduce innovative solutions, products or business models to the market. Innovative businesses that are being created contribute to fundamental changes in entire sectors or to the formation of new economy sectors.

In view of the above, today's universities are becoming very important places where knowledge and technology of high innovative potential are created. In the relevant literature one can find extensive discussions, as well as scientific research relating to the functioning of universities and institutions of higher learning in general in the post-industrial era. Many modern universities - aware of the changes taking place in their environment - implement fundamental changes in both their strategic endeavours and operational activity. Universities increasingly often depart from their model based entirely on science and tuition, striving instead toward a new model, known as the Third Generation University. In such universities, in addition to traditional goals such as scientific research and education, a third goal emerges, which is the cooperation with industry and the commercialisation of knowledge.

Extensive cooperation between scientists and business makes it possible to shape the added value of ideas, technologies and potential new products. H. Etzkowitz coined a new term, entrepreneurial university, which emphasises even more the new role of academic centres; this term is currently used to describe universities that efficiently implement their third mission, as mentioned above [3]. B.R. Clarke thinks that an entrepreneurial university tries to actively introduce innovations, while striving to make organisational changes and to become a meaningful market player who dictates his own conditions to the market [4]. It is difficult to imagine today's university without an extensive, efficient co-operation with its environment. According to L. Leydesdorff and H. Etzkowitz the model known as "triple helix" is appropriate for innovation: it comprises mutually comprehensive

relations occurring in the creation and transfer of knowledge between three types of entities: scientific centres (universities, research centres and supporting institutions), industry (businesses) and government (including local government institutions) [5]. Among the several models for technology transfer and commercialisation of knowledge that describe ties between the worlds of science and business, there is a network model which is in practice the Knowledge Integration Community (KIC). This community comprises six key nodes that bring together four institutional sectors (Industry, Government, Research and Education) through two binding mechanisms: knowledge exchange and the study of innovations in knowledge exchange [6].

One of the ways that can significantly strengthen the ties between universities and industry is to establish and develop university spin-offs. S. Shane understands university entrepreneurship as precisely the ability to create new undertakings in the form of spin-off businesses [7]. In the literature devoted on this topic, one can find many definitions and interpretations of the term academic entrepreneurship, but most often they focus on issues associated with the creation of new business undertakings conducted on the basis of intellectual property originating from a university, commercialization of knowledge and the transfer of technology as well as establishing businesses known as spin-offs. [8]. The establishment of new business entities that implement intellectual property created at universities is a very dynamic way of developing how to commercialize the results of research and development work (known as indirect commercialization). Observation of the ecosystems of knowledge transfer and commercialization that exist around the best academic centres in the world support the thesis that spin-offs exert a significant influence on regional economic and social development.

The creation of academic spin-offs around universities is considered to be the most innovative mechanism supporting the transfer of technologies originating from scientific communities [9]. However, one should bear in mind the fact - emphasised by researchers and those connected with practice - that commercialization proceeding along this path is a multifaceted complex process with many links and interactions. In this paper, the authors focus on the very process of university spin-off creations and on the challenges that technology transfer centres and university special-purpose companies responsible for the transfer and commercialisation of knowledge are faced with. An attempt was made to direct attention to these issues from the viewpoint of a new approach to the issues of knowledge management described by the term knowledge logistics.

## **2. LOGISTIC ASPECTS OF KNOWLEDGE COMMERCIALIZATION AT UNIVERSITIES**

In the relevant literature, one can find dozens of various definitions of the term "knowledge logistics". The authors of these publications emphasise various aspects of the meaning this word, most often focusing on economic knowledge. The Council of Logistics Management defines logistics as the process of planning, implementing and controlling the efficient and cost effective flow and storage of raw materials, production feedstock, finished goods and related information from point of origin to point of consumption for the purpose of meeting customer requirements [10]. In practice, logistics can be considered in terms of two aspects: systemic (thinking about the whole) and process-related (the principle of flows). Considering the increase in importance of knowledge, it can be noticed that organisations are increasingly focussed on the flow, diffusion and transfer of intellectual property. It is thus justified to strive to optimize these processes from the viewpoint of the organization's goals. In this literature one can find attempts to adapt terms relating to logistics - which were worked out and based on material and physical elements - to the analysis and diagnostics of processes involving the sharing of intangible things and knowledge [11]. Knowledge logistics, as a new approach to issues of knowledge management, can mean supporting the distribution and storage of knowledge, while bearing in mind its flow and idle time.

In the context of changes occurring in the domain of legal regulations pertaining to the functioning of science and academic education, as well as the management of universities, the management of knowledge becomes

of key importance to the academic community. The mission of universities is to create, but also to transfer knowledge. Universities are faced with such organisation of their research (optimization of these processes), that their results can be applied in industry. This is in particular the case of universities conducting research, which are even more open to the business environment and focus on actions aimed at the commercialization of research results.

