RESEARCH PAPERS OF WROCŁAW UNIVERSITY OF ECONOMICS No. 136
Economics 9 2010

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SPIN-OFFS AS EXAMPLES OF INDUSTRIAL AND POST-ACADEMIC SCIENCE ADOPTION

Summary: The interaction of business sector and science institutions through the exchange of knowledge and technology has become a central concern not only for theoretical economists but also for economic policy of states in the last years. Science exerts an increasingly large influence on innovation in knowledge economy. At the same time it is worth noticing that science is also subject to transformation. From academic to post-academic or industrial science – it changes its aims and becomes more market oriented.

The goal of this article is to show the importance of changes within innovation process as well as within the aims of science and its transformation. Spin-off firms are an example of post-academic science evaluation.

Keywords: innovation, university, industrial science, post-academic science.

1. Innovation in traditional and modern recognition

Previously innovation was usually seen as a radical invention accomplished by a heroic inventor in linear innovation processes[1]. In the traditional linear model of innovation (science push and market pull models) the basic idea is to characterize innovations as (causal) linear chains. In the "science push" model the chain runs as follows: first, theoretical knowledge is generated by academic science in form of basic research, next, the generated knowledge flows down to a practical context in which the knowledge is applied in problem solving and eventually an innovation may occur. The chain runs only in one direction: all the questions and information come into the process from an earlier or the present state of the chain. In the market pull model the chain is the same but the questions come from the market. Although this model seems to be more "enterprise friendly" – both models characterize innovation as something far from practical, everyday life. Moreover, neither model can explain success and lack of success in innovation processes.

[1] V. Harmaakorpi, A. Mutanen, *Knowledge Production in Networked Practice-Based Innovation Processes – Interrogative Model as a Methodological Approach*, "Interdisciplinary Journal of Information, Knowledge, and Management" 2008, Vol. 3.

Nowadays innovation is considered most often to be a result of cooperation in normal social and economic activities[2]. The innovation process normally includes many kinds of interaction and innovations do not have to be radical; on the contrary, they are incremental, social and organizational changes, as well as technological advancements. Consequently, innovations are not just the results of scientific work in a laboratory-like environment. They are made in networks where actors with different backgrounds are involved in the process setting new demands for innovativeness. The science push effect as the driving force of innovations is an exception rather than a rule in these processes. Factors like the ability to interact, learn collectively, and build trustful relations between the innovating partners seems to be a more influential source of innovation. Innovativeness depends in most cases on the innovation network's ability to interact rather than on an individual actor's progress in a particular scientific field.

The networked innovation environment places new demands for collective knowledge production. Gibbons et al.[3] define two classes of knowledge used in the innovation processes. Mode 1 is hierarchical and tends to preserve its form. Mode 2 is more heterogeneous transient in nature. Mode 1, traditional knowledge production based on single disciplines, is homogeneous and primarily cognitive knowledge generation context sets within largely academic paradigms. Mode 2, knowledge production, by contrast, is created in broader, heterogeneous interdisciplinary social and economic contexts within an applied setting. One of the key contrasts between the two modes is that in Mode 1 problem-solving is carried out following the codes of practice relevant to a particular discipline and problem-solving whilst under Mode 2 knowledge activity is organized around a particular application and is more diffuse in nature. Gibbons et al. report an epoch change in knowledge activity in innovation networks with a shift from Mode 1 to Mode 2 knowledge creation. In this study, the very often practice-oriented Mode 2 knowledge production is seen as the main "business" of the innovation networks.

Table 1. Attributes of Mode 1 and Mode 2 knowledge production

Mode 1	Mode 2
Academic context	Context of application
Disciplinary	Transdisciplinary
Homogeneity	Heterogeneity
Autonomy	Reflexivity/social accountability
Traditional quality control (peer review)	Novel quality control

Source: L.K. Hessels, H. van Lente, *Re-thinking New Knowledge Production. A Literature Revive and Research Agenda,* Innovation Studies Utrecht Working Papers, Series 08.03.

[2] Ibidem..

[3] M. Gibbons, C. Limoges, H. Nowotny, S. Schwarzman, P. Scott, M. Trow, *The New Production of Knowledge*, London 1994.

