

Industry needs universities and vice versa

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Competitiveness emerges from knowledge

Today we have approx. 1 billion Internet connections and more than 3 billion mobile phone subscribers. Both numbers are steadily increasing. Information flows around the world instantly through electronic media. Today, people send more than 1500 emails per person per year, and the distance or the size of the mail does not increase the cost. One can send a person's annual accomplishment of creative work, in industrial design or humanities, anywhere in the world in a few seconds. Internet telephony has resulted in the price of transatlantic telephony disappearing into the monthly broadband connection cost. The fundamental capability of people being connected easily and at low cost to each other, and to various kinds of data banks such as Google and Wikipedia, is changing our lifestyles and work practices probably faster than ever before.

At the same time, less and less labour force is needed to make physical products. This is largely due to increased use of automation and innovative product concepts. In the U.S.A., the manufacturing of goods corresponded to approx. 27% of the labour force in 2004 and only approx. 3% to agriculture, with the remaining 70% working in software, development and services. Transport of physical goods over long distances has become faster and less expensive. Obviously, in physical transport, we cannot have quite as significant cost reductions as those seen in transporting bits.

This all means that the role of geography is playing a decreasing role in determining where companies locate their activities. Manufacturing tends to be located in countries where the balance between the needed competence level and labour cost is optimal. Knowledge does not travel over long distances as easily as information. Even though creating knowledge requires strong international networking, it is, to a large extent, tied to locations with proven track records and the capability to attract the best people. The top universities tend to be the same few universities year after year.

As the competitiveness of companies increasingly depends on their ability to renew themselves, it is only natural that their interest in leading-edge research is increasing. This is a good motivation to companies to participate in international or national development programmes, as well as establishing direct links with leading universities in their fields of interest.

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Basic research lays the foundations

As the paths of curiosity-driven basic research are countless and the outcomes are largely unknown, it is only natural that this activity is publicly funded. On the other hand, results from basic research form the foundations of practically all industrial sectors. Let us take one example from the telecommunications sector to show how at first unrelated research results start to show a pattern, and how emerging technological advances amplify basic research and make it also adopt new paths.

As outlined above, there has been phenomenal progress in the area of telecommunications, and especially in mobile phones, during the last 20 years. As shown schematically in Figure 1, the major basic research contributions that were necessary for the first GSM (global system for mobile) phone call to be made in Helsinki in 1991 date back to the early 1800s. The top line follows advances in physics-related disciplines, and the bottom line in mathematics. It is interesting to note that the two lines of development have already for a long time interacted, as shown by the arrows. Seemingly unrelated research breakthroughs form a meaningful chain of advances. It is also worth noting that both physics and mathematics have given birth to numerous other specific areas of scientific research as the first applications of telecommunications have emerged.

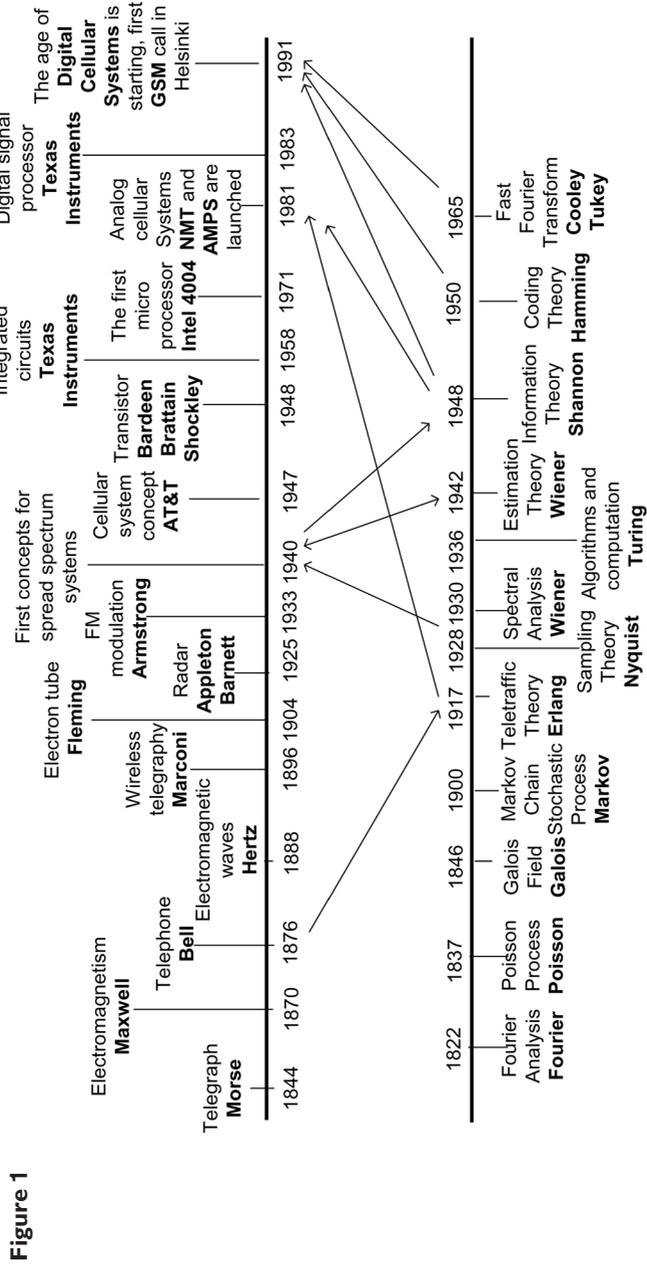
These include: telecommunications theory, computer science, semiconductor physics and microelectronics. In fact, research activity related to the telecommunications industry has grown so much since the 1970s that it has become impossible to put them on one simple chart. Instead, some technological breakthroughs are shown.

