A2006:006

Commercialization of Life-Science Research at Universities in the United States, Japan and China

Anna S. Nilsson
Henrik Fridén
Sylvia Schwaag Serger

SWEDISH INSTITUTE
FOR GROWTH POLICY
STUDIES

Commercialization of Life-Science Research at Universities in the United States, Japan and China

Anna S. Nilsson

Henrik Fridén
Sylvia Schwaag Serger

SWEDISH INSTITUTE
FOR GROWTH POLICY
STUDIES

ITPS, Swedish Institute for Growth Policy Studies
Studentplan 3, SE-831 40 Östersund, Sweden
Telephone: +46 (0)63 16 66 00
Fax: +46 (0)63 16 66 01
E-mail info@itps.se
www.itps.se
ISSN 1652-0483
Danagårds Grafiska, Ödeshög 2006

For further information, please contact Anna S. Nilsson
Telephone +1 202 467 2672
E-mail anna.nilsson@itps.se

Foreword

Policymakers in Sweden are concerned that too few science-based companies are being generated, and hope to see new companies created out of university research – largely because much of Sweden's private research and development is concentrated in a few large companies. In Sweden, researchers own the intellectual property rights to their inventions and have the option of using the service of a university technology-transfer office. The question of whether a change in rights ownership would increase commercialization of university research is currently being reviewed.

The aim of this study is to identify current challenges experienced by actors involved in commercialization of university research in the field of life sciences, along with efforts which have been implemented to overcome those challenges.

The study provides policy intelligence from the US, Japan and China and shows the need to consider a number of mechanisms collectively in order to design policies that will help create opportunities for economic growth through increased commercialization of university research. Ministries thus need to collaborate in bringing forth a strategic plan. This study contributes with a proposal for a framework on policy issues for commercialization of university research. This framework brings forth three key issues for policymakers to consider for commercialization processes to work: critical mass of diverse range of actors, efficient transfer channels, and interaction.

The report has mainly been written by Anna S. Nilsson. The content about China is written by Sylvia Schwaag Serger. Henrik Fridén, assisted by Kyoko Nakazato, has written about Japan. A reference group has provided valuable input defining the focus and limitations of the project and regarding the results. The members are: Karin Markides, VINNOVA; Sofia Medin, Ministry of Industry, Employment and Communication; Stina Gerdes, Ministry of Education, Research and Culture; Jan Nylander, Innovationsbron; and Henryk Wos, Swedish Foundation for Strategic Research.[1]

Östersund, March 2006

Sture Öberg,
Director General

[1] *We would like to thank the interviewees for their participation in this study, see list in Appendix. We also express our gratitude to the following expert reviewers: Randall Kempner, Vice president for Regional Innovation, Council on Competitiveness; Peter M. Pellerito, Policy Consultant, Bio-technology Industry Organization; Dr Carl-Johan Sundberg, Karolinska Institutet/Karolinska Investment Fund, Prof. Yuko Harayama, Tohoku University; Lennart Stenberg, Tokyo University/-VINNOVA; Dr. Nannan Lundin, OECD and Dr. Yani Liu-Wu, Chindoc Pharma Services.*

Table of Content

Summary **7**
Sammanfattning **9**
1 Commercialization on the policy agenda **11**
1.1 Aim 12
1.2 Focus: Life Sciences 13
1.3 Methodology 14
1.4 Limitations 15
1.5 Mechanisms of Commercialization of Research – A Knowledge Overview 15
1.5.1 Structuring the Case Studies 18
1.6 Outline 18
2 Commercialization of University Research within Life Sciences **19**
2.1 The United States 19
2.1.1 Key Findings from Case Studies 22
2.2 Japan 24
2.2.1 Key Findings from Case Studies 27
2.3 China 29
2.3.1 Key Findings from Case Studies 34
3 Major Challenges and Efforts to Overcome Them **37**
3.1 Critical Mass of Diverse Range of Actors 38
3.2 Efficient Transfer Channels 39
3.3 Interaction 41
4 Main Issues: Sweden **45**
4.1 Critical Mass of Diverse Range of Actors 45
4.2 Efficient Transfer Channels 47
4.3 Interaction 50
4.4 Moving Toward a Strategy for Commercialization of University Research 52
References **55**
Interviews 55
The United States 55
Japan 56
China 57
Written 57
Appendix **65**
Case Studies 65
University of Pennsylvania 65
University of North Carolina at Chapel Hill 72
University of Tokyo 79
Tohoku University 84
Peking University 90
Fudan University 92
Challenges and efforts 95
Statistics on R&D 96

Summary

Through studies of six universities in the US, Japan, and China, we have identified current challenges experienced by actors involved in commercialization of life science research, along with efforts being implemented to overcome those challenges. A number of challenges were found to be generic:

- Lack of seed-financing and human resources
- Creating and maintaining top-quality science
- Engaging commercial actors early in the processes
- Policymakers focus on the structure – rather than the content – of activities, and expect quick returns on investments
- University managers are unclear about priorities and goals regarding technology transfer
- Informational and cultural barriers exist between universities and companies (lack of trust and respect)
- Conflicting goals at universities, including insufficient rewards and/or negative impacts for researchers who participate in commercialization processes

This study highlights the need to consider a number of mechanisms collectively in order to design policies that will help create opportunities for economic growth through increased commercialization of university research. As seen in other countries, and as predicted by scholars, changing a single factor (such as ownership of intellectual property) is not likely to be a magic bullet. The complexity of these processes demands a strategic plan with a long-term view.

One contribution of this study is a proposal for a framework: "Policy issues for commercialization of university research." This framework, which emerged through the analysis, brings forth three key issues for policymakers to consider for commercialization processes to work:

- **Critical Mass of Diverse Range of Actors** There must be a diverse range of institutional actors involved, who can contribute a variety of information, as well as depth and breadth of experience.
- **Efficient Transfer Channels** There must be time- and cost-effective ways of transferring university research to commercial actors so that development can continue.
- **Interaction** There must be links between university researchers and commercial actors that enable opportunity-recognition and successful development of research results.

The framework is used to discuss the Swedish situation. As a first step toward a strategic plan, we present competitive advantages, challenges and related policy implications that Sweden appears to have in each of the three policy domains with regards to commercialization of life science research.

