UNIVERSITY RESEARCHERS DEVELOPING TECHNOLOGY TO COMMERCIAL MARKETS

A BRIEF REVIEW TO THE 20TH CENTURY FINLAND

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Today universities are required to contribute to national economies more than ever before in the history of European science. Some think that because of these commercial expectations the independence of university research is at risk while others consider that only now academic world is turning into a resource of societal well-being. Historical analysis of the university-based technology indicates that both views are wrong – at least to some extent. For the last 100 years researchers have also been developers of technology aimed at commercial markets, and at the same time active connections to the society have existed.

At the beginning of a new millennium universities globally face new demands and challenges. A different kind of activity is now required besides the traditional academic work of teaching and research. In several countries an explicit intention of science policy is to change the academic world from a passive bystander to an actor participating actively in societal issues.

In Europe this new interest in universities is noticeable both at the national level and at the European Union. In the case of the multinational community it becomes apparent in the discussions, publications and concrete actions of science policy. In the Lisbon declaration of 2007 the EU committed to the better use and commercialisation of university research.[1] The EU has commissioned studies where the universities' commercial activities are mapped – for example, links between universities, technology and commercial activities have been studied.[2] New scientific institutions with a clear commercial orientation in mind have been founded: in October 2006 the European Commission proposed establishing the European Institute of Innovation and Technology (EIT), the commercial basis of which is clear.

Universities are also facing these new expectations and challenges in Finland. The government has worked actively in order to promote the commercial activities of the academic world. In the 2004 amendment to the Universities Act a "third task" was included in the agenda of the academic world besides teaching and research. Now universities are expected to be in more direct contact with the rest of society and they must promote the use of research results for the benefit of society. One important part of this direct contact is the commercialisation of university-based technology. Another law came into force in 2007, which strengthened the position of universities in their performance of the third task. Some of the immaterial property rights previously belonging to individual scientists were shifted

to their academic institutions. This was considered to promote the commercialisation of technology developed in universities.

Besides increased discussion and legislative changes relating to the commercial activities of universities, a growing body of research has also been published in Finland and elsewhere concerning the connections between universities, research, technology, innovations and commercialisation. Studies have examined e.g. the possibilities of universities to engage in commercial activities, attitudes towards the commercialisation of science inside the academic world and the university-industry relations.[3] Until very recently the actual technology developed in universities has remained as less-known topic, which is exactly the focus of this article.[4]

The article concentrates on some of the main findings of a study analysing the role of academic scientists as developers of technology aimed at commercial markets and the use of different industries in Finland during the 20th century.[5] How much commercial technology[6] has been developed inside the academic world during the last century and how common has it been that scientists develop new applications? Which scientific fields and which groups of scientists have been active as developers of technology? Another question is the technical quality of inventions and innovations – what kind of technology has been invented by scientists in academia? A closer look at the technical quality of inventions of university origin enable also the analysis how important scientists have been as developers of new technology at national level. In addition, two viewpoints are taken into account which illustrates the participation of academic scientists in the development of new technology: firstly, the relationship between individuals' scientific work and technological output and secondly, the commercialisation of the technology developed.

Answers to questions mentioned above are sought at the level of two Finnish universities. Both the University of Helsinki (UH) and Helsinki University of Technology (HUT) were leading institutions of teaching and research in 20th century Finland. When concentrating on UH and HUT it is possible to analyse differences in the technological output of two different types of academic institutions: a traditional science university and a technical university (*technische Hochschule*). These academic institutions are typically perceived to be different in working culture and basis of research.

The article concentrates on scientists working at the University of Helsinki and the Helsinki University of Technology during the period 1900–1975. The group consists of 2150 individuals, of whom 1247 worked in UH and 1020 in HUT. They obtained 1021 Finnish patents in the period 1891 and 2004 and these inventions form the basis for statistical analysis.[7] The purpose of the article is twofold: the work of the UH and HUT scientists in commercial technology will enhance our understanding of the activities of the academic world in the 20th century. Hopefully, the analysis can also offer insight into the ongoing debate about the role of universities in a knowledge society and knowledge-based economy, and even give a perspective on contemporary science policy, where the universities' technological contribution is being promoted more than ever before.