In order to understand the new demands for creating knowledge in the – very often practice-based – innovation processes, one must take a little closer look at them. Innovation is an intentional activity in which there is more or less specified goal to acquire – sometimes only a feeling that something should be done. In innovation the specification of the goal is the main problem. Also, with product innovation it is very difficult to specify the goal – the commercial end product. In a sense, in innovation one tries to develop something new, something that has not occurred before. Innovation is not made out of nothing. It presupposes systematic work including both specific innovative processing of the subject matter and building an innovative environment in order to produce and combine knowledge. Moreover, both factors must be synchronized. The nature of innovation is that the innovation process generates something new. In a sense it is something unexpected. Of course, the result is surprising also in a scientific knowledge-seeking process. However, the source of the goal is different. In basic research the goal is specified by the underlying theory. The role of the theory can be seen from the fact that the theory or rather the method provides the foundation for justification[4]. In innovation there is no such an justifying theory: justification occurs within the markets. Products or services have to be sold out on the market. That is the needed "justification". So, the technological or organizational "justification" is not enough. Hence innovation cannot be reduced to scientific research. Justification which is given by the market is temporary and has to be constantly earned. The results in scientific research are underdetermined by the evidence. Hence, there is constantly a need for further justification. In science, experiments play a central role both in the theory formation (abduction) and in the theory testing (induction). While testing, a scientist tries to formulate a falsifying experiment for the theory. In fact, any experiment can be a falsifying experiment, but no number of positive experiments guarantees the truth of knowledge. Also, business innovation is a continuous process in which new products and services are sought or the existing products and services are further developed. However, in contrast to scientific innovation there is no such falsifying activity in business innovation – all the activity directs to innovation. Business innovation is essentially tied to practical business. That is, the framework of research is only one factor that determines the context of innovation. To innovate usually means to cooperate. Cooperation means here knowledge production within the groups of people that have a common interest, determined by the practical context in which the group works. However, these people often have a very different background (work history, education, etc.) In practice-based innovation processes there is a common practical context within a problem to be solved which has to be specified. The practical context is a specific object and within it every cooperator may have a different point of view. Hence the specific problem they have in mind may differ.

[4] V. Harmaakorpi, A. Mutanen, op. cit.

There has been a revaluation of opinions concerning the role of higher education institutions in the society in Western Europe since the middle of the 1980s. Schools of higher education are perceived not only as educational institutions and scientific centres but also as a potential that becomes an impulse for its dynamic development owing to approaching technology. The experience of the European Community countries and other developed countries from all over the world unequivocally shows the mutual benefits that flow from the close relations of schools of higher education with their economic environments.

2. Universities as sources of innovation

2.1. Transformation of universities

Universities we know derive from the Humboldt model, pioneered by Wilhelm von Humboldt who established the University of Berlin in the early 19th century, now named after him. The mission of the university was to expand public knowledge by carrying out research according to the scientific method that had emerged in the Renaissance and matured in the Enlightenment period. Universities were not interested in applying the results; all the major technologies of the 19th century were developed by innovators-entrepreneurs outside the universities (steam engine, telegraph, radio, electric power, telephone, photography and many others).

The Humboldt model started collapsing when universities expanded rapidly in the 1960s and, in association with this, it became increasingly subject to government intervention and bureaucracy. At the same time, multi-disciplinary and interdisciplinary research became the mainstream; an academic hospital now employs more scientists and engineers than physicians. Faculty organization became a handicap. In the 1970s, the first universities, especially in the US, became the cradles of new, technology-based, firms: Hewlett Packard, Dell, Intel, Sun Microsystems and many others. In addition, universities started joint research projects with industry where industry was increasingly eager to farm out their fundamental research. Universities are changing in a fundamental way, moving from the model of the science-based university that emerged after the Napoleonic period into what we will call the Third Generation University or 3GU for short. At the moment, we are in a period of transition. For a number of reasons, the science-based university model does not function anymore. Universities are experimenting with new forms[5]. Universities nowadays are competing on an international market to acquire the best industrial contracts, the best academics and the best students. Competition creates winners and losers. Winners will be those universities that establish themselves as the centre of an effective know-

[5] J.G. Wissema, *Technostarterzy, dlaczego i jak?*, Polish Agency for Enterprise Development, Warszawa 2005.

how hub, which is a dynamic scientific environment that incorporates all kinds of research, education and know-how commercialization, in which the university collaborates with established technology-based firms as well as start-ups.

2.2. Spin-offs

The phenomenon of spin-offs development, which creates the mainstream of so called academic entrepreneurship and is one of the mechanisms of commercialization and technology transfer, focused the attention of politicians and universities' authorities[6].