Sammanfattning

”Kommersialisering av universitetsforskning i USA, Japan och Kina”

Kommersialisering av universitetsforskning anses av många länders regeringar vara en väg till ekonomisk tillväxt. Vägen dit är dock inte självklar. Vi har identifierat vad personer som arbetar med kommersialisering av universitetsforskning inom livsvetenskaperna upplever som utmaningar, genom sex fallstudier av universitet i USA, Japan och Kina. Vi beskriver även åtgärder som vidtas för att öka kommersialiseringen. Situationen i de olika länderna skiljer sig kraftigt åt, men ett antal utmaningar framhålls av aktörer i alla tre länder:

- att hantera brist på sådd-finansiering och humankapital
- att skapa och bibehålla forskning av hög kvalité
- att få företag att engagera sig tidigt i processerna
- att policyansvariga fokuserar på struktur – snarare än innehåll – i kommersialiseringsaktiviteter och har höga förväntningar på snabbt resultat
- att universitetsledningar har otydliga prioriteringar och mål för sina tekniköverföringsaktiviteter
- att kulturskillnader mellan universitet och företag leder till brist på tillit och respekt, vilket skapar informationsbarriärer
- att universiteten har ett flertal mål som kan upplevas som motstridiga, vilket inkluderar bristfälliga belöningssystem för forskare som engagerar sig i kommersialiseringsprocesser

Studien visar att policyansvariga bör ta hänsyn till hur olika mekanismer samverkar i processerna när de vidtar åtgärder för att öka kommersialisering av universitetsforskning. Erfarenheter från andra länder tyder på att en ändring av en faktor, som till exempel lärarundantaget, kan vara otillräckligt eller t.o.m. olämpligt. De komplexa kommersialiseringsprocesserna kräver en långsiktig strategisk plan. Med det syftet ges ett förslag till ett ramverk: ”Policyfrågor för kommersialisering av universitetsforskning,” där tre nyckelfrågor lyfts fram:

- **Kritisk massa och mångfald av aktörer** Det måste finnas olika typer av aktörer inblandande i processerna för att få den variation av information, samt det djup och den bredd på erfarenhet som krävs.
- **Effektiva överföringskanaler** Det måste finnas tid- och kostnadseffektiva sätt att överföra universitetsforskning till företag så att resultaten kan vidareutvecklas.
- **Interaktion** Det måste finnas relationer mellan universitetsforskare och företag som ger tillfälle till identifiering av kommersialiserbara forskningsresultat och som skapar bättre förutsättningar för vidareutveckling av dessa.

Vi använder ramverket för att diskutera konkurrensfördelar, utmaningar och policy implikationer för att öka kommersialiseringen av universitetsforskning inom livsvetenskaperna i Sverige.

1 Commercialization on the policy agenda

It is generally accepted that technological progress is the source of up to half of the growth in the United States economy and it is reasonable to believe that the same is true for other developed countries (Schacht, 2005). Special efforts are therefore made in Sweden and many other countries around the world to create opportunities for growth by establishing excellence within specific research areas (Regeringskansliet, 2004). As governments are increasingly focusing on how publicly-funded research contributes to growth, universities are often targeted as underutilized resources.

The primary role of universities is to create and disseminate knowledge by teaching and performing research. They also contribute to innovation processes through: educating and training, adding to the stock of codified knowledge (patents, publications), increasing local capacity for scientific problem-solving (including support for creation and development of spin-offs, contract research, joint research ventures, licensing) and, providing a public space for conversations on development pathways and new opportunities. Out of these different contributions, there is presently a major focus on technology transfer (Lester, 2005).

Technology transfer is a process by which technology, developed in one organization, in one area, or for one purpose, is applied in another organization, in another area, or for another purpose (Schacht, 2003). "The economic benefits of a technology or technique accrue when a product, process, or service is brought to the marketplace where it can be sold or used to increase productivity" (Schacht, 2003, p 3).

In the US, considered by most to be the forerunner in commercialization of university research, 40 percent of the research results disclosed by faculty lead to licenses. Less than half of those licenses generate income. The top five income-generating licenses account for 76 percent of the total income that universities get from licensing, according to Thursby and Thursby (2005). They argue that "university administrators should not participate in licensing or promoting entrepreneurial behavior for the purpose of making profits… it is risky and few universities profit from it." (Rosenberg and Hagén, 2003, also discuss this issue.)

Policymakers in Sweden are worried that not enough science-based companies are being generated, and hope to see new companies created out of university research – largely because much of Sweden's private research and development (R&D) is concentrated in a few large companies. With the assumption that universities do not have the financial incentives to prioritize commercialization activities and the fact that costs associated with developing research results are high (Sellenthin, 2004), policymakers face the dilemma of how to engage university managers and researchers in the process. Moreover, policymakers struggle with how to engage commercial actors, who are necessary to bring research to the marketplace in the very early, high-risk stages.

A main concern of Swedish policymakers during the last ten years has been the lack of efficient organizations capable of collaborating with researchers to further develop discoveries with commercial potential (SOU 2005:95). The Swedish government has increased the responsibility of the universities; in 1996, a law regarding universities´ responsibility to spread knowledge of research results was amended to require interaction with society. Then, in 1997 and 1998, universities were further encouraged to increase interaction with industry and public organizations. Technology-transfer (TT) offices were also established, but without clear methods for efficient research transfer or long-term financing solutions. In a study of the role of technology parks in Sweden, Deiaco et al (2002) present five aspects to keep in mind with regards to commercialization of university research: 1) it takes a long time to transfer research results into commercial results 2) good university researchers should not be encouraged to become average entrepreneurs 3) the universities can not build clusters on their own 4) financial gain from commercial activities for universities is often limited or even negative 5) early exposure to market actors is a key to success for companies that are commercializing university research.

In Sweden, researchers own the intellectual property rights to their inventions and have the option of using the service of a university technology-transfer office. The question of whether change in rights ownership would improve the situation in Sweden has been investigated several times, and the recommendation has generally been that such a change is not the solution. A recent government-commissioned report regarding the ownership of research discoveries in Sweden (SOU 2005:95) acknowledges that if the university owns the rights, it is likely to create prolonged and complicated processes, which are not beneficial to commercialization. There would also be a need to build costly infrastructure at each university to work with commercialization activities that have a high degree of uncertainty as to the results. The report's authors state that the goal of a possible change of ownership is not to make the universities self-reliant through licensing income, but to allow research discoveries to benefit society to a larger extent than at present.

The authors of the Swedish report also state that the universities' primary tasks – research and education – should not be compromised. They propose to change the law to include a new task for Swedish universities: a duty to promote research discoveries in a way that benefits the public. In addition to this primary proposal, the report makes two mutually exclusive proposals with regard to commercialization of research at universities: researchers maintain the right to own their discoveries, but are required to inform university management of discoveries with commercial potential; or, the right to ownership is simply transferred to the university. In general, the work of the commission charged with preparing the report focuses primarily on ownership and related, legal issues.

Laws that are implemented to reach a certain goal may end up doing quite the opposite, if the considerations of the various mechanisms determining the processes of commercialization are insufficient. This is seen in the case of Denmark, discussed in Chapter Four. To improve the chances of increasing commercialization of university research, policymakers cannot limit themselves to ownership and legal issues, but need to address a number of mechanisms collectively.

