Measuring the Economic Effects of Companies Collaborating with the University of Copenhagen

Copenhagen, June 2012

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Content

1 Executive summary

This economic impact analysis measures the effects of R&D collaboration with the University of Copenhagen. The effects are measured at company level in terms of increased value-added in companies. Thus, the analysis only focuses on a part of the total value that the University of Copenhagen creates for the surrounding society through collaboration with companies. As such, the impact of education and other activities at the university are not included in of this analysis.

The main conclusions from the analyses are:

- We find strong evidence of a positive causal link between companies entering into R&D collaboration with the University of Copenhagen and the development in companies' productivity per employee. More specifically, **companies entering into collaboration increase their productivity per employee with a yearly average of 6.5 pct.**

- The positive causal link to increasing productivity corresponds to an annual **net gain of € 7,000 per employee on the bottom line** for each company as an effect of collaborating with the university.

- On average this corresponds to a yearly € 2.43 million **improvement of the bottom line of each collaborating company,** as the average company size is 350 employees. With 625 unique companies in the analysis this adds up to a **total economic impact of € 1.5 billion a year**.

- As many as 1,537 different companies have formally collaborated with the University of Copenhagen in the period 1998 to 2009. In that time frame the number of collaborations has increased year by year. In 1998 the number of formal collaboration was 227. In 2008 this figure peaked with almost 800 individual formal collaborations between companies and the university.

- Whereas the econometric analysis shows that formal R&D collaboration generates higher productivity, the qualitative case studies indicate that such formal collaboration often rests on a much broader and often informal set of interactions between the collaborating partners. This has important policy implications, as it is not enough to stimulate formal R&D collaborations; policymakers and the university itself must also stimulate and facilitate other forms of interaction between companies and universities in order to create a solid fundament for fruitful collaborations.

The University of Copenhagen does play a significant part in creating value for companies located in Denmark. The figure economic impact of € 1.5 billion is merely a minimum estimate of the total value that the university creates for its surroundings. This analysis does not identify effects from informal R&D collaborations, the direct impact of alumni or the indirect effects of alumni who create well-functioning public institutions, general knowledge stock increases and others.

The following presents a short version of the report "Value of a Research-intensive University - Measuring the economic Impact of the University of Copenhagen". For a more in-depth version and a more thorough review of the methodology, please read the full report.

2 Motivation and scope

Universities play a significant role today. Historically they have played a crucial role as the backbone of society, a role they still fulfil by educating excellent skilled citizens, but also by conducting basic and cutting edge research. The universities are an important engine for knowledge production and innovation. Thus, the universities are a determining factor in the global knowledge-based economy.

As such, universities carry out many different activities with different impacts on society: building knowledge, developing new insights, education, knowledge transfer through collaboration with external partners etc. The activities vary between many disciplines, and the impact on society therefore takes on many different forms.

One of these many activities refers to the relations between the universities and knowledge spillover through research and R&D collaboration with companies. This topic has in the Danish context as well as in international research policy debates been subject to increasing focus.

There is only limited tradition for evidence-based and knowledge impact assessments. This is so despite the fact that more and more demands regarding this knowledge are put forward in terms of evidence of the effects of funds invested in research. Some universities in the US, e.g. MIT, University of British Colombia and Princeton, and the University of Cambridge in the UK measure the economical impact though these studies are more descriptive than analytical[1].

This analysis will uncover potential effects of the University of Copenhagen. The analysis is based on econometric modelling and on applied methodologies used in academic research and pinpointed among international organisations as best practice for measuring the effects of R&D collaboration[2].

This analysis focuses solely on the value created through interaction between the university and companies and the value it creates in companies in terms of productivity and employment growth.

On the contrary, this implies that a lot of the value a university creates for the surrounding society will not be covered. Figure 2.1 provides a number of examples of how a university creates value for the surrounding societies. The examples are categorised between effects that are quantifiable and effects that are not. Furthermore, the general increase in knowledge stock can to a certain extent be quantified. Value can be in terms of:

Non-quantifiable effects:

- Sound Supreme Court judges to enforce the laws of the country and thus create the institutional stability that is crucial for a country's economic stability and development.
- Skilled economists in order to prevent the country from running with large deficits on national accounts, which either will lead to national bankruptcy or strong austerity measures resulting in unemployment and economic stagnation and recession.
- Setting social norms and cultures, e.g. through theology, which has played a crucial part in the

[1] One can discuss whether these economic impact studies are in fact measuring the effects of the universities. Measuring effects and impacts implies setting up a counterfactual situation; see OECD, Eurostat, the World Bank Group and NBER. Setting up a counterfactual situation is setting up a situation without the particular university. Sudmant (2009) denote this approach as '... an extreme approach to economic impact'. Even so, it is the ambition of this analysis to conduct an economic impact assessment setting up a counterfactual situation and thus measuring the value-added created through collaboration with the University of Copenhagen.

[2] E.g. OECD: *Outline of principles in impact evaluation*, Eurostat (2002): *RTD Evaluation tool box,* World Bank (2010): *Hand book on impact evaluation – quantitative techniques and practices*, Fernandez-Ribas & Shapira (2009): 'The role of national and regional programmes in stimulating international cooperation in innovation' in *International Journal of Technology Management.*

development of society and norms throughout the past centuries.

- Skilled doctors who provide treatment for the population and wellbeing for the workforce, improving the mortality rates with increasing populations as a consequence.

Quantifiable effects:

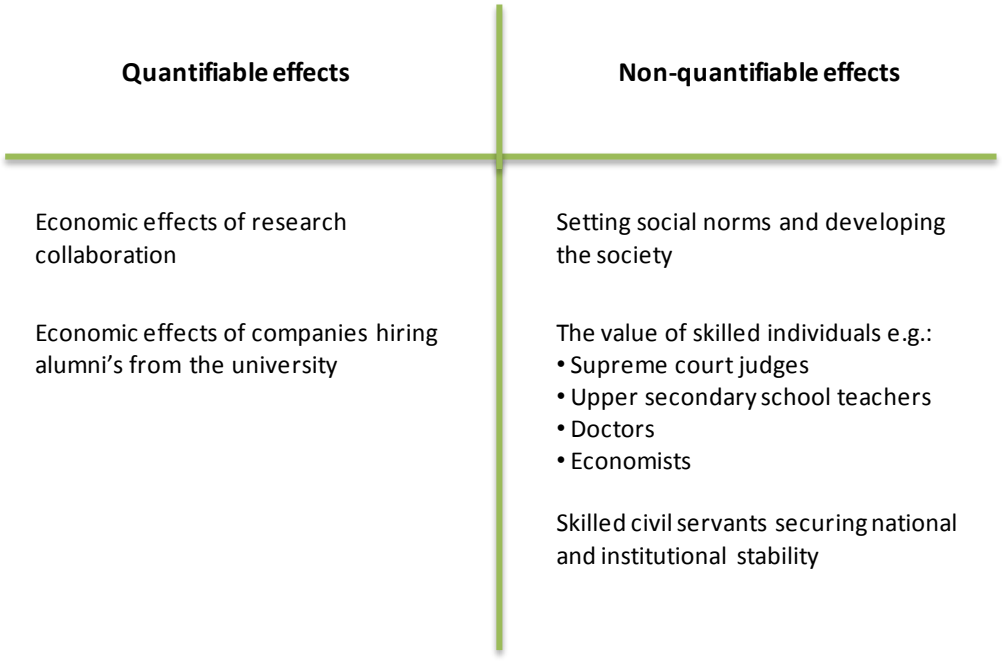
- Gains from knowledge spillover between university and companies. Knowledge and especially cutting edge knowledge have proven to be a crucial competitive parameter for nations, regions and individual companies.