Some of the new research fields locate themselves somewhere between the two lines, and signal processing is a good example of such a field. Advances in signal processing has also greatly benefited research areas that are outside the scope of Figure 1. Examples of these are: acoustics, phonetics and human visual-systems research. The first book on signal processing was published in 1969 [1]. Today, signal processing is taught in both undergraduate and graduate courses all around the world. As a whole, this long path serves as a good example of the complex set of multidisciplinary interactions that lay the foundations for technological advances.

Industrial research and development

Companies spend a varying amount of their revenue on R&D (research and development). This percentage depends on the nature of industry, as well as on their relative position in the innovation chain. In basic manufacturing industries, R&D is approx. 1% of revenue, and can be above 10% in companies where the product is practically ready once the R&D phase has been completed. Examples of this latter are system and software companies.

A list of the world's top R&D spenders in 2006 [2] shows that the most R&D-intensive company was Toyota Motor, with an annual R&D spend of \$7486 million. Most of the top R&D spenders are within the automobile, pharmaceutical and ICT (information and communications technology) industries. In the ICT field, Microsoft has the lead, with \$7121 million, followed by Samsung, Intel,



Historical milestones needed for cellular telephony to emerge

IBM, Nokia, Sony, Motorola, Sisco and Ericsson in the range from \$6 billion to \$4 billion. These sums are many-fold larger than university budgets. However, the R&D budgets are tightly connected to the short-term business-related product-development targets. Typically only a small fraction of R&D money is available for applied or basic research within the business scope of the company.

Let us take the Nokia Corporation as a concrete example of R&D activities. Nokia spends approx. 10% of its net sales in R&D. Product development is conducted in 11 countries by 14 500 people. They are needed to develop the technical solutions for the next generation of mobile phones. The R&D sites are strategically located, taking into account available competencies, market presence and, for some sites, the proximity to manufacturing sites. NRC (Nokia Research Centre), with approx. 830 employees, develops the longer-term future of Nokia. In certain selected areas, NRC is at the leading edge of basic research. NRC actively contributes to the scientific community, as shown by the number of conference papers, journal articles and books written by NRC personnel. In addition to continental Europe, NRC conducts research in Tokyo, Japan; Beijing, China; Cambridge, U.K., and Cambridge and Palo Alto, U.S.A. It is easy to see that these are major innovation and research locations. Nokia co-operates with roughly 100 universities worldwide.

Benefits of industry–academia co-operation

One often hears negative statements concerning co-operation with industry from the university side. There is the fear that industry, with its large financial resources, could leash the university in order to serve industry's short-term needs and thus make it lose the interest and capability to conduct open long-term research.

Certainly, industry knows what areas of science and technology might be of interest in the future. Sponsoring co-operation in those areas is only natural, but the target should be knowledge that industry does not have nor cannot create with its own personnel. It would be extremely short-sighted for a university to sacrifice its own basic research for short-term industry-led projects. In doing so, the university would gradually deplete its knowledge base and so lose the interest of industry to co-operate. A summary of industry's expectations from a good university partner is given in Figure 2. We will take a closer look at the IPR (intellectual property right) and contractual issues below.