1.1 Aim

The aim of this study is to identify current challenges experienced by actors involved in commercialization of university research, along with efforts which have been implemented to overcome those challenges. This has been done by reviewing literature on mechanisms of commercialization of university research, and by collecting information on present-day practices through case studies of six universities.

The case studies were performed in three very different countries; US, Japan, and China. This allowed us to pose the question: which challenges are generic and which are country-specific? The answers are of interest with regard to policy-learning.

One contribution of this study is a proposal for a framework for commercialization of university research, which emerged through the analysis. This framework brings forth three key issues for policymakers to consider for commercialization processes to work:

- **Critical Mass of Diverse Range of Actors** There must be a diverse range of institutional actors involved, who can contribute a variety of information, as well as depth and breadth of experience.
- **Efficient Transfer Channels** There must be time- and cost-effective ways of transferring university research to commercial actors so that development can continue.
- **Interaction** There must be links between university researchers and commercial actors that enable opportunity-recognition and successful development of research results.

The analysis section of this report is structured according to these policy domains, and implications for Sweden are provided in the framework "Policy issues for commercialization of university research."

1.2 Focus: Life Sciences

Life science is an area prioritized by Sweden because of the benefits for the public health and the potential economic contributions. Sweden has a strong position in terms of research in the field[2], and 20 percent of all business R&D in Sweden is spent by life-science companies.[3] In a recent strategy document (Regeringskansliet, 2005), the Swedish Ministry of Industry, Employment, and Communication, in collaboration with industry and university representatives, agreed on the need for various efforts to increase commercialization of life-science research. Countries in many regions of the world are striving to do the same but, several universal challenges remain:

> *"(In biotechnology)…there is now a substantial mismatch between the real world and the unrealistic expectations of policymakers, consultants and social scientists…policy needs to address the uncertain, systematic nature of technical change and the very long time scales between advances in basic knowledge and productivity improvements."*

Nightingale and Martin, 2004, p 568

The important role of life science in Sweden, in combination with the inherent difficulties of commercialization of such research, creates a need to highlight the specific challenges characterizing the field, and explains the focus on life science in this study. Although there are aspects within commercialization of life-science research which differ from other fields (long and expensive development times due to patenting, clinical tests, regulations etc), we believe that the findings may be useful to consider for commercialization of research in other fields as well.

---

[2] *For example, Sweden ranked first in the world in research excellence, with regard to the number of citations in clinical medicine per 1000 population, in a study published in The Lancelot, 2004, Vol. 363.*

[3] *OECD Science and Technology Indicators, 2003*

1.3 Methodology

Funding from governmental agencies is often geared towards basic research within life science. Still, expectations that the research will be applied sooner, rather than later, are frequently expressed. By choosing cases that receive primarily government funding, we obtain insights into how that challenge is handled. The cases are based on secondary data as well as primary material, in the form of personal interviews with actors involved in the design and implementation of the commercialization efforts. The choice to take an in-depth look at a few universities through interviews – rather than an overview of many – was made in order to develop an understanding of processes that are not visible through secondary data. The drawback: findings for the cases cannot be applied to all universities within that specific country, and should be seen as examples. The case studies are complemented with secondary material and expert interviews to provide a broader picture of each country.

Criteria for cases studied are based on scientific excellence in life science (based on absolute amounts of funding from government). The universities are not necessarily located in the top biotechnology-industry region in the country, but strategies are being implemented at state and/or regional levels to improve the situation.

The countries in this study include:

- US: a forerunner in commercialization of university research, with both positive and negative experiences to study;
- China: a beginner in the field that recently began commercialization efforts, providing a picture of the designs chosen when starting without an inherited system; and,
- Japan: a country currently undergoing comprehensive structural changes in order to increase commercialization.

The material on each country has been reviewed by local experts in the field, and the case studies were also reviewed by the interviewees to ensure that the overall picture was correctly interpreted.

Carrying out a comparative study between the processes at universities in the US, Japan, and China is complicated by the fact that China differs considerably from the other two countries in several respects. First, it is difficult to obtain information and to interpret it. Second, interviews and interview requests with professors and other university staff have to be approved by the university's office for international cooperation. This element makes interview-based studies more cumbersome and may also affect the willingness of interviewees to express themselves freely. A third complicating factor is that, even when granted permission for interviews, the results may be limited and/or misleading because interviewees are commonly reluctant to speak about their research and experiences. This can be explained partially by a low level of trust.

Finally, biotechnology is a highly-prioritized sector in China's national policy, and the government has high hopes of achieving international excellence and academic and commercial success in this field. The information provided by some actors may therefore be aimed more at promoting China as a highly promising biotechnology country, rather than at identifying or conveying weaknesses or problems. As a result of these factors, it has been difficult to obtain reliable and relevant information. In order to ensure the quality of the material collected in China, the interview approach has been slightly modified to suit the Chinese situation. Rather than identifying researchers and actors from two universities as primary interview targets, we have identified a number of key experts who can provide valuable insights into the functioning of the commercialization process in China and at the two universities.

1.4 Limitations

The aim of this report is not to study the countries´ whole systems of innovation and characterize each difference between them. As we focus on challenges and efforts in commercialization of university research at the micro level, differences in the larger systems are, however, discussed as explanatory factors.

There are many activities and collaborations between university and industry, some of which become clear technology-transfer cases, and others where the contribution from universities takes the form of adding competence, development capacity, and legitimacy to a project (Mannervik and Arvidsson, 2005). The aim of this report is not to investigate all types of collaborations.

There is an ongoing discussion about whether or not "commercially oriented activities will come to overshadow other intellectual values" (Bok, 2003, p 16). It is a fundamental issue that deserves attention, but lies outside the scope of this report.

There is a wide variety of research within the field of life science, some of which is considered more applicable than others. We do not enter the discussion regarding basic versus applied research in this study, nor do we investigate which specific subfields of life science the countries choose to focus on.

Many of the efforts that we study are new, and evaluations of these efforts are therefore limited, as expressed by the Kauffman Foundation (2003, p 18): "Descriptions of practices followed by universities with the strongest track records in technology transfer and commercialization do not exist nor do experts agree on the most effective methods for universities to organize and operate in this area."

Efforts are described in more detail in the case studies, and references are made in cases where evaluations exist. On a more general level, there are many attempts to evaluate commercialization efforts, but too many metrics are based on what is easily measured and therefore lack an integrative context. It remains a major problem that, what is understood to be innovation and entrepreneurship – and thus what is measured – varies between universities, market actors, and politicians. Universities focus on patents and publications; market actors focus on profits; and politicians focus on economic growth and new jobs. A major challenge in evaluation is finding the common ground between these focuses and metrics that make sense for all (Walshok, 2005). The lack of evaluations of commercialization efforts means that this report will not be able deliver a list of the "best practices."