Minority's contribution was nationally important

The patenting activity would suggest that the development of commercial technology has been quite rare among the scientists: 10,5 % of UH and HUT personnel were academic patentees, individuals who parti-

	UH %	HUT %
1901-05	3,3	-
1906-10	1,4	6,3
1911-15	1,3	12,8
1916-20	2,2	14
1921-25	1,8	7
1926-30	2,2	8,3
1931-35	4,3	8,3
1936-40	1	8,8
1941-45	3,7	3,5
1946-50	2,8	2,5
1951-55	1,3	8,6
1956-60	1,1	9,4
1961-65	0,5	4,4
1966-70	2,8	5,7
1971-75	2,1	9,6
1976-80	2,5	9,2
1981-85	1,7	9

Table 1: Researchers participating in academic patenting in the University of Helsinki and the Helsinki University of Technology in 1901–85 (HUT was founded in 1908, and because of this the 1901–05 column is empty). Source: Kaataja 2010.

cipated in patenting during their university careers.[8] This shows clearly how teaching and research have been the most important forms of activity in the academic community while the development of commercial technology has concerned only a minority of scientists. The number of patented inventions has also been modest in proportion to the overall number of scientists studied. Both in UH and HUT less than 0,1 patents were granted per scientist during the period 1900–1985. Nor were there any significant changes in patenting activity throughout the nine decades studied – the number of academic patentees and quantity of patents remained modest in all periods.

Nevertheless, table 1 shows interestingly that the notable changes in researchers' patenting activity occurred typically during the periods of crisis. For example, in the Helsinki University of Technology researchers activated during the World War I. In the University of Helsinki academic patenting became more common in the early 1930s, when economic crisis hit also Finland, and during the World War II. The 1940s was also the only period when academic patenting was more common in the UH than in the HUT and when more patented inventions were developed there than in the technologically oriented neighbour university.

Even though researchers' patenting activity initially seems to be modest, in some particular fields of technology their inventive contribution was substantial and significant also at national level. In four patent classes UH and HUT scientists were responsible for more than 20 % of the inventions patented by a Finnish patentee in Finland during the period 1900–85. In other four classes their share was 10–20 %. Researchers' contribution was exceptionally high in technology relating to food and foodstuffs and separation of solid materials. In those two fields the share of academic patents was approximately 27 % – every fourth invention, patented in Finland by a domestic patentee was technology of UH or HUT origin.[9]

Preceding paragraphs are very important when the nature of researchers' technological output during the last one hundred years is defined. They show that regardless of the modest patenting activity of the whole research community, in some specialised fields university scientists have acted as significant developers of new technology, also in quantitative terms. Furthermore, this is not only a Finnish phenomeon. Similar results have been obtained

from other European countries (e.g. Italy, Germany and Sweden) in studies focusing on technology developed inside the academic world more recently.[10]

Scientific and technological fields of university-based technology

Activity in developing technological applications has varied significantly between different parts of the academic world. In some faculties it was common practice while in others practically non-existent. For example, in the HUT departments of Forest Products, Mining and Metallurgy and Chemistry the share of patents per working scientists was approximately 1,0 but in Architecture only 0,11. In the first three of the four departments research has materialised most as commercial applications. Mining, wood processing and chemical industries developed greatly in Finland during the 20th century, and in each of them university researchers were also part of the modernisation process as developers of new technology.

It is a predictable result that the number of patents was smaller in the UH. In the Faculty of Medicine researchers received 0,13 patents, in Agriculture and Forestry their share was 0,15 and in Mathematics and Science 0,26. What can be considered slightly surprising is that from the three faculties analysed natural scientists received more patents than their colleagues in medicine and agriculture and forestry, which – at least research-wise – could be considered more practically oriented faculties.