The spin-offs are the result of deep transformation of activities of universities and research units and their relations to economy. This transformation is an effect of changes which have taken place inside the economies' mechanisms during the last couple of years (liberalization of capital flows, privatization, increase of migration).

Spin-offs despite their attractiveness and popularity still have not been clearly defined neither by academics themselves nor by international institutions like OECD. It is troublesome especially for building statistics and international comparisons.

Spin-offs build a bridge between innovation capacities and the market for products and services, and a tight relationship is thus created. This relationship can take multiple forms that may result in at least two different types of spin-offs:

– The University spin-off (and the spin-off of a non-profit R&D organisation)[7]:

It may be founded by researchers, by lecturers or even be a service offered by a department. Here the university plays the role of business incubator, supporting its employees' initiatives. By setting up a spin-off, the incubator generates, develops and spreads its knowledge, and finds both an appropriate environment to transfer its scientific research results as well as, sometimes, help in the search for investors (business angels or venture capitalists). The university can obtain its own benefits from the spin-off by selling or licensing its R&D results (for example patents obtained by grant holders, lecturers, etc., and the outcome protected by other intellectual property rights (IPR)). Through the efforts of the spin-off, the university's technology can be improved by further development and finally result in products which can be directly produced and sold on the market by the spin-off.

The university and its spin-offs are generally linked by a cooperation agreement that sets up the individual cooperation scheme, specifically the management of the

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[6] D.S. Siegel, D.A. Waldman, L.E. Atwater, A.N. Link, *Toward a Model of the Effective Transfer of Scientific Knowledge from Academicians to Practitioners: Qualitative Evidence from the Commercialization of University Technologies*, "Journal of Engineering and Technology Management" 2004, No. 21, p. 115-142.

[7] G. Raday, *Academic Spin-off Ventures and Corporate Spin-off Firms at the High-Tech Industries*, Debrecen University's Faculty of Economics and Business Administration, http://www.econ.unideb.hu/oktatas_es_kutatas/doktori_iskola/download/2007jun/20070626_raday_gabor_academic_spin-off_ventures_and_corporate_spin-off_firms.pdf

university's research results and IPR by the spin-off, the related spin-off's commercialization activities including a profit participation for the university and provisions for the use of university assets by the spin-off for the mutual benefit of the parties.

– A corporate spin-off:

It is created within a company which shareholders or employees acquire the essential organization or infrastructure to set up a new company by which they either split up different business sectors or realize their ideas outside the parent company. The corporate spin-off can be used to collaborate with the parent company by improving external activities or products directly connected with the principal enterprise. It may serve as a means of becoming active in different industrial branches or fields or production lines outside the scope of the core business of the parent company and may even be used to outsource a defined field of business activities, as well as the liability risks related to the defined field.

The spin-off concept itself has no controversial interpretations. It is used for describing the entity that emerges in the process of insulation from the parent entity in order to run the new kind of activity which was previously (in the parent corporation structures) not possible to conduct[8]. The spin-offs can be enterprises which emerge as satellites of large corporations mainly to implement risky technological projects. Spin-offs may originate from the idea of shareholders of an existing company (the parent company) to split the company up into separate companies operating in different business sectors. The owners thus expect an increase in the stock valuation of two companies operating independently in two different sectors, as compared to the stock valuation of one company covering the two sectors: stock holders would own stock in both companies and could participate in the increased profit generated by the commercialization success of the two split companies.

Apart from the profit incentive, spin-offs may be generated when employees promote the division of an existing company to create a new one in order to initiate a new business opportunity for themselves[9].

Spin-offs often derive from universities and public or private research institutions, with the aim of ensuring that the research carried out there has the industrial application through the spin-off. In this sense of meaning the spin-offs are interpreted mainly in the context of commercialization, and the transfer of knowledge and technology. That narrow concept of spin-off differs in some details. Professors E.B. Roberts and D.E. Malone[10] pointed out that spin-off is a separate entity that basis its acting on the technology provided by the parent organization with the financial

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[8] P. Tamowicz, *Przedsiębiorczość akademicka. Spółki spin-off w Polsce*, PARP, Warszawa 2006, p. 11.

[9] M. Steffensen, E.M. Rogers, K. Speakman, *Spin-offs from Research Centers at a Research University*, "Journal of Business Venturing" 1999, No. 15, p. 93-111.