1.5 Mechanisms of Commercialization of Research – A Knowledge Overview

The main commercial mechanisms for transferring discoveries from universities to the market are licensing agreements, research joint ventures, and university spin-offs (Siegel and Phan, 2005). Two categories of conditions must be met in order for a transfer to take place: 1) the seller must be able to locate a buyer for whom the intellectual property (IP) has potential value and convince them to investigate the IP; 2) the buyer must assess that the IP has a value that exceeds the costs of licensing, patenting, and other opportunity costs (Elfenbein, 2005). Although laws and regulations have been put in place to facilitate technology transfer, the level of commercialization of federally funded research is still considered unsatisfactory by most governments.

There are several reasons why discoveries that could be commercialized and contribute to economic growth remain "on the shelf:"

- Discoveries in universities are often embryonic and characterized by a high degree of technical and market uncertainty (Branscomb and Auerswald, 2001; Colyvas et al., 2002; Thursby et al., 2002; Shane, 2004; Elfenbein, D., 2005).
- The difficulty of valuing university technology prevents many private investors from investing in early stages, even in countries that have an efficient capital market, which creates a “valley of death” (Branscomb and Auerswald, 2001).
- There is little incentive for a university to withhold technologies for internal development. Technology transfer constitutes a small part of university activities and those offices rarely have the money or expertise to reduce the technical uncertainties in order to bring the discovery to a stage that attracts private financing (Toole and Czarnitzki, 2005; Elfenbein, 2005).

A lack of efficient transfer channels thus becomes a challenge to commercialization of university research.

An inherent difficulty for universities with regard to commercialization efforts is that having “working ties to operating sectors of the economy are not central to the internal design of the university as an institution” (Lester, 2005, p 9). Confusion over the mission to contribute to economic growth has been common among universities as they increasingly open up to interaction with market actors. Meanwhile, the significance of the economic contributions through technology-transfer offices is often exaggerated. In the US, only a small fraction (2–3%) of new companies is based on university research, and the same goes for patents[4]. The chances for significant financial benefits for the universities from technology transfer efforts are also low. According to an international study, Lester (2005) concludes that it is probable that many of the technology-transfer offices do not break even. Some universities are strengthening the capacity at their TT offices and count on future profits in return. Although profit may not be a realistic goal for all, the participation of universities in commercialization efforts is important to make the processes work.

According to Florida (2000), policymakers have overstated the degree to which universities can drive the national and regional economies, and the pressure that US university managers experience with regard to expanding commercialization efforts through technology transfer must be reduced. Regional policymakers cannot pass responsibility for bolstering the region´s economy on to university presidents. It is up to policymakers to ensure that their region has the infrastructure, eminent universities, and amenities that can attract top talent, including private actors who can commercialize university discoveries. The one thing that top-notch universities can contribute, with regard to critical mass, is attracting top researchers to a region (Florida, 2000).

Although local spillover benefits exist, scholars caution policymakers who look at universities as catalysts for local job creation: “the strongest universities are focused on attracting and educating top students and disseminating research on a global basis” (Thursby, 2005). With regard to the incentives of universities to engage in commercialization of research, it is important to remember that universities have multiple missions. An analysis of performance within US and European biotechnology research centers, in terms of academic functioning, prestige, industry collaboration, and networking, shows that, whereas 72 percent of the centers achieved a high performance in at least one of these areas, only two percent scored highly in all four areas. The result implies that the goals public research centers in Europe and the US are pressed to attain can be conflicting (Viola, 2004).

[4] *Of about 150 000 US patents issued in 2001, about 3700 were granted to US universities (Lester, 2005).*

Another challenge, related to science policy, is found at the national level. The basis for a successful transfer is a perceived market need, but public research funding often targets needs of the public sector where the incentives are insufficient for the commercial actors (Azzone and Maccarrone, 1997). The result is that "a technology is developed and a use for it established because the expertise exists, rather than because it is needed" (Schacht, 2003, p 2).

Most technologies from universities are licensed at a very early stage. They require significant additional investment from the licensees and it takes years before the technologies enter the market (Jensen and Thursby, 2001). The cost of bringing a product to market varies depending on the characteristics of the product, but studies show that approximately 25 percent of the total costs are related to research. Thus, the commercial actor has to be ready to face large expenditures (e.g. developing a drug and getting it to market) (Schacht, 2003). The number of development projects that companies can take on is limited, and there is also a limit to the number of companies developing life-science products. A lack of such companies in a region or country therefore constitutes another challenge to commercialization of university research.

Moving on to mechanisms that improve chances for commercialization success, several studies (Zucker et al. 1998a, 1998b, 2002; Nilsson, 2001; Toole and Czarnitzki, 2005; Elfenbein, 2005) point out that transfers of university research to commercial settings seem most successful when dedicated individuals work one-on-one. Trust, developed through long-term relationships, plays an important role in initiating and facilitating transfers, making social capital a key issue. Social capital can be defined as aspects of social organization such as: networks, values, and unwritten rules of conduct and trust that facilitate cooperation for mutual benefit. A high level of social capital can significantly reduce transaction and monitoring costs (Putnam, 2000). From a company perspective, university licensing is related to personal contact between the company´s R&D personnel and university researchers (Thursby and Thursby, 2003). The difficulty of valuing a university technology makes the status or prestige of a university an important factor, as a measure for decreasing uncertainty of quality. Prestige also enhances a university's ability to license technologies beyond what would be predicted by past licensing performance (Sine et al., 2003). An inventor´s academic profile may play an important role in creating positive expectations regarding the value of a certain discovery. For university researchers who are relatively unknown, receiving a patent on the IP seems to be a strategy that helps reduce uncertainty regarding the value (Elfenbein, 2005).

Interaction between researchers and market actors is not only shown to be a mechanism for transferring intellectual property rights, but also for the continued process of developing the discovery. According to Thursby and Thursby (2005), technology-transfer officers in a recent survey estimated that 71 percent of the inventions they licensed could not be successfully commercialized without further collaboration with university researchers. In cases where a new company is created in order to commercialize a discovery, the social capital of the researcher decreases the probability of failure of companies and increases the likelihood of venture capital (VC) funding, according to a study of MIT start-ups (Shane and Stuart, 2002). The key determinants of spin-off creation are faculty quality and the ability of the university and inventor to assume equity in a startup (rather than licensing royalty fees), according to DiGregorio and Shane (2003)[5].

[5] *Study used AUTM data from 101 universities and 530 spin-offs.*

The relationship a university builds with commercial actors is likely to be more successful in the long run if built through relational, rather than transactional, ties (Powell et al, 2005). The latter focuses on bargaining and legal oversight, while relational ties focus on mutual interest and long-term gains from trade. The effectiveness of the processes of commercialization of research from a specific university is ultimately determined by the competencies of the researchers, entrepreneurs, technology-transfer officers, and other university administrators, and it relies on these actors' incentives to engage in the processes (Siegel and Phan, 2005).