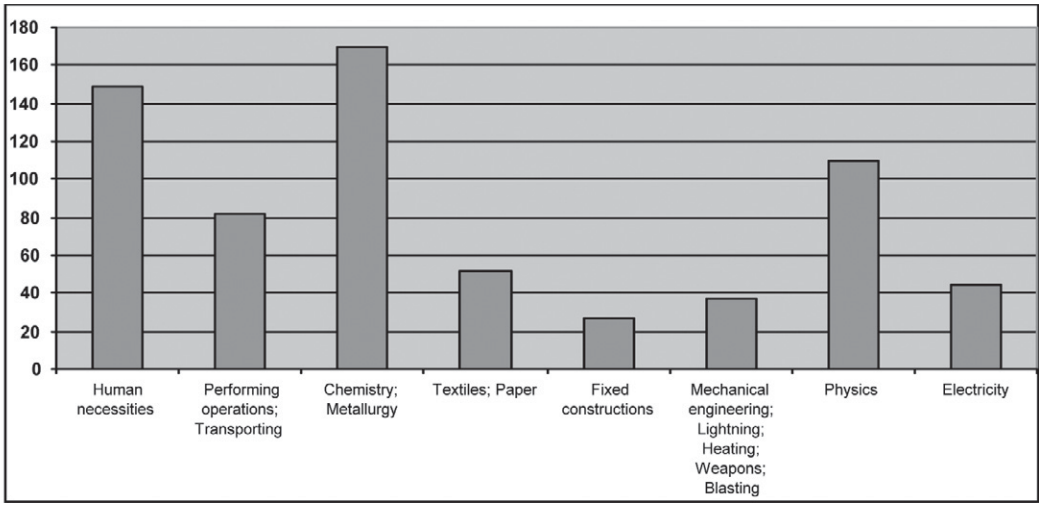
But what is common for both the University of Helsinki and the Helsinki University of Technology is that researchers with a background in chemistry were the most active developers of technology. In HUT the share of chemists was 33 % of all academic patents. In UH they were responsible for 40 % of patented inventions. Another group of scientists active in developing commercial technology in two universities was physicists. They concentrated especially on devices and methods of measurement, analysis and control.

Besides scientific fields there was also notable variation in academic patenting according to the individuals' academic status. At least in light of patent statistics the development of commercial technology was more typical among experienced scientists than their junior colleagues. Of all academic groups professors clearly dominated patenting. Second big group was adjunct professors (*docents*), who in many cases had their primary careers outside the academic world.

Department	Academic patents	Number of researchers	Patents per researcher
Architecture	8	119	0,07
Chemistry	90	94	0,96
Mechanical Engineering	70	202	0,35
Surveying	3	104	0,03
Forest Products	51	50	1,02
Civil Engineering	23	143	0,16
Electrical Engineering	58	114	0,51
Technical Physics	32	60	0,53
Mining and Metallurgy	65	66	0,98
General Science	7	107	0,07

Table 2: The share of academic patents among the researchers in different departments of the Helsinki University of Technology 1900–75. Source: Kaataja 2010.

Figure 1: The distribution of UH and HUT academic patents to different IPC-sections. Source: Kaataja 2010.



When analysing university researchers' technological output one key question is the nature of inventions developed. Figure 1 represents the distribution of UH and HUT academic patents to different IPC-sections. Even though patents can be found in all patent sections, inventions relating to chemistry and metallurgy, human necessities and physics dominated clearly academic patenting. At the other end of the spectrum are fixed constructions: scientists' contribution was minimal in technology relating, for example, to the construction of roads, railways, bridges and structural elements of buildings.

Some notable changes also occurred in the orientation of academic patenting during the 20th century. The proportion of the two biggest sections of academic patents – chemistry and metallurgy and human necessities – were stable for most of the period studied. Changes occurred in sections for electricity and physics: in both fields the number of patented inventions started to grow at the end of the century. The increase was especially notable in physics: in the 1970s and 1980s UH and HUT researchers became active as developers of new measuring equipment and physics became the most active section in academic patenting. At the level of individual patent classes another change occurred in biotechnology; there are clear signs that during the 1990s it became one of the most important fields of university-based technology.[11]

An important detail is that in patent section of physics it was not instruments of science that were patented, but applications for industrial or commercial purposes, which were often based on devices and methods with a scientific function. Thus, patenting of scientific measuring equipment was not considered necessary; patenting of commercial applications based on them was. Another typical feature relating to this technology for measurement, analysis and control is that it was developed across scientific boundaries. Researchers in several disciplines of natural sciences and technical sciences created different devices

and methods. This explains why technology relating to measuring and testing was the biggest single patent class among university scientists during the 20th century.

Science and technology simultaneously

In contemporary discussion about universities' changing role in the society one main concern is how to combine scientific research and commercial activities. Question is, can a closer university-industry linkage jeopardize the basic research with no immediate financial potential? Or can a growing activity in academic patenting hinder the publication of the gained results and increase the secrecy of research that is publicly funded and the results of which should be freely available to all?