Figure 2.1 is divided into effects that are quantifiable and those that are not. Whereas gains from knowledge spillover related to company-university collaboration can be assessed, it is somewhat more difficult to quantify the value of setting cultural and social norms, having skilled civil servants secure national and institutional stability.

It is beyond doubt that skilled doctors, civil servants, high court judges etc. have a massive economic impact on society. However, this is not the focus of this analysis. The focus of this analysis will solely be on the effects of collaborations between the University of Copenhagen and companies based in Denmark.

FIGURE 2.1

Examples of the impact a university can have on society



Source: DAMVAD 2012
Note: The list is by no means exhaustive

3 Collaboration: definition, magnitude and potential effects

It is important to this analysis define the concept of collaboration between university and companies. Collaboration is by no means a one size fits all term. Collaboration varies across the participating parties, the areas of research and collaboration focuses. In order to define collaboration we distinguish between formal and informal collaboration.

Informal collaboration can be difficult to identify and difficult to quantify. They cover activities such as conferences, dialogues, presentations and lectures. This analysis focuses solely on collaboration of a more formal nature, such as R&D collaboration based on public R&D schemes, contract-based co-financed R&D projects, acquisition of R&D or joint publications and patents. The figure below shows four channels of formal collaboration:

- Buying R&D from the university (e.g. based on a contract).
- Co-financed R&D projects (e.g. financed through company budgets and basic university funding).
- R&D collaboration based on public R&D schemes (e.g. the Danish Council for Strategic Research or the Danish Innovation Consortia).
- Joint publications and patenting.

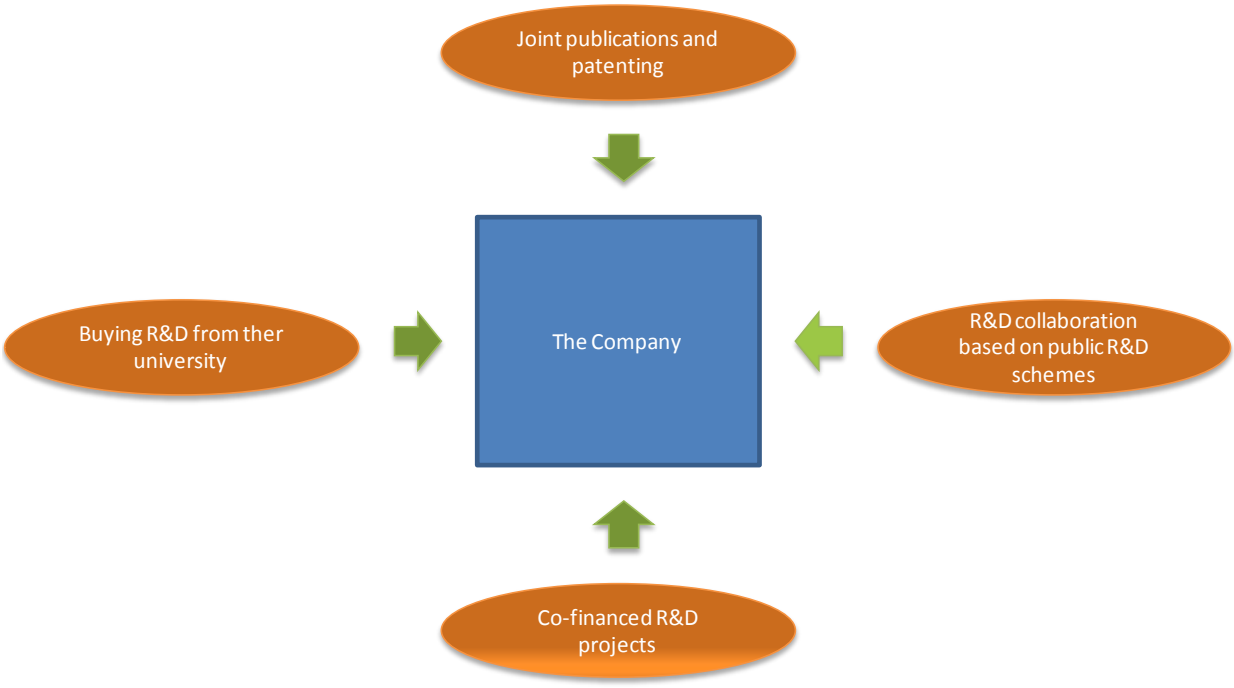
This analysis only focuses on two of the above-mentioned channels of collaboration: R&D collaboration based on R&D schemes and co-financed R&D projects. As such the definition of collaboration is:

Definition of collaboration:

In this analysis collaboration is defined as the formal collaboration between a company and the University of Copenhagen. Formal collaboration involves a financially binding agreement between the two parties and typically participation in a formal project e.g. financed through public R&D schemes or the company buys access to research or technical help conducted by the university.

FIGURE 3.1

Channels of collaboration between the company and the university



Source: DAMVAD 2012

TABLE 3.1

Number of collaborations with Danish and foreign companies via different channels of collaboration

	Danish	Foreign
Projects registered at the University of Copenhagen	1,634	649
Public R&D and innovation schemes	360	8
Joint publication	3,671	N/A
Patenting	16	N/A
Total (on nationality)	5,681	657
Total	6,338	

Source: DAMVAD 2012

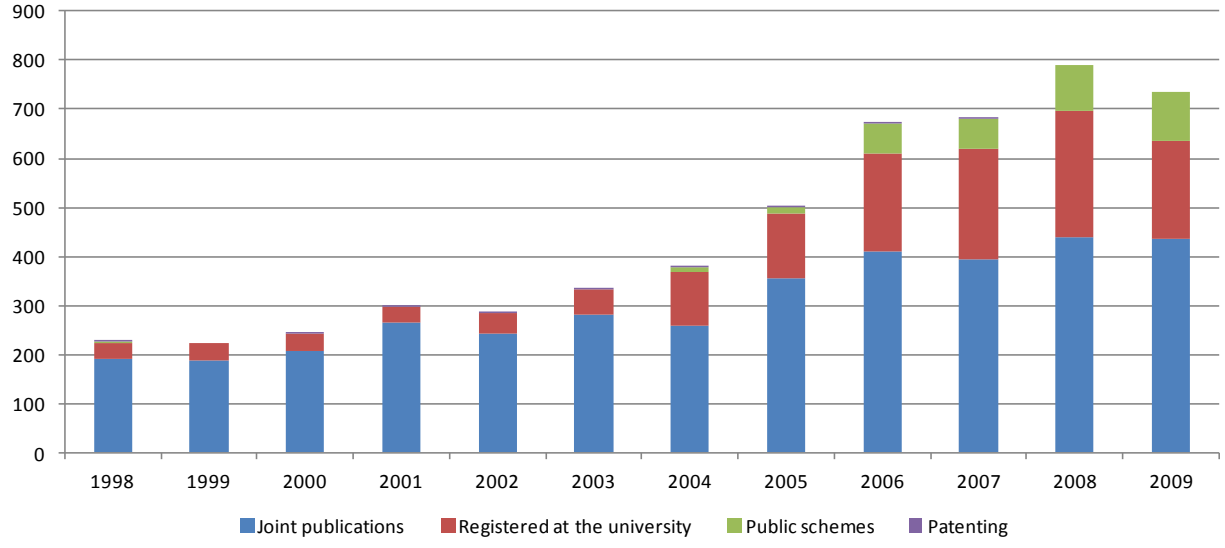
The University of Copenhagen has a broad interface with companies. Table 3.1 shows that companies have been participating in 6,338 collaborations with the university in the time span from 1998 to 2009. 1,537 unique companies have been involved in these collaborations of which 1,020 are located in Denmark and 517 are foreign companies. This means that several companies have collaborated with the university more than once and that these include companies located in Denmark primarily.