1.5.1 Structuring the Case Studies

With this accumulated knowledge regarding mechanisms of commercialization of research, we conducted case studies on six universities in an effort to find out more about current commercialization processes in different regions of the world. We asked about the major challenges of these processes, and what efforts were undertaken to overcome those challenges.

Because literature shows interaction to be an important mechanism for commercialization of university research, we were also interested in how this issue is handled. Although the university researcher and the commercial actor may be the same person, in most cases they are not. Based on the knowledge overview, we assume that direct interaction between these two persons is important for the identification and transfer of research with commercial potential. We also assume that continued interaction is important for successful development of life-science products. University researchers are, however, motivated by publication goals and usually not professionally rewarded for engaging in commercial activities. Interaction between researchers in universities and commercial actors may not take place automatically, which creates a challenge in the commercialization process. In the case studies we therefore posed the following questions:

- How does the connection between university researchers and commercial actors work?
- In which ways are researchers encouraged to engage in commercialization efforts?

Although we could not get information about the absolute extent of existing interaction in the different cases, it was possible to get an understanding of factors that might limit interaction in the US, Japan, and China. We also gathered insights into actions taken to increase interaction.

1.6 Outline

The following chapter reviews the situation in the US, Japan, and China, with regard to commercialization of university research and provides key findings from the case studies. In Chapter Three, the major challenges are presented and comparisons between the countries are made, identifying some challenges as generic. Three main issues emerged as critical for consideration in commercialization of university research within life sciences: critical mass of diverse range of actors, efficient transfer channels, and interaction. These issues make up the framework used to discuss the Swedish situation and provide policy implications in Chapter Four. The case studies, tables on challenges and efforts in the different countries, and statistics on the countries' research and development expenditure and performers are available in the Appendix.

2 Commercialization of University Research within Life Sciences

The US, Japan, and China are in different stages of maturity with respect to commercialization of university research and whether it is new to society or not. In the US, the goal to commercialize university research in order to create economic growth is not new, but used to be more focused on institutions where applied research is the core. More recently, the goal to commercialize research has come to include all universities, some that have not traditionally had close interaction with industry. In China it is seen as a solution to a variety of national challenges (social, economic, and environmental). There is a strong belief that science and technology, and the commercialization thereof, will lead to prosperity and national pride. In Japan, commercialization of university research is seen as a solution to recover the strong economic position the country once had and now seems to be regaining. The idea is to support an industrial renewal – moving from a production-based, to a knowledge-based economy. This chapter describes the respective situations regarding commercialization of university research, and presents key findings from the case studies of universities in each country.

2.1 The United States

”If innovation is the fuel of growth, then entrepreneurs are the engine.”

David Sampson, US Deputy Secretary of Commerce

The current strategy of the federal government is to create a good environment for organic growth, which allows for innovation and encourages entrepreneurship. The government used to see industrial re-localization as a means of creating growth in certain regions of the country. They have now reached the conclusion that such strategies do not fulfill that purpose. Current policy focuses on federal support for basic research along with indirect efforts such as: tax policies, strong intellectual property protection, and antitrust laws to promote commercialization of research.

The federal research and development (R&D) budget for 2006 is 134.8 billion USD, which is a 1.7 percent increase from the previous year. There are two areas that will gain from that increase: defense weapons development and human space exploration technologies. All other federal R&D programs will collectively fall nearly two percent after adjusting for inflation. Life-science-related R&D has a budget of 29.8 billion USD, which means that it has declined for the first time in over 30 years due to cuts in the budget of the National Institutes of Health (NIH). The NIH 2006 budget is 28.6 billion USD, which, after adjusting for inflation, is a smaller budget than in 2003. These figures show us that, although both political parties appeared to recognize that the US leadership in science and technology, innovation, and technology-based competitiveness was threatened by emerging economies, R&D investments in most fields have had to give way to meet restrictive budget targets. (AAAS, 2006)

There are a number of federal programs intended to increase commercialization of research (see Karlsson, 2004). The National Science Foundation´s Science and Technology Centers and Engineering Research Centers, where federal research funding is made available for university-industry collaborations, are receiving continued support. Two other examples of programs considered to have great impact in the commercialization processes are Small

Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) (Schacht, 2003). The aim of SBIR is to increase commercialization of federally funded research, as well as to increase the share of procurement contracts going to small companies from the largest federal R&D agencies. All applicants must start with Phase I: awards up to 100,000 USD for a feasibility study. With positive results from that study, companies may apply for up to 750,000 USD for prototype development (Phase II). SBIR thus targets the challenge with the "valley of death." The program is authorized through 2008 and has become the largest commercialization program, focused on small companies, in US history[6]. The program has also been shown to work as a policy tool for fostering academic entrepreneurship in several ways:

- It funds unproven technologies earlier than private investors.
- Biotechnology companies that work closely with the inventors are more successful in the commercialization of the discovery (Zucker et al. 1998a, 1998b, 2002) and in SBIR the applicant has to commit 51 percent of his or her time to the firm in which the discovery is being developed.
- In a study of companies that had received SBIR funding, those demonstrating linkages to the inventor performed significantly better in terms of follow-on VC financing, SBIR-program completion, and patenting than companies without such links (Lerner, 1999; Toole, A. & Czarnitzki, D, 2005).[7]

A problem with the SBIR, experienced by life-science entrepreneurs, is that companies that are majority-owned by venture capitalists cannot apply for grants. A bill ('Save America's Biotechnology Innovative Research') has been introduced to reverse the rule, but it has yet to move through the Committee process (National Dialogue on Entrepreneurship, 2005).

STTR provides funding for research proposals which are developed and executed cooperatively between a small firm and a researcher in a university or institute. There are competitive grants of up to 100,000 USD for proof-of-concept research (Phase I) and grants of up to 750,000 USD for R&D (Phase II). The private sector is expected to fund the remaining commercialization of the research. The STTR is financed by the R&D budgets of all federal departments that spend over 1 billion USD per year on R&D. The US Congress has extended STTR through FY2009.

The key to a grant like STTR is collaboration with a company that can take on development of university research. Although not all companies are willing to do that (due to the reasons listed in Section 1.5), the US has more life-science companies than any other country[8].