[10] E.B. Roberts, D.E. Malone, *Policies and Structures of Spinning out New Companies from Research and Developmental Organizations*, "R&D Management" 1996, No. 26(1), p. 17.

support of venture capital funds. Others[11] pointed out that in the role of entrepreneur-founder of the spin-off there is an ex-employee of the base entity-university. More elastic attitude is represented by N. Nicolaou and S. Birley[12] who say that the prerequisite of spin-offs rise is the technology transfer (from university), but not necessarily the transfer of scientific personnel.

There are also some differences concerning the character of the technology that is being transferred. Professors E.B. Roberts and D.E. Malone introduced some elasticity in this issue by the agreement for non-technological character of transfer (for example personnel transfer) which leads to including in the spin-off definition the consulting companies set up by academics. This attitude might seem to be too liberal, but it affects the important issue: in some areas of science and research the transfer can refer to unique knowledge (easy to transform to the commercial product) not a technology in a sense of patent. The answer for such a defined problem can be the spin-off definition introduced by S. Birley (2002) who defines spin-offs through the prism of intellectual assets transfer.

Nicolaou and Birley[13] have also defined three types of spin-offs that differentiate the size of mutual interconnections of key factors (men, scientific institution, property relations):

– orthodox – the entity is based on the academic-inventor person and the transferred technology,
– hybrid – the entity is based on the transferred technology, while academics (all of them or just some) can still work in the university structures as advisors and controllers,
– technological – the entity is based on the technology transferred from the university, but academic-inventor has no contact with the newly set firm. He can possess the shares of the firm or provide consulting services.

For the purpose of launching and marketing products and services which derive from research, spin-offs are often considered the exploitation tools by non-profit R&D organisations and universities, as they can be used as vehicles to enter the market and undertake marketing activities, which the non-profit institutions – due to the legal restrictions implied by their non-profit status – cannot do themselves. This is especially important for non-profit R&D units, for which spin-offs[14] represent an opportunity to set up a business that is based on the non-profit R&D unit's know-how, but at the same time moves much further into the market with its own product line, production capacities and marketing channels, which can be created.

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[11] R. Smilor, D. Gibson,G. Ditrich, *University Spin out Companies: Technology Start-ups from UT-Austin*, "Journal of Business Venturing" 1990, No. 5, p. 63-76.

[12] N. Nicolaou, S. Birley, *Academic Networks in Trichotomous Categorisation of University Spinouts,* "Journal of Business Venturing" 2003, No. 18, p. 333-359.

[13] Ibidem.

[14] P. Tamowicz, op. cit., p. 11.

Spin-offs could thus be defined as new, independent companies originating at the heart of another entity (university/research institution/company), with the primary goal of commercialising the parent organisation's knowledge in the marketplace and/or with the aim to increase the profits of the owners of the parent organisation by means of splitting it into several companies.

Innovative technologies are continuously created and require appropriate commercialisation which might be well served by the spin-off. For non-profit organisations/universities in particular, the relationship formed between the parties can be particularly advantageous: it can serve as a permanent platform for technology transfer, offering the non-profit partner a more attractive perspective than licensing out only one patented technology, for example.

The diversity of spin-off definition does not ease the estimation of real size and the dynamics of the sector. The creation of spin-offs is not under the statistical offices' supervision (no matter what definition is used) and only few countries (Belgium, Germany, France, Canada, USA and UK) can show some data collected on the country level. The data collected by the single institutions (regional, scientific or associations) are often a picture of some part of the sector. Because of them the characteristics of spin-offs are often based on incomplete and incomparable information. The particular weakness of the spin-offs data is lack of data on economic impact of spin-offs activity.

One can collect relatively a lot of data on spin-off sector in countries which discovered this kind of entrepreneurship first – Great Britain and the USA.

In Great Britain spin-offs statistics are collected by the Higher Education Funding Council of England[15]. According to these reports a spin-off company is an enterprise exploiting IP owned by the higher education institutions (start-ups are similar new companies but not based on higher education institutions IP), but these companies often take some time to reach profitability, so data is also collected on the survival rate of firms. In 2003-04 133 companies were formed on the basis of IP generated by the United Kingdom higher education institutions. The number of spin-off companies which were created fell four years in a row. This trend was regarded by many as better market awareness in higher education institutions: while the created numbers had fallen year-on-year, the number of firms that survived for three years increased in each of the three years. In 2003-04 there were 920 active spin-off companies from the United Kingdom higher education institutions, with 625 being over three years old. In the next period 2005-06 187 spin-off companies were formed from the United Kingdom higher education institutions' intellectual property. That represents an upward trend in comparison with the trend of recent years. Overall, higher education institutions responding in the survey estimated that formal spin-offs had employed over 16.000 people and their annual turnover was more than £500 million. Higher

[15] Higher Education – Business and Community Interaction Survey 2003-04, 2004-05, 2005-06, 2006-07, http://www.hefce.ac.uk/econsoc/buscom/hebci/

education institutions report that their graduates had formed 1.172 new companies in 2005-06. In 2006-07 226 spin-offs were formed which was continuity of an upward trend. There were over 1,200 higher education spin-off companies in 2006-07 period which was an increase of 7 per cent from 2005-06.