Among the various paths to such commercialization, spin-off businesses deserve special attention. These technology-related university start-ups are dynamic undertakings, which are based on knowledge, advanced technologies and organizational solutions; they introduce to the market the results of their research and development work done in the academic community. The process of commercialization of scientific discoveries and research results is not an easy task. Scientific research and commercialisation of its results are two entirely separate processes. The first one involves transformation of funds into knowledge, whereas the second one transforms knowledge into funds. A question thus arises, how commercialization of knowledge and technology should be managed by establishing spin-off businesses.

### **3. THE CREATION OF THE UNIVERSITY SPINOFFS - INDIRECT COMMERCIALISATION**

With the emergence of the term “academic entrepreneurship”, which means business activity of the academic community, other new terms were coined, spin-offs and spin-outs. In the relevant literature one can find many definitions of university spin-offs, which are very often mutually contradictory and can make it more difficult to understand this notion unequivocally. A spin-off business is primarily distinguished by the fact that it is established by a scientific worker, PhD student, university undergraduate or graduate who uses the intellectual property developed at his university. These businesses constitute a separate legal entity, but they are characterised by a constant relationship with their university from their very creation.

A spin-off is a new enterprise that was established by at least one university worker, PhD or an undergraduate student and a university’s special-purpose company, with the purpose of joint commercialization of technology. It is thus established to generate profit and commercialize technology. A spin-off business usually has personal, formal, legal and capital ties with the university, which means the close cooperation of both parties [12].

In practice, one can find many factors that describe the motivation to starting this path to commercialization. Spin-offs make it possible to implement and develop inventions and technologies, which might miss their moment if not put into practical use, due to the high uncertainty associated with their implementation and, consequently, a lack of interest on the part of large companies [13]. Spin-offs guarantee involvement of creators and inventors in the development of university’s technologies, which is of primary importance when these technologies are based on tacit knowledge [7].

University spin-off businesses are increasingly gaining popularity among scientists, creators, as well as among potential partners from industry sectors and financial investors. They are an interesting vehicle for implementing innovative technologies to the market, developing the added value on the basis of the results of research work and development work or the scientists’ know-how. In situations where big companies and corporations turn out to be too large and too slow to create and implement innovations that change the rules of the game, academic start-ups gain particular significance.

It should be noted, however, that the creation of spin-offs is one of the most difficult ways of commercializing the scientific results of research facilities, although considering possible solutions in the long-term perspective; it is also one of the most profitable solutions. In general, the value of a developed technology, which becomes a basis for the creation and development of a business, is greater than a one-time sale of an idea or granting of a licence.

The difficulty of building a spin-off results, among other things, from the very specific character and way of functioning of scientific entities and legal conditions. In the relevant literature concerned with this topic, one can find attempts to describe the process of the creation of university spin-offs. Attempts are made to systematize the assumptions, specialised terms and relationships characteristic of the formation of businesses based on the university's intellectual property in such a way that they best describe the reality and show the general course of the process (**Table 1**) [7, 14, 15].

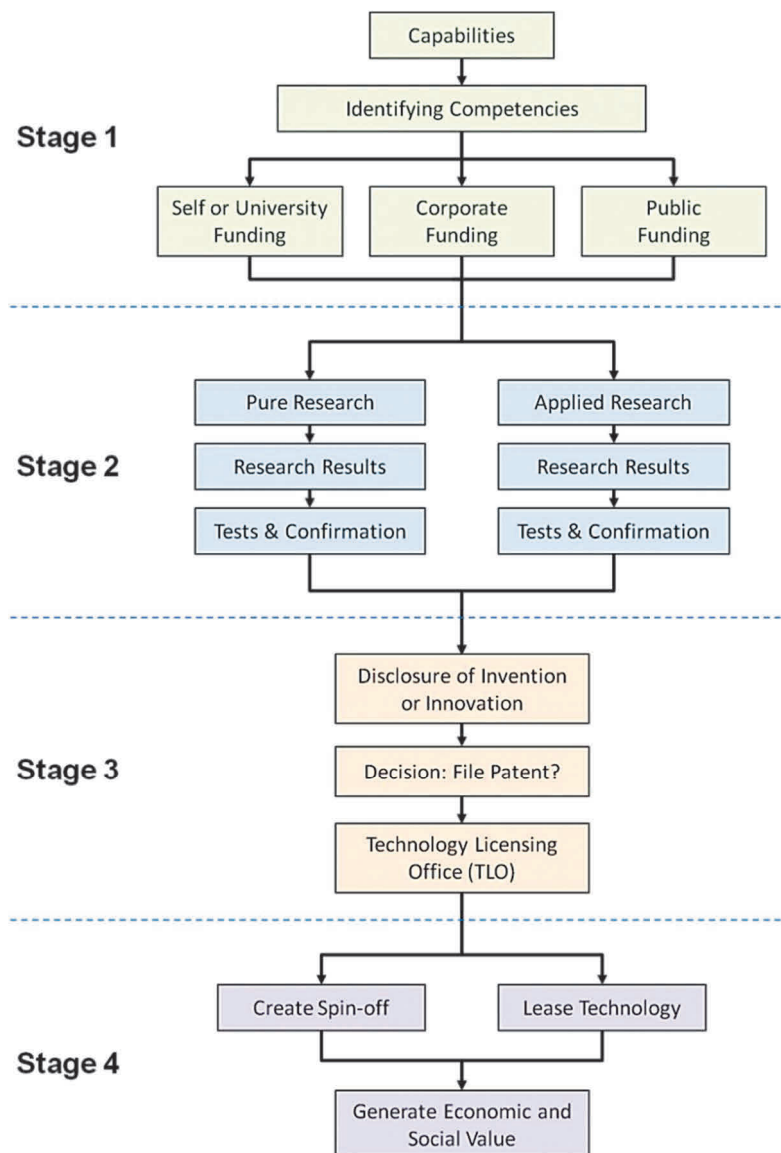
**Table 1** Models for the creation of University spinoffs (according to the individual authors)