Furthermore, Table 3.1 shows the different channels of collaboration and the number of collaborations that have in fact been identified. As such, the table shows that for companies located in Denmark the most common form of collaboration is through joint publications. On the other hand, the most common channel of collaboration for foreign companies is a formal collaboration with the university.

Figure 3.2 shows the number of collaboration over time. The total number of collaborations has in-

FIGURE 3.2

Number of collaborations per year, 1998-2009



Source: DAMVAD based on data from the University of Copenhagen, Thomason Innovation and the Cooperation Database.
Note: Information exists from 1994 to 2011, but the focus of the analysis is only on activities between 1998 and 2009, as this is the period in which it is possible to measure the effects hereof.

creased constantly since 1998, though there is a small decline in the number of collaborations from 2008 to 2009. In 1998 the number of identified collaborations was 227. The figure has increased to 736 in 2009 and initially peaks in 2008 with almost 800 collaborations.

3.1 Potential effects of collaboration

The economic effects from research collaboration between the university and companies can be multiple and appear at different times. Figure 3.3 shows the plural effects companies can experience from collaborating with universities at different time levels:

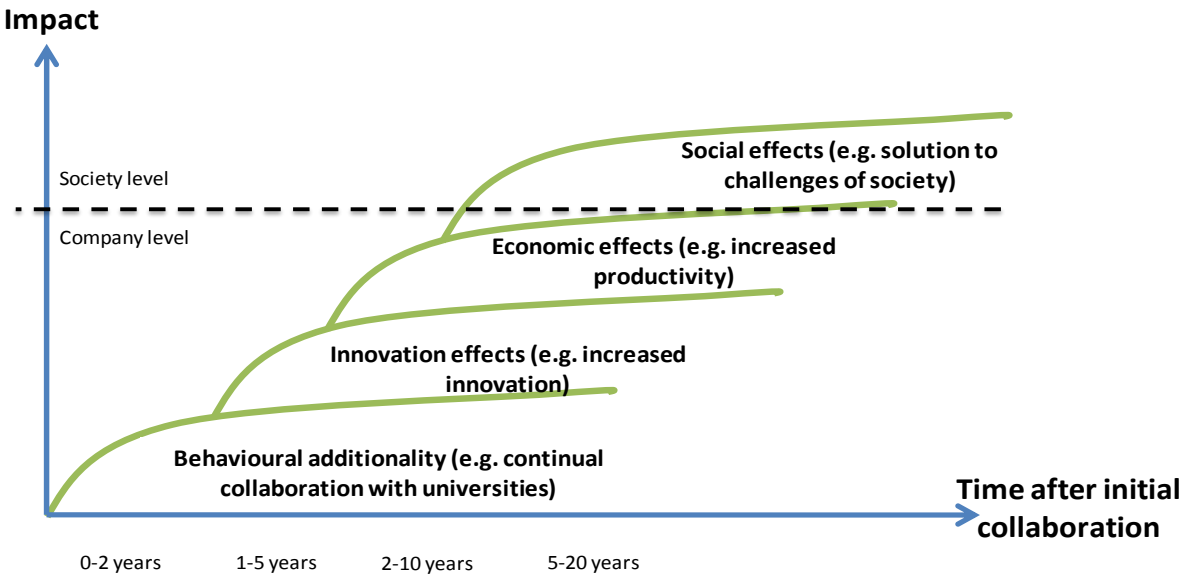
- **Behavioural additionality,** e.g. strategic changes in management, organisational changes via R&D collaboration with universities.
- **Innovation effects,** e.g. more innovation, increased R&D activity or patents.
- **Economic effects,** e.g. increased productivity or increased employment.
- **Social effects,** e.g. socio-economic growth, new solutions to challenges in society related to health, environment or energy.

The above levels of effects show that the effects of company collaboration with the university underline the fact that collaboration affects companies and the surrounding society in many different ways. Furthermore, one type or level of effect does not exclude others. E.g. innovation effects in terms of increased innovation can lead to economic effects at company level, whereas effects at society level will manifest themselves on the long term, e.g. in the course of 5 to 20 years or in some cases even longer. The behavioural changes, on the other hand, may be present immediately after the initiation of the collaboration.

This analysis will focus on the economic effects on company level through econometric and quantitative analysis. Furthermore, the analysis will focus on a particular behavioural additionality. The behavioural and innovation effects will be included in the quantitative part of the analysis. Thus, they will be in focus in the case studies.

FIGURE 3.3

Different impacts of R&D collaboration on private companies



Source: DAMVAD 2012

4 Measuring the effects of collaboration

This central part of the analysis focuses on the quantitative effects companies experience from their collaboration with the University of Copenhagen[3]. The results are:

- We find strong evidence of a positive causal link between companies entering into R&D collaboration with the University of Copenhagen and the development in these companies' productivity per employee. More specifically, **companies entering into collaboration increase their productivity per employee with a yearly average of 6.5 pct.**
- The positive causal link to increasing productivity corresponds to an annual **net gain of € 7,000 per employee on the bottom line** for each company as an effect of collaborating with the university.
- The net gain of € 7,000 per employee **improves the bottom line of each collaborating company by € 2.43 million,** as the average company size is 350 employees. With 550 unique companies in the analysis this adds up to a **total economic impact on companies located in Denmark of € 1.33 billion**.
- On the contrary, we have not been able to find valid results from the analysis on spillover effects. The lack of validity is due to a lack of proper data and information about investments in R&D.

The following provides a more in-depth description of the results.

[3] The analysis is based on econometric modelling. The models used are being pinpointed among international organisations as best practice for measuring the effects of R&D collaboration. The methodology builds on the concept of creating the most solid and robust control group based on companies that do not collaborate with the University of Copenhagen. The more alike the control group is the more solid and robust are the results. Our analyses show that there is great accordance between the two groups and as such we are able to compare alike with alike and obtain solid and robust results.

4.1 Companies gain from collaborating with the University of Copenhagen

The econometric analyses point to a positive causal link between companies entering into R&D collaboration with the University of Copenhagen and the development in these companies' productivity per employee. Figure 4.1 presents the collaboration effect over time and shows the percentage-wise productivity growth that companies experience as a result of collaborating with the University of Copenhagen.

The analysis in figure 4.1 is based on 170 companies collaborating with the university. The control group consists of 1,402 companies.