In the USA the Bayh-Dole Act regulates the spin-off creation. University spin-offs are rare entities. During 20 years (1980-2000) only 3376 academic spin-off companies were established[16]. Given the relatively large number of faculty, staff and students at academic institutions in the United States this number of spin-offs is quite low. It is so not only in the absolute sense, but also in comparison with other types of academic activity at American universities. The spin-offs are only a small portion of all start-up activity of these educational institutions.

While university spinoffs are rare entities, they are quite important. University spinoffs are valuable in at least five ways:

1) university spinoffs enhance local economic development (by generating significant economic value, job creation, inducing investment in university technologies),

2) they are useful for commercializing university technologies,

3) they help universities with their major mission of research and teaching (support additional research, attract and retain faculty, help to train students),

4) they are disproportionately high performing companies,

5) they generate more income for universities than licensing to established companies.

The data on spin-offs in European countries is not unified so a decent picture of the European spin-offs is troublesome. Available data usually concern some part of scientific sector and is usually incomparable because of differences in defining the problem.

There are some examples of university spin-offs in Poland. They are spin-offs in a wide meaning of this word without the "license criteria" used in the USA. The interconnections with the university are of different scale, so in a context of this article one can call them "quasi" spin offs. They specialize mainly in biotechnology, chemicals and nanotechnology. All of them are new (established after 2000)[17].

There are a few examples of spin-offs that have been successful: Kronodoc OY (Finland), founded in 1997 as a spin-off from an engineering project of the European Organisation for Nuclear Research (CERN); Infineon Technologies AG (Germany), founded in 1999 for the semiconductor operations of Siemens AG; Lenntech (the Netherlands), a spin-off of the Technical University Delft; or several spin-offs set up by the members of the University of Cambridge as Akubio or Astex among others.

It is worth underlining that sometimes spin-offs may find a complement or favourable context in technology parks. They offer the appropriate space and facilities

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[16] S.A. Shane, *Academic Entrepreneurship: University Spinoffs and Wealth Creation*, Edward Elgar Publishing, Cheltenham 2004.

[17] Pharmena, Novasome, Proteon Pharmaceuticals, Biomast, Immunolab, Ifotam, Opticon Nanotechnology, Bioinfobank, Bujno Synthesis, and many others.

to develop and promote the transfer of R&D results from universities and other institutions to the market. Other actors involved are the Technology Transfer Offices (TTOs), which help identify and protect research results and act as a mediator between private and public organizations and researchers.

3. Conclusion

Universities can deliver a significant contribution to the economy in terms of knowledge creation. The key channels for knowledge commercialization are patents, licenses, research joint ventures and the formation of spin-offs. In this regard, university spin-offs (USOs) play an important role in knowledge transfer, and as a consequence, in economic development.

As the universities and science model transformation became a fact, the spin-offs became the natural consequence of this process. The impact of technology spin-offs on country's economy is worth supporting. Success in developed countries can also benefit developing ones. The model of technology (or rather innovations) creation described in the article can be a key feature in fostering knowledge-based development and, at the same time, knowledge-based economies' development.

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FIRMY SPIN-OFF JAKO PRZYKŁAD WYKORZYSTANIA NAUKI POSTAKADEMICKIEJ I PRZEMYSŁOWEJ

Streszczenie: Interakcje pomiędzy nauką i biznesem polegające na wymianie wiedzy i technologii są w obszarze zainteresowania zarówno teoretyków ekonomii jak i polityki ekonomicznej wielu państw. W warunkach gospodarki wiedzy rola nauki dla innowacji jest ogromna. Warto zauważyć, że również nauka podlega transformacji: od nauki akademickiej do postakademickiej czy przemysłowej zmienia ona swoje cele i staje się bardziej zorientowana rynkowo. Celem artykułu jest ukazanie wagi zmian zachodzących zarówno w procesie innowacyjnym jak i w celach nauki i jej transformacji. Firmy spin-off stanowią tu przykład rozwoju nauki postakademickiej.