[6] *8.6 billion USD has been awarded in direct subsidies through SBIR, according to the Small Business Administration. There are many differences across SBIR agencies in the focus and administration of the program. For more information of the grants, within NIH, see http://grants.nih.gov/-grants/funding/sbirsttr_programs.htm*

[7] *For a description of SBIR, from a Swedish perspective, please see VINNOVA Rapport 2004:10, "Forskning och innovation i småföretag." Downloadable from www.VINNOVA.se*

[8] *There were 1473 biotechnology companies in 2003 (The Bio Industry Organization) and there are around 50 pharmaceutical companies. Total varies according to method for counting subsidiaries, etc. (Pharma).*

With regard to intellectual property, the patent and trademark act (Bayh-Dole Act) grants universities and federal laboratories the rights to inventions arising from government-sponsored R&D. The purpose is to increase the commercialization of research through cooperative ventures between and among universities, federal laboratories, and industry. Bayh-Dole is often referred to as the factor that made patenting of university research increase in the US. Careful assessments do not support these claims, however (Eisenberg, 1996). Studies show that rather than being the sole reason for increased patenting, Bayh-Dole is an effect of growth in patenting in universities in the 1970s, as well as one of several causes of increased patenting in the 1980s (Mowery, 2005).

The universities own the research results and channel those with commercial potential through internal technology-transfer offices. In 1980 there were less than 25 such offices at US universities, but the number increased to over 200 in 2000 (Mowery et al, 2004). In a survey in 2000, technology-transfer offices at 156 of the universities in the US reported 1.24 billion USD in income from royalties and cashed-in equity. The income represents 4.7 percent of the research expenditures at those universities. The average income was about 8 million USD, but 79 percent of the respondents earned less than 5 million and half reported income less than 824 000 USD (AUTM, 2000):

> *"Most universities have not earned much money from royalties; the odds of making anything substantial from patenting a new discovery are extremely small. Still, the extraordinary success of a few patents and the many millions of dollars in royalties earned each year by a small minority of schools are enough to keep scores of institutions scouring their labs for commercially valuable innovations."*

Derek Bok, former President of Harvard University

In recent years, state governments put more pressure on universities to contribute to economic growth (Lester, 2005). The interest in creating new companies based on university research has increased, but there was a decline in the number of such companies from 401 in 2002, to 374 in 2003. The given explanation points to the difficult conditions for raising early-stage funding, beginning in 2002. Between 1980 and 2003, 4081 university spin-offs were created by the 136 to 190 universities included in the surveys (AUTM, 2004).

There are a number of direct efforts to increase commercialization of university research implemented at state level. Those efforts are, however, not performed in isolation from the federal agencies. Federal resources, such as federal personnel and labs, are used in various local programs. The development of incubator centers for small companies may, for example, rely on federal laboratories supplying technical expertise to companies in such centers (Schacht, 2005). Many states are taking actions to make biotechnology a part of their economic development plan. Forty-one states have life-science initiatives underway (Battelle, 2004):

- Sixteen states are using tobacco settlement funds for life-science R&D.
- Three states are using tobacco settlement funds to improve technology transfer and commercialization.
- Twenty-eight states have at least one publicly supported seed-fund that can invest in biotechnology companies.
- Five states have funds that invest exclusively in life sciences.
- Twenty-six states have research parks where biotechnology companies are located and nine of these are focused exclusively on bioscience.

Two senators recently presented a new legislative proposal “the National Innovation Act of 2005” which builds on the message of the Council of Competitiveness (2005): “Innovation is an ecosystem requiring a strong and well-educated talent base; a commitment to long-term, frontier research; and, a physical and regulatory infrastructure that supports innovation.” The main proposals in the act, related to commercialization of university research, are to:

- Establish a President´s Council on Innovation to develop a comprehensive agenda to promote innovation in public and private sectors. The council would develop and use metrics to assess the impact of existing and proposed laws that affect innovation. It would also help coordinate various federal efforts that support innovation.
- Establish an Innovation Acceleration Grants Program, encouraging federal agencies that fund science and technology research to allocate three percent of their research budget to high-risk grants.
- Increase national research investment by nearly doubling the National Science Foundation´s research funding by 2011.
- Make the research and experimentation tax credit permanent and expand its eligibility for incentives to a greater number of companies.

The success of this proposal remains to be seen, especially considering the recent priorities regarding research funding. The proposal does, however, reflect the interest in innovation at top political levels in the US, as well as the insight that there is constant need for improvement.

2.1.1 Key Findings from Case Studies

> *“There is no such thing as a single US model, but an array of different combinational elements.”*

Powell et al, 2005

The quest for economic growth, based on the commercialization of university research, is clearly articulated at the state government levels. Financial resources are dedicated to support this process, be it through venture funds, grants or different kinds of services. Certain states have engaged university presidents in formulating the strategies, in order to ensure collaboration between university and industry. Intermediary organizations have been created to support efforts of bringing more university research to the market place.

Technology-transfer offices are increasingly working to find ways to engage commercial actors in the funding of their activities

In the US, the university researchers´ intellectual properties are owned by the university and handled through technology-transfer offices. Technology-transfer officers strive to identify commercially viable discoveries and connect them to market actors. The more basic the research at a university is, the harder it is to gain the interest of market actors, who are already weary of the risks of taking on early stage development projects (as discussed in the introduction). The universities need money for proof-of-concept, i.e. to further develop discoveries before industry can be expected to take interest. For smaller amounts, the universities may use internal sources, but technology-transfer officers are increasingly working to find ways to engage commercial actors in the funding of their activities.

Universities do not necessarily encourage direct interaction between their faculty and companies

Technology-transfer officers often prefer being in control of industry interactions to prevent faculty from “spilling the beans,” and therefore put a limit on the direct interaction between researchers and commercial actors. At US universities there are strict procedures on how agreements with companies should be worked out, and lawyers are heavily involved at all stages in order to protect the interest of the university. The complexity of these processes explains the hesitancy of technology-transfer officers to have faculty, without insight into the processes, interact directly with companies.

Commercialization processes are heavily dependent on technology-transfer offices which, depending on university priorities, may become a bottleneck

The design of commercialization efforts in the US universities relies heavily on the ability and network of the technology-transfer offices. The offices may, depending on the university’s priorities, become a bottleneck in the processes of commercialization of research. Some universities strengthen the capacity of the offices and count on future earnings. Other universities have technology-transfer offices so that they are able to comply with the Bayh-Dole act, not necessarily because the university management in itself prioritizes those activities.

Universities that are dependent on government funding engage in commercialization efforts to show that they contribute to economic growth

The large number of universities in the US and the fact that the attitude towards commercialization differs between them, undermines the notion of unified praxis (SOU 2005:95). Universities that are top funding recipients from different sources are not necessarily interested in commercialization issues, since resources from such activities are likely to constitute only a small part of their budget. Many states are cutting university funding however, and public universities that are heavily affected by the economic downturns have to become more creative in ways of financing their research, which creates a drive for entrepreneurial activities. In persuading federal and state governments to provide more funding, the universities argue that they, in exchange, will contribute to economic growth. They manifest their intentions by prioritizing technology-transfer activities. A recent trend is to put offices of entrepreneurship and economic development in place at the universities, close to the president. Several university presidents also make use of external advisors on issues of commercialization of research by establishing boards of science and innovation.[9]

The priority of commercialization efforts at universities is to a large degree dependent on culture

The way universities relate to technology transfer is not only a question of appealing to governments to secure appropriations, but also of culture. Universities in the US were established with different foci, which affect their culture. Some universities are very well funded and so focused on academic excellence that the culture of partnering with industry is treated as a welcome byproduct. Other universities have focused on applied research and partnered with industry from the very founding.