Figure 2

- Top-level scientific knowledge
- Broad, cross-disciplinary understanding, understanding broader perspectives
- Being international, global - competition is increasingly global also for universities
- Excellent and relevant education to nurture new talent and to succeed in international competition
- Atmosphere of enthusiasm and renewal, hard work
- Innovativeness, capability to create innovations from research results
- Streamlined contract policies and practices
- Clear and motivating IPR policies

Industry's expectations from universities

On the other hand, dialogue with industry can help the university to guide its education and research activities. The motivation to learn and to conduct research increases with the knowledge that the areas of teaching and research have relevance to industry. The scientific approach mastered by university researchers lets them tackle difficult problems in co-operation projects. The basic research contribution can be separated from this context and published jointly in scientific journals. Companies can, in return, give guidance to universities on how to manage large projects with tight schedules and budgets. Companies have processes that impose certain standard ways of handling daily practicalities. Adopting a similar approach can help university researchers to focus on substance.

There is evidence that good basic research problems can be extracted from the industrial environment. These problems can be hiding behind the 'rule of thumb' practices used in a company. The creation of a solid underlying theory can be enormously valuable for the company, and a valuable basic research contribution as well. For instance, replacing a tedious optimization task with a set of analytical expressions characterizing the problem and giving the optimal solution helps with design work and possibly opens up new avenues for development.

There is no doubt that industry-academia co-operation benefits both parties [3]. Both sides can and should receive the benefits of co-operation as equal partners. A common mistake from the industry side is not to tie enough of their own resources to the project. The research results need to be transferred to the company's knowledge, and that takes time and effort.

In addition to joint research programmes, there are many other forms of co-operation. Industry can participate in university governance, teach courses and naturally help in starting enterprises. A summary of areas where industry can help a university in reaching its mission is listed in Figure 3.

- Employ researchers and students
- Teach courses at universities
- Be member of Council, Board, Trustee
- Finance and participate in research projects
- Increase the industrial relevance of education
- Give challenging problems to tackle
- Increase the motivation to researchers by showing the relevance of research
- Help in getting innovations out of research
- Train managing large projects
- Help in establishing new enterprises

Figure 3

Different ways industry can help universities to reach their missions

IPRs

Global competition for innovation and jobs has increased the pressure for universities to show that research also has commercial value. Science and technology

parks around universities are excellent examples of how university research can be transformed into high-technology companies.

Producing patents can be seen as another measure indicating that research results are of practical value. There is also the hope that patents can be sold out or used to collect royalties in order to make a profit or, at least, to cover the costs of creating and maintaining a patent portfolio. For professors who have long lists of scientific publications in their CV, adding a few patents there can be an additional differentiating merit.

Getting a patent is not that difficult once you have reached a certain level of knowledge in a certain discipline. However, getting a patent that is of any significant value is difficult. Here, well-established co-operation relationships with industry are of great help. Industry can guide the researcher to a potentially interesting and relevant area of study. If something emerges from the research that might be patentable, good co-operation with an interested industrial partner can make a very significant contribution to the relevance of the patent. Once the invention itself is ready for patenting, there are still many ways to write the patent claim. At this phase, the best results are generally obtained if the company that wants to acquire the patent is already in the driver's seat. In an ideal case, this is the phase where the researcher can start working on new challenges and let the tedious details of patenting become the responsibility of the co-operating company.

Patenting and keeping a patent portfolio is a significant cost item for companies. Companies have IPR strategies where the areas of patenting, as well as the number of patents to be created per annum in each specific area of interest, is explicitly stated. Statistics on U.S.A. patents granted in 2006 by leading companies in different industrial sectors gives an estimate of the relative strength of the portfolio. For instance, in the telecommunications equipment manufacturers sector, the top five companies in patenting in the U.S.A. were: Alcatel-Lucent (885 patents), Motorola (798 patents), Nokia (744 patents), Cisco Systems (676 patents) and Qualcomm (415 patents) [4]. As these numbers do not include European and Asian patents, the total number of patents granted is larger. However, the U.S.A. figures alone suffice to show that patenting is a regular major activity of leading companies.

In the telecommunications sector, standards play a significant role, as the interoperability of different manufacturers' implementation of the same system is required. A patent is called essential if the implementation of a system requires using that patent. Essential patents are more valuable than normal patents, as all companies manufacturing products based on that standard have to get licences to use these patents. An essential patent in a widely used standard would provide a nice income to a university having such a patent. Let us take a simplistic example. Let us assume that the annual sales of cellphones complying to GSM standard is 1 billion, with an average sales price of €100, and the royalty from one essential patent is 0.01%. This would result in an annual €10 million licencing income.