According to the UH and HUT academic patentees of the 20th century the answer to both questions is that not necessarily. Researchers were able to combine their everyday scientific work, development of commercial technology and publication of the gained results. Only in rare occasions problems emerged and usually the connection between the three worked well.

The interconnectedness of academic research and commercial technology becomes evident in the nature of the technology scientists patented. The great majority of academic patents belonged to science-based fields of technology, where inventive activity would have not been possible without a scientific background (e.g. chemistry, medicine, instruments). On closer examination of a random sample of 58 academic patentees a clear pattern was found when their scientific careers and technology developed were compared: the great majority of patented inventions related directly to individuals' scientific expertise and to the themes they were working on when the patents were applied for (table 3).

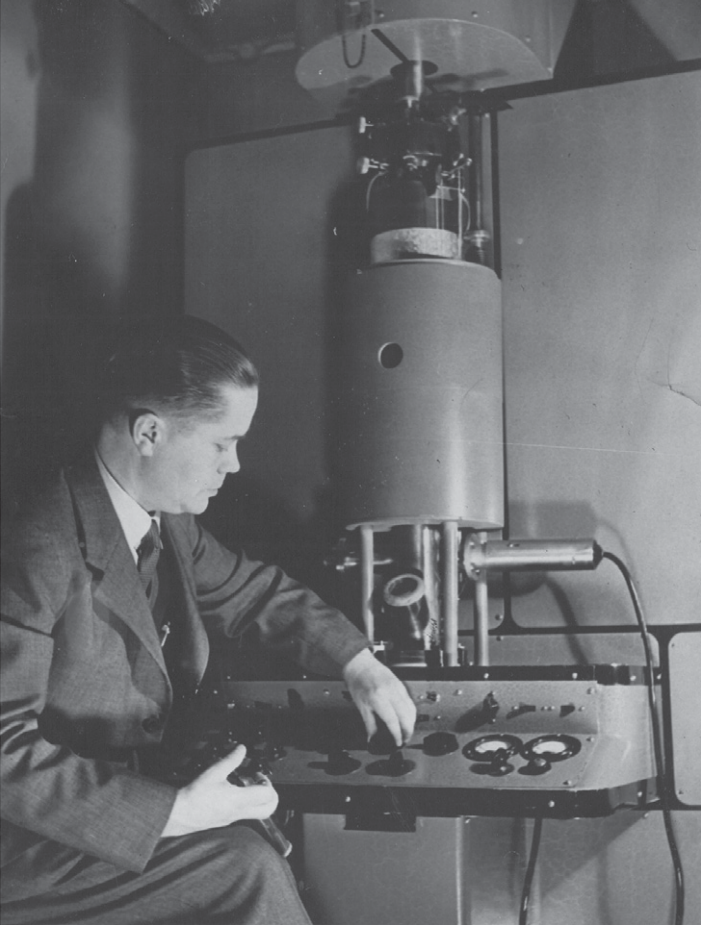
Consequently, for the UH and HUT academic patentees university career and the development of commercial technology were not separate activities, but were carried out in parallel and usually inside the academic world. The individuals studied often had a true compound career[12] where teaching, research and technological innovation activities were closely connected.

Technology transfer and commercialisation of academic inventions

A granted patent tells nothing about the importance of the technology developed. Only if inventions are transferred to markets and successfully commercialised can they become innovations of commercial and societal significance. In the case of academic patents it was possible to examine the level of technology transfer with the help of inventions, which patent rights ended up to company possession. It turned out that 57 % of the patents developed inside universities became company property.

Table 3: The linkage between patented technology and scientific expertise. Source: Kaataja 2010.

	researchers examined	%	academic patents	%
Technology linked to scientific work	47	89	124	86
Technology and scientific work separate activities	6	11	21	14
Connection between technology and scientific work unknown	5	-	17	-



Alvar Wilska (1911–87) is an exceptional example among the 20th-century Finnish researchers who participated in the development of commercial technology. As a technically oriented person Wilska developed different kinds of widgets from very early on. As a young researcher he showed exceptional cleverness in instrument building, and for example the value of equipment and method used in his 1930s-research concerning stereophonic hearing have been only recently appreciated.