Ndonzuau, Pirnay, Surlemont	Shane	Vohora, Wrightm Lockett
<ol style="list-style-type: none"> <li>1. Generating a viable business idea.</li> <li>2. Translating the idea into a business process.</li> <li>3. Creating a firm.</li> <li>4. Contributing value to customers, employees, investors, and all other stakeholders (both internal and external).</li> </ol>	<ol style="list-style-type: none"> <li>1. Assessment by the scientist or inventor whether the new technology has the potential for commercialization.</li> <li>2. Disclosing the technology to the university's technology-licensing office (TTO).</li> <li>3. Evaluating the potential of the disclosed intellectual property from the viewpoint of its protection.</li> <li>4. Applying for protection.</li> <li>5. Granting a licence for the technology by TTO to an existing company or to a spin-off created jointly with the scientist(s).</li> </ol>	<ol style="list-style-type: none"> <li>1. Research. Opportunity recognition</li> <li>2. Opportunity framing.</li> <li>3. Entrepreneurial commitment</li> <li>4. Pre-organization. Threshold of credibility</li> <li>5. Re-orientation. Threshold of sustainability</li> <li>6. Sustainable returns.</li> </ol>

It should be pointed out that the model proposed by Vohor et al. emphasises the need of a systematic approach to the creation and development of university spin-offs. The model recognizes that opportunity analysis and identification is critical to successful commercialization [16]. The condition of success is, therefore, not only knowledge and competence associated with a given field of science, but also knowledge of management and business. The commercialization process involves the shaping of the added value of ideas, research results or technologies in permanent dialogue with the expectation of the market and customers.

When building their multistage holistic model for creating university spin-offs, P.N. Pattnaik and S.C. Pandey try to answer the following questions, which are of key importance to indirect commercialization [16]:

- How does a researcher identify and decide on specific opportunities?
- What kind of funding is available for conducting research?
- Do similar opportunities exist for both pure and applied research and the results thereof?
- What modes for commercializing research results are available to the researcher or the university?



**Figure 1** A multistage holistic model for creating university spinoffs

In accordance with the authors' intention, the multi-stage model of university spinoffs can be used by scholars in the area of academic entrepreneurship to build case studies and do phenomenological studies [16]. The model offers some value to practitioners who try to manage and transfer knowledge and thus make this process optimal from the viewpoint of university goals and benefits for the economy.

#### 4. THE CREATION OF ACADEMIC SPIN-OFF COMPANIES AT THE AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN POLAND

The AGH University of Science and Technology in Krakow (AGH UST) is a modern nationwide public institution of higher learning. It is a technical university, where in addition to faculties closely associated with mining and metallurgy, there are faculties where the research is associated not only with traditional branches of industry and earth sciences, but also with fields of key importance for the development of modern economy, such as new materials, renewable energy sources, biomedical engineering or information technologies.

The model for technology transfer and commercialisation of innovative solutions at AGH UST assumes full co-operation of two AGH institutions pursuing different ways of commercialization; these are the Centre for Technology Transfer, a university entity (CTT AGH) and the special-purpose company INNOAGH. These entities jointly create a comprehensive offer for scientists, students, the university's administration as well as industry.

The goal of INNOAGH is indirect commercialization of the results of research and development work; consequently, INNOAGH is responsible for the creation of university spin-offs. The mission of INNOAGH is to support inventors - both as regards the subject matter of their work and organization - in the creation of university businesses based on innovative technologies developed at AGH UST.