9 One example is the University of California System.

Faculties' perceptions of their universities' technology-transfer offices is a factor to take into consideration when talking about how motivated a researcher may be to disclose a discovery. University representatives report[10] that top researchers have started to interview technology-transfer officers before accepting a position at a university, and they take the quality of the office into the equation. Some universities thus experience a push from faculty to provide a competitive transfer service.

The acceptance of risk and reward related to entrepreneurship is generally considered to be high in the US, which would benefit commercialization processes. Attitudes between individual states vary widely however, and some US regions are still struggling with their abilities to learn from failure, according to biotechnology industry experts.

2.2 Japan

It is often heard in Japan that the Japanese innovation system lacks a strong interaction between the industrial and university spheres. This may not be completely true, since surveys indicate that the majority of R&D-based companies had cooperation with the university sector (Pechter, 2002; Motohashi, 2004). However, the notion that Japan lags behind the US in developing university-industry cooperation, at least when it comes to policy measures, has been an important argument for a change of the Japanese system. It is only in the recent decade or so that more formal mechanisms for commercialization of university research have been developed.

Since the beginning of the last decade's long stagnation, Japanese policymakers have considered improving R&D cooperation between commercial actors and researchers at universities and institutes to be an important factor to promote economic recovery and to increase industrial competitiveness (Motohashi, 2003; Harayama, 2004). The government initiatives have mostly been supported by METI (and the predecessor MITI).

Most renowned are the large consortia programs in areas such as VLSI, in microelectronics, and automotive – initiatives which are believed to have contributed significantly to the competitiveness of Japanese industry. The New Energy Development Organization (NEDO), an agency under METI, runs a number of programs where support is given to cooperation between both small and large corporations and university researchers. A smaller number of cases relate to the biomedical fields, however, and relate more to technology than drugs. These programs are an important source of R&D funding, not only for the researchers but also for university spin-offs. Ministry of Health, Labor, and Welfare is the main supporter of pharmaceuticals research and fund several industrial research consortia in fields relevant to the pharmaceutical/healthcare sectors, such as pharmacogenomics and proteomics. Japan Science and Technology Agency (JST) has also been a founder in this area, acting on the border between university research and industry. The fraction designated to life science has been significant (L. Stenberg, personal communication).

In the mid-to-late 1980s, the government initiated a system of "Centers for Cooperative Research" at universities all over Japan. This program is presently comprised of 62 units. The centers are located at major universities and provide venues for initiating and performing cooperative research between university researchers and industry. An example of these, NICHe, is described in the Tohoku University case study. Other general initiatives include Venture Business Labs and Incubators, and from industry, financing of "Donation Professors."

[10] *Technology Transfer Society Annual Conference, September 28-30, 2005*

Two of the more important, national initiatives to stimulate industrial-university cooperation in recent years are the Industrial Cluster and Knowledge Cluster programs, financed by METI and MEXT, respectively[11]. Both programs support regional projects and actors in order to strengthen the regional innovation systems in specific fields. The Knowledge Cluster program focuses more on the role of the universities in the regions and on emerging industry, whereas the Industrial Cluster program works more on the demand-side of existing industry. Of the two, the Knowledge Cluster program has a stronger focus on life sciences.

As these initiatives are supported from different ministries, it has become apparent that coordination is needed, and improved cooperation is seen at all levels. Both of these programs are important for R&D collaboration and the biomedical fields, and some are briefly described in the case studies.

The need for industrial renewal has also led the government to introduce a number of new legislations:

- The "Science and Technology Basic Law" (1995) states the government's responsibility for formulating and implementing policies for promotion of science and technology, and emphasizes the interaction between national R&D laboratories, universities and business – a balance between basic and applied research and the improvement of research training. Under this law, the Japanese government prepares a Basic Plan for Science & Technology, in which the priorities for the coming five years are set. The first plan (1996–2000) focused on improvement of the level of public research funding as well as strengthening of the research infrastructure. The Second Science and Technology Basic Plan (2001–2005), focused on the development of the national innovation system, is based on improving the networks of interacting actors. The core policy issues are a strengthening of university-industry-government cooperation – including improvement of the R&D links between university and business sectors – and promotion of four key research areas: nanotechnology, life science, ICT, and environment (see Stenberg, 2004 for an overview).
- The Law for Promotion of University-Industry Technology Transfer (1998) made it possible for Japanese national universities and public research organization to set up technology licensing organizations (TLOs) organizationally outside of the universities. Private universities may have the TLO inside the university. This created a more formalized route for technology transfer from university to industry. Under this law, the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and the Ministry of Economy, Trade and Industry (METI) and their predecessors Monbusho och MITI, have certified a total of 41 TLOs. These receive government funding and are entitled to other support measures. Some of the TLOs are linked to a particular university, whereas others serve several universities or other public research centers in a region. The TLOs have three major organizational forms: stock corporations, limited corporations, or incorporated foundations. Thus, they are not part of the university organization but are in many cases initiated by faculty of the university. Some National Research Institutes, supported by other ministries, have certified TLOs operating under this law (Japan Association of University Intellectual Property and Technology Management).

[11] *http://www.mext.go.jp/a_menu/kagaku/chiiki/cluster/h16_pamphlet_e.htm, http://www.nistep.go.jp//seminar/017/017_e.pdf*

- The Law to Strengthen Industrial Technology Capability (2000) relaxed the strict rules that prohibited researchers at public research organizations, as civil servants, from working for private companies. Japanese university professors were, until 1999, prohibited by law from entering into commercial partnerships with companies. Although this did put some restrictions on the ability to form partnership, Kneller (2004) argues that long-term interaction between universities and industry has been supported by other means, exemplified by the system of donations from companies to university departments, as a way to build partnerships. With the previous ambiguities in IP ownership, both knowledge and IP has probably been transferred from universities to industry as a result of such interactions. Contracted/commissioned research such as R&D cooperation under a government-funded program was also allowed under the previous legislation. The law of 2000 allows university professors to consult for private enterprises and take managerial positions with companies in which their research is used. This also made it possible for the researchers to gain economic benefits for such activities.
- The enactment of the Industrial Vitalization Law (1999) transferred the ownership of inventions from government-commissioned research. This law, also called the Japanese Bayh-Dole Act, established the public research institution, commissioned by the state, as the owner of the IP emerging from the research. However, any invention or IP resulting from research done through the basic funding provided to each university professor was excluded, and the invention belonged to the professor. In reality, this situation probably led to an under-reporting of inventions as it was up to the researcher to determine which results came from the commissioned research and which from basic funding. Although not quantifiable, there were probably a large number of inventions not reported to the respective research institution (Kneller, 2004). The university reform in 2004 has changed the situation for the national universities.
- The National University Law (2004) made the Japanese national universities independent administrative organizations. After being an integral part of MEXT, the universities now have a significant degree of independence and their staffs are no longer employed as civil servants. This change in status also made it possible for the universities to claim the rights to all inventions made by their employees. In anticipation of the changes, MEXT provides the resources for universities to handle this change, which has led to the establishment of Intellectual Property Centres at national, regional, and private universities. Their goal is to promote management and utilization of intellectual property at universities in a strategic and systematic way.