To get an essential patent to a standard requires a fair amount of research resources working on the topic for years before the standardization work is started. During the standardization phase, one has to have some tens of highly competent resources contributing to the features and functionalities of the forthcoming standard and, most importantly, one has to be able to defend the patented solution

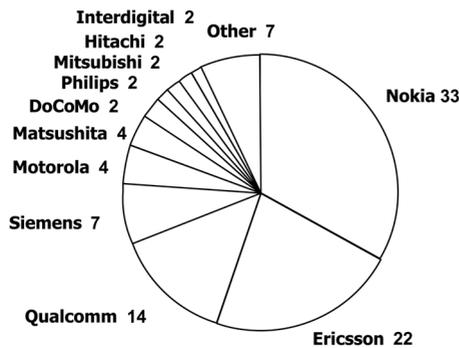


Figure 4

Distribution of essential patents in the WCDMA standard

Values are percentages of the total number of essential patents in the WCDMA standard for each company.

against competing proposals by using analytical and simulation methods. This makes it impossible for a university to create an essential patent alone. The distribution of essential patents in the 3G cellular standard currently being deployed around the world is shown in Figure 4 [5].

We have used the telecoms sector above as an example of patenting. Obviously there are differences between industrial sectors and also between small and large companies. In biomedical and pharmaceutical industries, the importance of patents seems to be even larger than in the telecoms sector. There is also the fact that the path from basic research to a stage where the value of the patent materializes is long and requires industrial-scale resourcing.

The phase of creating patents comes well after the basic research phase. Universities should focus on their unique capability to conduct basic research and base their co-operation with industry primarily on that skill. Obviously that requires a level of maturity from industry as well. It is paradoxical and sometimes frustrating to notice how tedious and repetitively time-consuming the IPR negotiations have become. Once a project has been started, the difficult issues in the negotiation phase seem to have become meaningless.

Towards open innovation

In the software and Internet fields, success of an innovation is often based on the fast adoption by a large number of users. In this kind of an environment, strict patenting and licencing procedures would be quite detrimental. Giving free use and rights to improve the application further (assuming that you agree to follow certain general principles) has turned out to be a very powerful approach. The Linux operating system and open-source web browsers are popular examples of this. The open-innovation approach can speed up innovation, improve the quality and lower the development and maintenance costs of a software package. In order to be successful, open-innovation projects also need good professional project-management resources.

An extreme example of the power of an open community working voluntarily for the common good is Wikipedia (<http://www.wikipedia.org/>), the web-based encyclopaedia. It is seriously threatening the existence of traditional encyclopaedias. Wikipedia is written collaboratively by volunteers from all around the world. Since its creation in 2001, Wikipedia has grown rapidly. There are more than 75 000 active contributors working on approx. 9 million articles in more than 250 languages. As of today, there are more than 2 million articles in English. All of the text in Wikipedia, and most of the images and other content, is covered by the GFDL (GNU free documentation license). Contributions remain the property of their creators, while the GFDL ensures that the content is freely distributable and reproducible.

A weakness in industry–academia joint projects tends to be the shortage of manpower from the side of industry. As a result, academia continues working essentially along their traditional research track and the company is not able to digest the results of the research sponsored by them. NRC has now established a new type of joint-research mode. The first setup is with MIT (Massachusetts Institute of Technology). The objective is to develop technologies beyond the commercial horizon in an open-innovation model by placing approx. 40 MIT and approx. 20 Nokia researchers in a common laboratory facility. Each joint project depends on both MIT and Nokia people.

Conclusions

Research co-operation between industry and academia benefits both parties. The requirement for knowledge-based competitiveness makes companies seek the best research teams, regardless of national borders. Industry–academia co-operation should never be a substitute for excellence in basic research and teaching. The most valuable domain for co-operation is where university basic research and the long-term strategy of a company start to have common ground. IPRs are one way of showing that university research has commercial relevance. To make IPR generation profitable, intimate co-operation with companies is essential. The open-innovation approach, common in software and Internet applications, is also a promising approach in broader environments.

It is important that universities have well-defined and streamlined processes for handling co-operation projects. Financial incentives should be used to encourage professors to seek external project funding. This chapter was written largely from a large company's point of view. In order to co-operate with small- and medium-sized companies, the university should be able to also address the shorter-term needs of a company. This can be done directly or via a broker. Anyhow, the main mission of the university should not be forgotten.

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