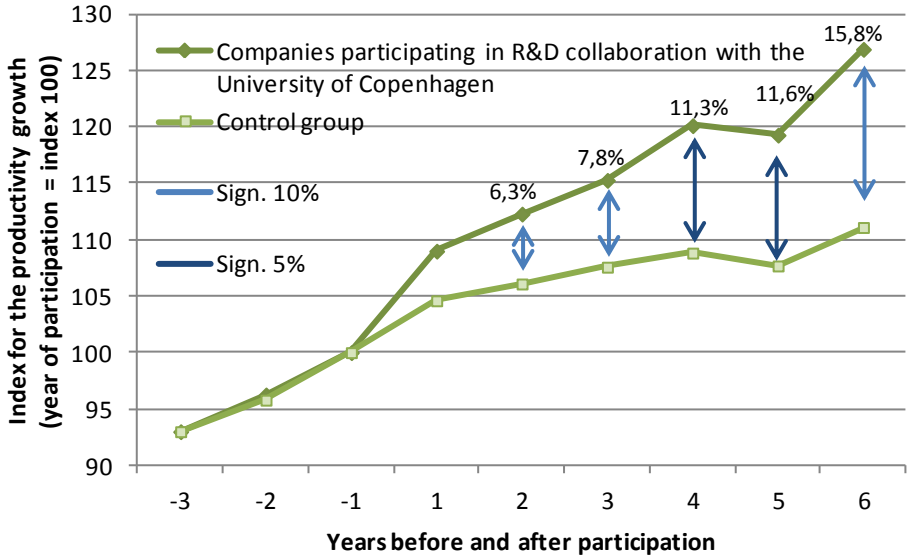
Two years after establishing the collaboration there is a significant positive effect on productivity per employee as a result of participating in R&D collaboration; the effect remains statistically significant and increases over the time.

The participation effect is measured as the difference between the two curves. Two years after establishing knowledge interaction, the companies experience a productivity return of 6 pct. which increases to 11 pct. gain four years after establishing the collaboration. The first year after participation does not show any significant differences in performance between the control group and the treatment group. This implies that it is not possible on a reasonable basis to reject that the two groups perform similarly the first year after participation.

Furthermore, the figure shows the productivity development prior to establishing collaboration for the control group and the treatment group. The pre-collaboration performance is denoted time -1, -2 and -3 meaning year 1, 2 and 3 before initial collaboration.

FIGURE 4.1

Causal effect on productivity increase of collaborating with the University of Copenhagen



Source: Calculations by DAMVAD based on micro data from Statistics Denmark

The two groups have an almost identical productivity growth in the year preceding the establishment of collaboration. This indicates that the methodology exploited has successfully managed to identify a credible control group. This implies that the result can be interpreted as the causal relationship between entering into R&D collaboration with the University of Copenhagen and an effect in productivity per employee.

The conclusions should take the question of unobservable factors into consideration. There is a fundamental difficulty in assessing factors with relevance for the identified effects that are unobservable. However, this is the best possible basis for assessing the impact. Furthermore, the analysis includes many different observable factors such as company size, industry, R&D, educational level and background, company performance, import/export relations etc. in the years prior to the initial collaboration. In total, this gives extensive knowledge about the individual companies. The potential unobservable factors do apparently not influence the observable factors regarding company industry, performance, R&D strategy, human resource strategy etc. prior to the collaboration.

4.1.1 Ruling out the effect from collaboration with other universities

This analysis concerns the companies with R&D collaboration with the University of Copenhagen. Meanwhile, companies might have knowledge interaction with other Danish or foreign universities which is not handled in this analysis.

The impact from collaboration might distort the estimated participation effect. The estimation could suffer from a downward bias due to the fact that the identified control group might have experienced an unobserved gain from collaborating with other universities. This in turn will reduce the estimated treatment effect.

On the other hand, the impact assessment could suffer from an upward bias, since companies collaborating with the University of Copenhagen might in addition collaborate with other universities. This

would imply that the participation effect from collaborating with other universities could potentially be ascribed to the interaction with the University of Copenhagen.

Figure 4.2 presents the results from limiting the control group data to include only collaboration with the University of Copenhagen. Thus, potential effects from collaborating with other universities are ruled out in the control group.

Overall the results are much alike as the figure 4.1 and 4.2 show. This is so even though we should expect a better performance of the treated group.

The results indicate immediate effects after year one, whereas figure 4.1 showed effects after two years. Here, there is an immediate effect in the form of a 7.4 per cent increase in productivity. There is a more immediate short term effect, whereas the effect levels are somewhat alike in the following periods of time. Finally, in figure 4.2 it seems that the effect diminishes in year 6. This is somewhat unexpected compared to the results in figure 4.1, where we see an effect in year 6 after the initial collaboration.

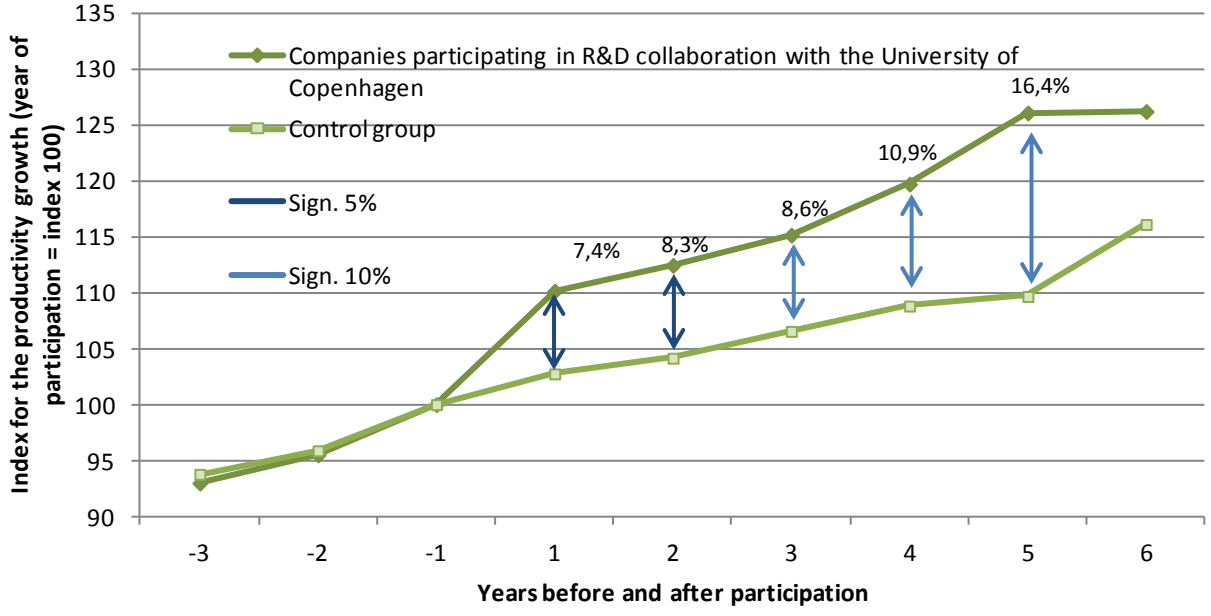
It is rather difficult to explain the differences in growth patterns. One reason though might be that restricting data also means a reducing the number of observations. The control group is different which also implies that the treatment group is different due to the choice of methodology.

4.1.2 Economic impact from collaboration measured in Euros

The first part of the analysis has identified a causal positive connection between entering into R&D collaboration with the University of Copenhagen and companies' development in productivity per employee.

FIGURE 4.2

Causal effect in the form of a productivity increase due to collaboration with the University of Copenhagen, restrictions on the control group



Source: Calculations by DAMVAD based on micro data from Statistics Denmark

This subsection follows the same approach as mentioned above, but converts the productivity impact to economic returns measured in Euros.

The analysis shows that companies participating in R&D collaboration with the University of Copenhagen experience an average yearly productivity gain of € 7,000 per employee. The result is measured over a six-year period, covered by the effect analysis, and indicates that companies experience a gain corresponding to € 7,000 in annual productivity due to collaboration with the University of Copenhagen.

Table 4.1 shows the development of the productivity effect after the time of collaboration. The effect is approximately € 5,800 two years after establishing collaboration and increases over the years to € 11,000 after six years.