INNOAGH is thus itself a special-purpose company, the University's investment fund, which has the goal of providing counsel and support to scientists interested in establishing innovative businesses building on the intellectual property created at the University, but also to invest in such companies, mainly by making contribution in the form of patent rights, know-how and also funding. INNOAGH is one of the key elements supporting - inside and around AGH - the transfer and commercialization of technology and knowledge.

The ecosystems, in which spin-offs are created at AGH UST, as is the case of other Polish universities, are still in the budding stage. After six years of INNOAGH operation and, consequently, more than a dozen case studies resulting in the establishment of more than twenty spin-offs built on the university's intellectual property, an attempt can be made to model the process of the formation of spin-offs. Valuable experience is also provided by projects and technologies which, until now, have not led to the creation of new entities. In scientific communities that are still implementing the concept of actions focused on innovation, people are a particularly important component. Spin-offs that introduce innovation to the market can be built on the basis of human resources, teams of professionals: duly motivated, learning by mistake, accepting risks and ready to face challenges. Consequently, an important task of INNOAGH is to promote the idea of academic entrepreneurship, with special emphasis on the commercialization of intellectual property via the creation and development of start-ups. The building of models for the transfer of knowledge and the creation of spin-offs will be worthless without an entrepreneurial culture developed around Polish universities.

The process of spin-off creation on the basis of research work results, processed by their authors, which provides a potential basis for the construction of undertakings with a business potential, consists of the following stages.

- 1) Identification of research and development work conducted by scientists at the university's departments.
- 2) Preliminary analysis of technologies and research work results prepared on the basis of interviews with their authors. This consists of a brief summary, identification of the field of engineering, the essence of the invention, quantitative and qualitative benefits, SWOT analysis, legal protection status, identification and verification of co-authors, but also of preliminary identification of possible ways to commercialization.
- 3) Preliminary market analysis comprising, among other things, the identification of potential target markets, competitive environment, resources, etc.
- 4) An in-depth analysis comprising the assessment of the legal and patent details, assessment of the current state of the knowledge, assessment of the technology in terms of its engineering correctness, assessment of the technology's maturity, and analysis of actions necessary to bring the technology to the status of implementation readiness, assessment of the research team in terms of their goals and motivation, as well as assessment of the technological, environmental, market and legal risks.

Each of the subsequent stages of verification of the research work results is implemented after successful verification of the preceding stage. A great majority of technologies created by the university reaches at most the 4<sup>th</sup> level of readiness, as assessed using the Technology Readiness Levels (TRL) methods, which is inadequate a level to gain investors' interest. In such cases commercialization is particularly difficult: it is a

lengthy process, spread over time, often over several years. The project's evaluation and an appropriate identification of market needs, both those we are aware of and those not, become the key element of the project application development. Defining the product, determining its commercialization path and finding an investor ready to co-finance the commercialization by the creation of a spin-off company is the key element of making academic knowledge commercial. A stage-based approach, based on gradual assessment of projects is in agreement with the "innovation funnel" concept, where the creation of a spin-off business and investment into it is preceded by the assessment of the concept, its development, the construction and verification of the prototype, market tests and preparation for launching on the market. It does not change the fact that it is possible to create a spin-off company in order to prepare for implementation of the results of scientific research and development work or the know-how associated with these results.

## 5. CONCLUSION

Although the term "commercialization" is still - in the opinion of university workers, both scientists and administration staff - not clear and remains unrelated to the university community, this situation will have to change in the nearest future. Universities often have false opinions on research commercialization and often assume that the process ends with dissemination of the results, rather than their implementation, which is confirmed by successive studies on barriers to commercialization of research work in Poland. For several years some Polish universities have been developing their systems for the transfer and commercialization of knowledge, improving the system in order to make it possible to use the results of scientific studies and development work practically. A particular challenge is the creation of spin-off businesses around the university, which attempt to implement the university's inventions, patents or know-how to the market.

Establishing a university company is a complex and difficult process. It begins with an idea, project or the result of research or development work. This is followed by many decisions and actions associated with the protection of intellectual property, transforming the technology into a market product, formalisation of management and continuous raising of funds for development, etc.

According to the authors of this publication, who also have practical knowledge on managing the results of scientific studies and the university's intellectual property, there is a need to map the processes of the creation and the transfer of knowledge at universities. This process should lead to effective implementation of research results to industry. Despite the abundant literature on the creation of new businesses, the case of businesses established in the academic community, where the results of scientific research are the basis for building value for customers, requires an individualised approach. Similarly, it is difficult to assume that the knowledge transfer processes that have turned out to be successful in other academic centres (e.g., in American universities), can be directly translated to Polish conditions. Structural, mental, cultural, competence or financial conditions provide an entirely different background for commercialization of research work in Poland.

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