During the World War II Wilska participated, for example, to the development of anti-tank weaponry and air defence systems. His instrument for locating splinters in the human body ended up to the use of war surgery also in the Third Reich. After the war, Wilska gradually focused his research more and more to electron microscopes. In the photo on the left, dating to the early 1950s, Wilska is portrayed next to one the first Finnish electron microscopes which he had developed.

In the late 1950s, Wilska became part of the brain drain from Finland. Because of his good know-how in electron microscope construction he was first invited to New Orleans, and soon after he was offered a professorship in the University of Arizona where he worked for the next two decades. The picture of Wilska in his Arizona laboratory in the early 1970s illustrates well the development of his electron microscope. After several prototypes and thousands of hours of work Wilska had been able to reduce the size of the machine to 40 cm. Nevertheless, work with the microscope continued till 1987 when Wilska retired. Only two weeks later he passed away. The production of Wilska's electron microscope was never started.

Photos: Alvar Wilska Archive.

Even though this is only an indicative figure it suggests that the technological contribution of university scientists has not remained inside the ivory tower, but diffused for the use of society.

It is more difficult to estimate what kind of financial value technology of university origin has had to the scientists themselves, to universities and to companies that put these inventions to use. It is impossible to examine the commercialisation of each academic patent and give an estimate about the financial profit they generated. However, the existing information about the monetary significance of the university-based technology is consistent: only a small share of North-American universities who have commercialised inventions developed in their sphere have benefited financially. This also applies to individual scientists in Europe: only a few have been able to gain substantially from their technological efforts.[13] Nothing implies that the situation was any different in the two Finnish universities during the 20th century.

Regardless of a few commercial success stories to be found among UH and HUT scientists' academic patents, for the most participation in the development of new technology has not been profitable. Why? The fact is that only a small share of all the inventions turn out to be commercial successes; the majority disappear without leaving a trace in society. In the case of academic scientists three additional aspects can be found leading to a negative outcome: inexperience of academic scientists in the commercialisation of technology, absence of support mechanisms in that process, and reluctance of scientists to participate actively in the further development and commercialisation of patented technology.

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[1] Lisbon Declaration. Europe´s Universities beyond 2010: Diversity with a Common Purpose.

[2] Jones-Evans 1998.

[3] E.g. Miettinen et al. 2006; Kutinlahti 2005; Balconi et al. 2004; Schmoch 1999; Schmoch et al. 1996.

[4] E.g. Lissoni et al. 2008; Meyer et al. 2003. Swedish Torkel Wallmar is an exception among European scholars because he has analysed the technological output of the Chalmers University of Technology from a more historical perspective. Wallmark 1997.

[5] Kaataja 2010.

[6] In the article the term "commercial technolgy" refers to researchers' applications that were developed for commercial purposes. The term is not to be mixed with Schumpeterian concept of innovation referring to commercialised invention.

[7] Also a detailed examination of seven individual UH and HUT scientists was included in the original study. Those cases offer more detailed information about the everyday experiences that cannot be traced from patent statistics: the opportunities, difficulties, demands, successes and failures researchers faced while developing commercial technology. These results are not included in this article.

[8] More of the definition of academic patenting see Meyer 2003.

[9] It has to be kept in mind that only two Finnish universities were examined. When other academic institutions are analysed in the future, more sectors of technology may appear where researchers have been important developers of new technology.

[10] Lissoni et al. 2008; Balconi, Breschi, Lissoni 2004, 136–137; Grupp, Schmoch 1992, 110–112.

[11] For the time being there is a lack of research concerning academic patenting in Finland at the turn of the millennium. Therefore it is impossible to say to what extend the shares of e.g. biotechnology and ICT have increased among the researchers' patents.

[12] Different terms have been used when describing researchers' working among both academic research and commercial technology. E.g. Eda Kranakis, Bernward Joerges and Terry Shinn write about hybrid careers (Kranakis 1992, 178–79; Joerges, Shinn, 2001, 3), whereas George Wise prefers compound career in his work (Wise 1985, 48). The idea of the university researchers' double role is by no means new. Already in the early 1960s Joseph Ben-David brought up the hybrid roles scientists have and the influence it has to science and technology. Ben-David 1960, 557–568.

[13] Mowery, Sampat 2001, 332–334, 353; Nelson 2001, 17; OECD 2003, 72.

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