With an average increase in productivity of € 7,000 a year the collaboration companies are 6.5 pct. more productive than the companies in the control group. Generally, the average productivity per employee is € 108,000 among companies with similar characteristics as companies collaborating with the University of Copenhagen. This corresponds to the fact that the average employee in these companies is 6.5 pct. more productive compared to similar companies that do not collaborate with the University of Copenhagen.

In other words, the companies' baseline increases on average with € 2.43 million on an annual basis after establishing collaboration. That is so because the average company size is 350 employees.

It is possible to make a rough estimate of the total productivity effect considering all the companies that have collaborated with the University of Copenhagen. The estimate amounts to € 1.5 billion by multiplying the company specific gain of € 2.43 million with the 625 different companies that collaborate with the University of Copenhagen. Collaboration centred on publishing is omitted from the impact assessment where this calculation is adjusted accordingly.

4.1.3 Socio-economic impact

This part of the analysis presents a simple estimate of the socio-economic impact related to the situation in which all companies that may potentially engage in collaboration with the university do so.

A previous Danish study has estimated that there are 2,447 companies in total in the Danish business sector with R&D activities which have not taken part in R&D collaborations in the time period in focus. They hold a potential for engaging in collaboration with the university.

Under the assumption that all of these 2,447 companies have the potential to participate in R&D collaboration with the University of Copenhagen, the associated change in company behaviour has a potential yearly socio-economic impact of € 3.05 billion. This amounts to 1.3 pct. of the Danish GDP.

TABLE 4.1

Average impact on productivity per employee by participating in R&D collaboration with the University of Copenhagen

Years after participation	1	2	3	4	5	6
Impact of at least one collaboration	Insignificant	€ 5,804	€ 6,320	€ 10,116	€ 8,446	€ 11,041

Source: Calculations by DAMVAD based on micro data from Statistics Denmark

A great amount of caution should be considered when interpreting the socio-economic impact. The estimation involves a high degree of uncertainty and makes use of the restrictive assumption that all additional collaborations yield the same impact from collaboration as documented in this analysis. There is no sound evidence of the participation effect, considering the companies' potential to establish collaboration, which means that the estimation serves as an illustration of the potential socio-economic impact.

At the same time, companies might have chosen not to engage in collaboration with the university due to the fact that the associated costs are expected to surpass the expected gains from the collaboration. Consequently, it is generally difficult to delimit the group of companies that may potentially engage in R&D collaboration with the University of Copenhagen.

4.2 Results from case studies

Whereas the econometric analysis shows that formal R&D collaboration generates higher productivity, the qualitative case studies indicate that such formal collaboration often rests on a much broader and often informal set of interactions between the collaborating partners.

The case studies show that the formal R&D collaborations represent only the tip of the iceberg; beneath the surface lies a myriad of more or less formalised interactions between companies and academia. These interactions range from informal personal ties to academic scientists serving as consultants to companies or members of scientific advisory boards.

Although these interactions are less visible than formal R&D collaborations, the case studies suggest that they play an absolutely vital role in building and maintaining robust, long-term relationships between universities and companies. It is from such relationships that successful instances of formal R&D collaboration emerge.

These findings hold important policy implications, namely that in order to generate the positive effects of R&D collaboration between universities and industry, it is not enough to simply stimulate formal R&D collaborations; policymakers must also stimulate and facilitate other forms of interaction between public and private science, notably the establishment of long-term relationships between scientists in companies and in universities.

4.3 Conclusion

The analysis implements econometric methods and uses several different sources to access micro-level data. This provides us with a unique possibility for following the recommendations of several economic institutions, including the OECD, Eurostat and the World Bank Group, in measuring impacts. The recommendations, among other things, focus on establishing a counterfactual situation.

Setting up a counterfactual situation is not an easy task. Can the counterfactual situation actually be simulated, or are there a number of unobserved factors that it is impossible to account for? The methodology and data used in this analysis put forward the best case given the data available. And as such the results are the most solid and robust given the data available.

Thus, the results reported here constitute the best case of an econometric analysis of the value-added and impact of the University of Copenhagen.

5 Cases

5.1 Case 1: Collaboration with linguists led to higher efficiency and more accuracy

Case: Collaboration between the Centre for Language Technology (CST) and Schultz Information.

Schultz Information is a publisher specialised in publishing information for public authorities as well as private companies. One of Schultz' existing products is a database via which decisions by The National Tax Board and The Danish National Tax Tribunal are made public on the internet for the use of lawyers, local tax authorities and citizens. Before the decisions can be made public on the internet, it is imperative that they are anonymised in order to protect the identity of persons and companies involved in the decisions. Traditionally, this task has been solved manually, which is a quite demanding task requiring double proofreading. Through an employee at Schultz with a background as a data linguist and who had previously worked at the CST, Schulz became aware of the centre and the possibility of cooperating with them on creating a solution that could solve the task based on computational linguistics.

The project consisted of three phases:

In the initial phase Schulz and the CST created a detailed overview of the requirements of the final product.

In the development phase the CST developed the product while the IT company Progresso developed a user interface.

In the test phase the product was implemented, tested and adjustments were made.

The initial phase in which the requirements of the final product were drawn up was quite time-consuming. Later, however, this investment proved to be worthwhile, as the development phase itself was relatively uncomplicated, and the test phase showed that the product the CST delivered was very close to what Schultz needed. According to Senior Advisor Claus Povlsen at the CST, this phase was really useful for the collaboration in many ways, 'making two equally strange worlds understand each other'. Editorial Chief at Schultz, Erik Nielsen also puts emphasis on this phase as a key factor in making the project a success: 'As a company we're interested in having a product delivered that works. We have to be sure that we get what we envisioned in the beginning of the project in order for it to make business sense for us'.

The case illustrates that collaboration between university and company can also work for projects that are relatively small and focused compared to huge R&D collaborations. Furthermore, the project shows the value of investing time in the beginning of the project, 'making two strange worlds understand each other'.

Effects on research. For the CST the project has given researchers the opportunity to the work on a 'real-world' project and to use their knowledge to solve practical problems. Another benefit is, as mentioned, a world-class dataset based on 25 million anonymised entities, which can be utilised in later research projects.

Innovation effects. The collaboration has resulted in a new product that is able to solve tasks automatically, which have previously been solved manually.

Societal effects. Economic effects include approx. 60-65 % higher productivity for Schultz. The money saved due to increased efficiency has already covered the development costs. The CST and Schultz are now investigating whether the project can be applied in other areas. Ultimately the project could lead to new high-tech workplaces in Denmark, if the programme or revisions of it are applied to other areas.

5.2 Case 2: Better business intelligence about SuperModels

Case: Collaboration between watAgame and the Centre for Communication and Computing

watAgame is a Danish company that produces a free online community for girls called goSupermodel. In goSupermodel each user creates an avatar, a virtual fashion model, and participates in competitions and games in order to earn in-game currency, which can be spent on virtual items that increase the looks and status of the avatar. There is a strong social element to the site and users have ample possibility to interact and chat with other users. Due to the age of the user group, goSupermodel works in the national vernacular. It was originally developed for the Danish market, but has later spread to the other Nordic countries, Germany, Poland, Belgium, the Netherlands as well as in an international English edition.

Researchers at the cross-disciplinary Centre for Communication and Computing (CCC) contacted watAgame and offered to help them measuring and analysing the activities of the users of the website. This is quite a complicated task, since it includes setting up different measurement points, implementing instruments for measuring activity and analysing data. Usually, companies fall back on measuring financial flows, because they are easy to measure. But by cooperating with CCC, watAgame get much more customised measurements focusing on the actual behaviour of girls on the site.

The researchers helped watAgame collect and analyse data about their users for the purpose of describing differences in use between different types of users and users from different countries. Results show that there are important differences between users, e.g. a small proportion of the most active users account for most of the traffic.

The research also shows important national differences between how users access the site. While users in some countries use the website to socialise, users in other countries are 'playing to win' and focus on achieving the highest possible status in the internal structure of the site. Key enablers in making the project a success included the ability of the researchers to make watAgame comfortable about letting them measure data on their platform and subsequently publish it.

Originally, the researchers had to approach several different companies, but were turned down because of fear of sensitive business information being disclosed, before they found the cooperation with watAgame.

A key factor in making the project a success was that both watAgame and the researchers, from different perspectives, had an interest in analysing the data of traffic on the site. Thus, there were complimentary interests in the same data.

Effects on research. The greatest benefit for researchers is the data about the actual behaviour of users on community websites, which holds great potential for further research in their field, since research built on this kind of data is currently the centre of international focus on research in online media.

Innovation effects. Via the project a new way of measuring user activity on online sites has been developed.

Economic effects. For watAgame the data is useful for adapting and developing the site to increase its appeal to different types of users. By cooperating with media sociologists they receive a much more customised measurement that focuses on the actual behaviour of users on the site, instead of a traditional analysis that focuses on financial flows that are easy to measure. The case illustrates that the contribution of research projects that incorporate perspectives from the humanities and the social sciences is sometimes/often located higher in the value chain than contribution from companies' cooperation with researchers from the health-related or technical sciences. These collaborations do not result in new products or patents, but in new knowledge that can be used for developing and focusing the product.

5.3 Case 3: The founding of Sophion

Case: Dual career in academia and industry helps create spin-off company

This case describes the creation of the Biotech company Sophion. Søren-Peter Olesen, Co-founder of Sophion, had a background as an employee in the Danish biopharmaceutical company NeuroSearch, before becoming a professor at the University of Copenhagen in 1998.

Søren-Peter Olesen's field of research is cardiovascular physiology and neurophysiology. Already as a visiting scientist at Harvard Medical School in the 1980s he had begun studying how the electrical functioning of the heart is affected by the molecular function of ion channels, and he had been introduced to a new technique called patch clamping for studying the electrical activity of the heart and the way it is influenced through ion channels. During his last years at NeuroSearch, before becoming a professor at the University of Copenhagen, together with a couple of NeuroSearch colleagues he founded Sophion Bioscience, a company that specialises in solutions for automated patch clamping aimed at companies doing drug discovery.

Sophion went through several phases before being sold to Swedish BiolinScientific in 2011. In the initial phase the product itself had to be developed. This involved the development of bio chips capable of measuring the activity in ion channels. Søren-Peter Olesen was, through his personal network, able to secure the cooperation of DTU Nano, who developed the bio chip. In the second phase, starting around 2005, focus in Sophion shifted from development to the creation of a marketable product and introducing it to potential clients in the pharmaceutical industry. This meant changing the nature of the company in a more sales-orientated direction. Finally, in the third phase the group of investors behind Sophion and Søren-Peter Olesen wanted to sell the company to a group of investors interested in launching the company on the stock market.

A key factor behind the success of Sophion was Søren-Peter Olesen's ability to use his network in both industry and academia to secure funding and academic cooperation as well as to ensure that the early phases of the company's development maintained a low transaction cost and a minimum of legal paper work.

Benefits for researchers. For researchers the creation of Sophion has provided an opportunity to see research put to practical use and to create something that has not been done before and to make a difference for society.

Innovation effects. The collaboration has resulted in a new world-class product within its field.

Societal effects. The main economic effect has been the creation of a viable Biotech company, now part of the fast growing Swedish BiolinScientific group. Spin-off companies are not necessarily a way for the university or for researchers to generate revenue for themselves, since the development of the product required several rounds of investments, during which the original owner shares were diluted to a minimum.

For the Danish society it has meant the creation of 30-40 high-tech jobs and contributed to the branding of Denmark as a nation with a strong medico-technical industry.

5.4 Case 4: Collaboration between Co-Constructing IT and Healthcare (CITH) & Logica

Case: Collaboration leads to patient empowerment, organisational efficiency and advancement of the understanding of heterogeneous and distributed work settings

The research collaboration between Co-Constructing IT and Healthcare (CITH), headed by Professor Finn Kensing at the University of Copenhagen, and the global business and technology service company Logica is currently engaged in furthering the understanding of heterogeneous and distributed work settings as well as, at the same time, showing the organisational, commercial and health potential of telemedicinal solutions for the treatment of patients with chronic diseases. Focus is on the treatment of patients with ICDs at The Heart Centre at the University Hospital of Copenhagen and local hospitals. ICDs are powerful pacemakers that detect cardiac arrhythmia and correct them by delivering a jolt of electricity.

The starting point for the collaboration is the study of an existing solution aimed at patients with ICD pacemakers. Via the current solution it is only possible to monitor the activity of the ICD, and the aim of the research project is thus to develop a web-based application that makes it possible for patients to monitor their health and report this to health professionals before consultations, whether in person or by virtual means. Potentially, this reduces the need for in person consultations and for more timely interventions.

The project consists of four phases:

- In the first phase researchers studied how the existing telemedicinal solution works through participant observation, interviews and workshops with patients, their relatives and health personnel through six iterations involving patients and health staff.
- In the second phase the researchers developed and tested a research prototype of the IT system/application.
- In the third phase the IT system/application was developed as a commercial product.
- In the fourth phase, the application is to be thoroughly tested in hospitals and in patients' homes, and health-related or other results need to be documented. This phase is only just about to start, due to delays in the project.

The project has not ended yet, but it is already possible to point to some realised and some potential effects hereof:

Effects on research. The main effect on research is the opportunity for researchers to study how telemedicinal solutions work in 'real life'. This furthers the understanding of heterogeneous and distributed work settings and how one may model, develop and implement socio-technical IT solutions for communication and cooperation within these.

Societal effects: Benefits for the industry include the opportunity to demonstrate the potential of Logica's e-health box for the treatment of patients with chronic diseases and to conduct evidence-based testing of the health effects of telemedicinal solutions.

Benefits for the health sector include more efficient ways of working, since the current system relies on decision-making on the basis of fragmented and insufficient data. This in turn leads to benefits for patients, better health as well as patient empowerment due to better access to data about one's own health.

5.5 Case 5: The founding of Epitherapeutics

Case: World-class research in epigenetics creates spin-off company

Kristian Helin had an international career as a research fellow at Harvard University, at the Danish Cancer Society and the European Institute of Oncology in Milan before returning to Denmark in 2003 to become a professor at the University of Copenhagen and the founding director of the Biotech Research and Innovation Centre (BRIC). BRIC scientists focus on understanding the molecular mechanisms that lead to various diseases, including cancer, CNS-related diseases and metabolic diseases.

Kristian Helin's studies the mechanisms that suddenly make cells start to grow. This field is called epigenetics – the study of heritable changes in gene expression or cellular phenotype caused by mechanisms that are not caused by changes in the underlying DNA sequence. This is useful e.g. for the study of why cancer occurs and what can be done to stop it.

In 2008 Helin founded the company Epitherapeutics with investments from the three seed funds. The idea was to try to develop medicine based on insights from epigenetics and to test how drugs developed on the basis of these insights can be used to inhibit the growth of cancer cells or kill cancer cells without harming normal cells. Due to Helin's international reputation as a researcher, Epitherapeutics has attracted funding from several investors, such as Novo A/S, SEED Capital Denmark and Lundbeckfond Ventures, Astellas Venture Management and Merck Serono Ventures.

The project runs through several phases. Before new medicine can be released, it has to go through several test phases. If the tests go well, a new drug can be released after 10-12 years. There is, however, also a big risk that the development of a drug has to be stopped before. Actually, only 2 out of 10 companies like Epitherapeutics make it and are able to release a new drug. At the same time the development of new drugs is very capital-intensive and new investments need to be attracted continuously. Due to this the owner share of researchers is 'diluted' throughout the project period; this means that the financial reward for the researchers if the drug is released is at best modest.

The creation of Epitherapeutics has benefits for the industry, researchers and the Danish society, although some of them remain potential.

Health effects. The most important benefit of the collaboration is the development of new drugs against cancer.

Effects on research. For researchers the main benefit is the practical application and utilisation of research. Furthermore, for the researchers it is rewarding to gain insight into how the pharmaceutical industry works.

Societal benefits. The benefit for the industry is the potential of getting a return on their investment. For the Danish society the benefit is the creation of high-tech jobs. The company currently employs 16 people, including 14 researchers in Denmark. Moreover, 8 researchers are employed outside Denmark.

5.6 Case 6: Collaboration between the Department of Human Nutrition and Arla Foods

Case: Improving public health through university-industry collaboration on nutrition research.

This case study describes the long-standing and multifaceted collaboration between the Department of Human Nutrition at the University of Copenhagen and the food industry. Among other things, researchers at the department engage in so-called 'arm's length' interaction with the industry, conducting objective nutrition research, e.g. the importance of protein and calcium in dairy products for the regulation of appetite and weight. Such research is often co-financed by the industry, e.g. through independently operated corporate research foundations such as the Danish Dairy Research Foundation that helps secure the arm's length relationship.

The importance of the arm's length nature of this relationship is underlined by Dr Henrik Jørgen Andersen, Head of Open Innovation at Arla Foods, a global dairy company and a long-time collaborator of the Department of Human Nutrition. Dr Andersen explains that 'the objectivity of academic nutrition research is crucial to ensure the legitimacy and credibility of nutritional recommendations'. However, according to Andersen, the industry contributes to the relevance of the research, which is undertaken by pointing academic researchers in the direction of important issues and questions that call for investigation.

In addition, researchers at the Department of Human Nutrition also engage in joint R&D projects with the industry and provide contract research and consulting, e.g. by undertaking or providing counselling on large-scale nutrition studies with human participants.

Effects on research. According to Professor Arne Astrup, Head of the Department of Human Nutrition, collaboration with the industry can have a significant impact on research strategies and activities at the department. He explains that working with companies can provide access to insight and R&D results from the industry than can help academic researchers identify more promising research paths and thus contribute to a more effective prioritisation and management of research activities at the university.

According to Dr Andersen from Arla Foods, collaboration with the University also generates benefits for the industry, notably access to state of the art insight into nutrition research and expert sparring on corporate R&D strategies and activities. It also opens the door to a broad international network of researchers, which can in turn provide important new sources of inspiration for companies.

Innovation effects. In addition, companies in the food industry also stand to gain indirectly from nutrition research, which provides important input to their research and product development.

Societal effects. Companies may also incur substantial financial gains or losses due to research results from the Department of Human Nutrition. E.g. Professor Astrup and colleagues have demonstrated that calcium may reduce blood pressure and that it is inversely related to body weight. Such results may carry great importance for recommendations regarding intake of calcium and thus for the sale of dairy products and calcium supplements. As a result, and because such research may result in nutritional recommendations of individuals and of policymakers, it is crucial that the research undertaken at the university remains independent of commercial interests.

The case illustrates how many-sided, long-term collaboration between public and private researchers can bring about knowledge that not only informs industry research and development, but also creates knowledge that helps the general public make informed nutritional decisions and thus supports the long-term development of public health.

5.7 Case 7: Breaking down the walls to produce tomorrow's biofuel

Case: Collaboration between the Department of Plant and Environmental Sciences and Novozymes

This case study describes a recently initiated and ongoing collaboration between the Department of Plant and Environmental Sciences and the Danish company Novozymes, a global leader in enzyme technology.

Professor William Willats at the Department of Plant and Environmental Sciences is currently undertaking research on how enzymes can be used to develop more efficient and cheaper methods for producing second generation biofuels, a more environmentally sustainable alternative to fossil fuels based on plant materials. Among other things, this research involves identifying relevant enzymes, discovering how they work, and investigating how to modify and use these enzymes in the production of biofuels.

Professor Willats and colleagues have developed a novel technology that can be used to identify and characterise enzymes that are relevant in the development of biofuels. This technology, which is the subject of a recent University of Copenhagen patent application, represents a paradigm shift in enzyme research for biofuel applications, because it enables the rapid and precise analysis of large numbers of enzymes, thus helping researchers find the most effective enzymes for use in the production of second generation biofuels.

To fully harness the potential of this technology, Professor Willats and colleagues have entered into collaboration with Novozymes. The collaboration is part of a larger project, SET4Future, funded by the Danish Council for Strategic Research, which started in 2012 and is expected to be completed in 2016. The project involves a number of other participants, including the Technical University of Denmark, Cornell University and UC Berkeley in the US, as well as the companies DONG Energy, Arrayjet and PlantProbes.

One aim of the project is to further develop the enzyme screening technology, so that it can be used in real-life commercial settings. In addition, the project also involves research on enzymes and their effects on plant cell walls, which the university researchers hope to build on in a series of parallel or subsequent research projects, e.g. aimed at better understanding the relationship between the physical characteristics of enzymes and their function, that is, how they actually work.

Innovation effects. Professor Willats and his research group hope that working with Novozymes will demonstrate the value of their technology. In fact, Novozymes has decided to take part in the project precisely because it provides access to the high throughput screening technology developed by the researchers at the University of Copenhagen. Rune Nygaard Monrad, Research Scientist at Novozymes, explains that the company believes the technology holds great potential with regard to speeding up the process of identifying and characterising enzymes.

The collaboration is expected to result in the application and further development of the screening technology developed by Professor Willats and his team. If successful, this will lay the groundwork for the commercial exploitation of the technology, either by Novozymes or by a third party.

Societal effects. Ultimately, the research undertaken in this collaborative venture is expected to generate new research tools and knowledge that can support the sustainable production of liquid fuels and thus contribute to addressing the environmental challenges faced by society.

5.8 Case 8: Innovative treatments for diabetes and obesity

Case: Groundbreaking basic research that led to innovative treatments for diabetes and obesity - Department of Biomedical Sciences and Novo Nordisk

This case study describes how groundbreaking basic research and a collaboration between the University of Copenhagen and the Danish pharmaceutical company Novo Nordisk that started 40 years ago has led to the development of an innovative treatment for type 2 diabetes and possibly also for obesity.

Professor Jens Juul Holst and his research group at the Endocrinology Research Section, Department of Biomedical Sciences, undertake basic research on intestinal hormones and their effect on diabetes and weight loss. In collaboration with colleagues at the University of Copenhagen and the Copenhagen University Hospitals, Professor Holst's research group has successfully identified and characterised a hormone, GLP-1, that can help type 2 diabetics produce insulin and lose weight. Based in large part on the groundbreaking research by Professor Holst and his team, Novo Nordisk has introduced an injectable drug called Victoza® for the treatment of type 2 diabetes. This case study tells the story behind the development of Victoza®, notably the collaboration between Novo Nordisk and Professor Holst and his colleagues.

In their work on GLP-1 and Victoza®, Professor Holst's group and Novo Nordisk have worked along parallel but distinct R&D paths; as such, direct collaboration has been limited to a few minor projects. The bulk of the collaborative relationship has instead centred on exchange of ideas, research insights and experiences, whereby the parties have informed and inspired each other's research efforts.

Effects on research. Insights gained from this collaboration have helped both Novo Nordisk and the researchers at the University of Copenhagen develop research ideas and steer their research activities in fruitful directions.

Lotte Bjerre Knudsen, a Senior Principal Scientist at Novo Nordisk, led the team that discovered liraglutide and spearheaded its development. She explains that the ongoing collaboration with Holst and his research team has provided Novo Nordisk with access to state of the art research insights and constructive sparring on research ideas, which is essential in the development and maturation of new ideas and thus influences prioritisation and directions in the company's research projects.

Similarly, Professor Holst explains that access to Novo Nordisk knowledge and research equipment has helped inspire and support research at the university.

Innovation effects. The research undertaken at the University of Copenhagen and at Novo Nordisk has resulted in an innovation that offers effective treatment of type 2 diabetes and possibly also for obesity, both of which are associated with multiple medical complications and reduced quality of life for patients.

The launch of Victoza® is an important achievement for Novo Nordisk, because it offers an effective treatment that is specifically targeted at the growing group of type 2 diabetics, who account for 90 per cent of all diabetics.

Societal effects. Victoza® is also a very lucrative product. In 2011 it generated more than 6 billion kroner in revenue to the company, and sales are expected to increase further if the drug is approved for other uses, for example in the treatment of obesity.

Ultimately, the research undertaken by Novo Nordisk and Professor Holst's research team has brought about a more effective treatment of important societal challenges, namely type 2 diabetes and possibly also obesity.

5.9 Case 9: Building the future of electronic components

Case: Building the foundation for the electronic components of the future – one molecule at a time. Department of Chemistry and IBM Research - Zürich

This case describes collaboration between researchers at the Department of Chemistry at the University of Copenhagen and IBM Research - Zürich in Switzerland. The collaboration was part of a larger project, SINGLE, which concerned basic research in the field of molecular-scale electronics, a subfield of nanoelectronics.

SINGLE ran from 2007 to 2011 and aimed at undertaking basic research on the possibility of using single molecules as components in electronic devices, e.g. to store or transmit information. The project was funded by the EU's 7th Framework Programme for Research and Technological Development and included three additional academic partners: Chalmers University of Technology in Gothenburg, the Delft University of Technology and the University of Mons.

Molecular-scale electronics is a field of research that studies and tries to use molecules as electronic components and thereby to develop faster, cheaper or more effective methods for processing, transmitting and storing information. The field is still in its infancy, and research conducted is therefore very basic in nature, aimed at understanding and exploring the possibilities of replacing traditional silicone electronic components with plastic molecules.

Professor Mogens Brøndsted Nielsen of the Molecular Engineering Group at the university's Department of Chemistry headed one of the work packages in the SINGLE project. He explains that a key role of the researchers at the University of Copenhagen who participated in the project was to design and produce new molecules and to investigate their properties so as to provide insight into their potential use in building electronic components. This is a complex trial-and-error-based process that requires continuous input on the function and usability of the molecules developed.

Professor Nielsen explains that the main role of IBM Research - Zürich, alongside several of the other participants in the project, was therefore to test and characterise the molecules developed in Copenhagen. The SINGLE project was designed to incorporate several different techniques for measuring and testing molecules, and the partners were selected because they excelled in one or more of these techniques.

IBM Research - Zürich was the only non-academic partner in the project; the other measurements were performed by university-based research groups. Dr Heike Riel leads the nano-scale electronics group at IBM Research - Zürich, which undertakes basic research in molecular-scale electronics, among other things, to identify materials for use in the future development of electronic components. IBM Research invests in nano-scale electronics research, even though it is a highly uncertain research area with a long time horizon in terms of commercialisation, because it is also a research area with a great future commercial potential.

Innovation effects. Both Professor Nielsen and Dr Riel point out that the project has produced valuable, fundamental insight into how molecules can be designed so as to optimise their use as electronic components, which can ultimately be used to develop smaller and faster computers and other electronic devices.

The collaboration has thus generated fundamental knowledge that will ultimately help build electronic devices using nanotechnology, which will enable the development of smaller, faster and better electronic equipment.

5.10 Case 10: Discovering nature's secrets

Case: Finding solutions to society's problems by discovering nature's secrets. Collaboration between the Nano-Science Center and Maersk Oil

Professor Susan Stipp is Head of the NanoGeoScience research group at the Nano-Science Center at the University of Copenhagen. The group applies nano-scale analytical techniques to develop fundamental insight into interactions between fluids such as water, oil or gases and natural materials like minerals or rocks. Because nano-scale techniques enable the study and manipulation of matter at an atomic or molecular level, they offer an entirely new level of insight into activities and reactions in nature, which can be applied to address important challenges to society. E.g. the group's research can be used to increase oil recovery from chalk, to bind and neutralise toxic materials in waste and to reduce the amount of CO2 in the atmosphere by incorporating it into minerals.

Susan Stipp and her research team work closely together with the Danish oil company Maersk Oil on an ongoing joint research venture, Nano-Chalk. The project is motivated by the fact that the oil that it is possible to produce economically in Denmark is running out. Meanwhile, renewable energy technologies have not yet been developed to a point where they can replace oil as a low cost source of energy. The aim of the Nano-Chalk venture is to explore one possible way of increasing oil production, namely by developing an environmentally friendly way of manipulating the size of the pores in the chalk reservoirs from which much oil is extracted, making them larger, so that they can release oil more freely and thus increase the amount of oil that can be recovered. Professor Stipp explains, 'the Nano-Chalk project is about solving a practical problem with a whole new approach. Basic research provides the background, and ideas drive towards the solution. A new approach can be much more valuable to industry than improvements on existing methods, because it places them ahead of their competitors. The bonus is that, at the same time, we can further scientific research, educate young scientists and generate interesting publications, which we are obligated to do as academic researchers'.

Effects on research. Finn Engstrøm, Principal Petrophysicist at Maersk Oil, explains that the benefits for Maersk Oil of collaborating on projects such as Nano-Chalk extend far beyond the purely scientific results of the collaboration. Key benefits for the company from such collaboration include ideas for new research activities and a strengthened foundation for future collaboration with universities.

Effects on education and recruitment. Moreover, Dr Engstrøm explains, such collaboration provides an effective base for recruitment, because it allows the company to interact with and participate in the training of young researchers, some of which later go on to pursue careers in Maersk Oil.

Innovation effects. The research project, which is still ongoing, has generated new fundamental insight that can, in time, be used to develop techniques for the more effective production of oil, which are already being explored further. The collaboration has also paved the way for other research partnerships between the university and Maersk Oil. In addition, for the research group at the University of Copenhagen, the Nano-Chalk venture has produced a number of interesting spin-off activities that could ultimately turn out to be of important commercial value, including knowledge about how to inhibit the production of calcium carbonate (the substance that forms scale at the bottom of a tea kettle or in water supply pipes) and about new ways to store CO2 permanently in rocks underground. Moreover, the group has created software in order to develop methods for studying pores and changes in their shape and size in real time; this has many other potential applications for materials science and will form the basis for new grant applications.

Societal effects. Ultimately, the knowledge generated in the collaboration between Professor Stipp's research team and Maersk Oil will contribute to the more effective utilisation of global energy resources.

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