Before the incorporation of the national universities, Japan Science and Technology Agency (JST), a national agency, gave financial support to researchers willing to patent their inventions. This system appears to have been appreciated by the researcher interviewed at University of Tokyo. Under this system, JST also took some responsibility for licensing to companies and funding of commercial development projects, but did not issue exclusive licenses until after 2002 (Kneller, 2004). A number of other measures in the late 1990s were set to target the development of R&D-based companies as a new important base for economic development. These included tax incentives for R&D and the development of new stock markets for small and mediumsized companies. Another significant initiative was the launch of a Japanese version of the SBIR program, to increase university spin-offs.

The development of a dedicated and entrepreneurial biotechnology industry has been much slower than in the US or Europe, and the number of university spin-off companies is still very small in comparison. In Japan, the majority of biotechnology companies seem to have origins other than universities (i.e. from large corporations). Of the approximately 1,100 companies created under the government's goal of 1,000 university-born companies by 2005, around 25 percent are listed as "biotech" (Ministry of Economy, Trade and Industry, 2005)[12]. Few university-born biotechnology companies have reached the stock markets, but those that have gained much interest from investors and were able to raise significant amounts of money.

The Japanese life-science industry is, to a large extent, comprised of larger established corporations in different sectors – chemicals, fermentation, and pharmaceuticals. Many large non-pharmaceutical companies also perform drug discovery as one part of their total operations. These companies are found in a variety of, and often span, different industrial sectors. Geographically, Japan has two major life-science regions – Kanto (mainly Tokyo area) and Kansai (Osaka, Kyoto, Kobe, Keihanna). Theses regions are considered to have the strongest academic research base and are home of the major life-science/pharmaceutical companies.

Differing from their US or European rivals, the Japanese pharmaceutical companies tend to do more in-house basic research and to a lesser extent rely on alliances with biotechnology companies or universities (Kneller, 2004). It has been suggested that this self-reliant mode of drug discovery is a result of organizational and operational structures within the companies, i.e. rigid labor market (life time employment, low mobility between companies and to/from universities), in-house training rather than specific recruitments and possibly cultural barriers. The restructuring of domestic pharmaceutical companies may lead to more interaction with universities.

2.2.1 Key Findings from Case Studies

Many regional actors, including universities, are directly dependent on measures and funding from ministries to perform their tasks. Through new legislation during the last eight-to-ten years, the government has set up the framework under which these actors operate. In many cases, this has led to similar setup of the main functions for commercialization of research at the universities and in regions. These functions are, however, organized and run by local actors. Differences are mostly seen on a "micro level" – organization of the functions, local networks, etc. – and in the experience and "drive" of the individuals involved.

The new technology-transfer offices are in a learning period

Both University of Tokyo and Tohoku University have strong, high-performing TLOs, which appear to be the core around which other, newer, functions and activities are built. Much of the practical expertise in IP, contracts, and corporate contacts still resides in the TLOs. The university reform and creation of "institutionalized" industry cooperation and IP functions within the university is still too recent to evaluate. In the "old" system, the researchers had more options for industry interaction. As each university now is responsible for formulating policies on cooperation, disclosure, patenting, and contracts, the experi-

[12] The "Association of Campus Bio-Ventures" lists around 100 member companies. According to Ernst & Young's definition (2004), Japan only holds around 40 companies – less than Korea or Taiwan. This number should be compared to Japan Bioindustry Association's figure of around 400, many which are service providers or spin-offs from major corporations (JBA, 2004).

ence and competence of those involved is even more crucial. One may say that this is a learning period, both for university management in general, and particularly for university-industry cooperation. In our interviews, it became apparent that the successful TLOs linked to University of Tokyo and Tohoku University tried to set up a contact between the researchers and prospective "customer" companies early in the marketing process. The researchers own network was also mentioned as an important asset when identifying prospective companies.

Structural changes lead to conflict and initially slow processes

We are aware of cases where the newly created functions led to conflicts with existing institutions (e.g., causing friction between the more established TLOs and the new university IP Offices). In the case of Tohoku University, this was initially hampering cooperation. For the two cases studied, the present situation is that of functional cooperation. However, this required long discussions and negotiations and, in the Tohoku case, a change of management at one of the functions. The new, university-level IP offices have been questioned even before their creation (Kneller, 2004). From actors on the research side, it was felt that this new level made the process of securing and managing inventions, as well as setting up cooperation, more complex and possibly slower than the previous situation. Whether the IP functions as such hamper commercialization is too early to assess.

Individuals can be highly-effective change agents

The traditional role of the Japanese universities has been one of education and basic research, and much of the applied research has been done either inside the major corporations or at application-oriented research institutes. The attitudes towards commercialization of research and cooperation with industry are definitely changing. In engineering – and to some extent also medicine – the tradition of cooperating with industry has generally been stronger than in other fields. One often-mentioned factor motivating researchers to pursue commercialization of their research is personal interest in seeing one's research results put to practical use, for the benefit of individuals and society. The possibility of personal economic reward does not seem to be the number one driver, but the possibilities of increased funding for research may stimulate researchers to cooperate with industry. Still, the share of researchers involved in commercialization and cooperation with industry is probably lower than in Sweden. The presence of "drivers" – a small group of professors in the Tokyo area, some with experience from the US, who have been especially active in the creation of new start-up companies – was highlighted by the interviewees. There are still few individuals with extensive experience in commercialization of university research through, for example spin-offs, as compared to the US, UK, and some other European countries, but the emergence of "star" scientists/entrepreneurs is an apparent change in the innovation system in several regions of Japan.

Limitations exist in the Japanese life-science companies´ collaboration with universities in Japan

An important issue for commercialization processes is the incentive for university and industrial sectors to collaborate. Japanese pharmaceutical companies often select overseas partners for R&D collaboration rather than universities and biotechnology companies at home. The US, and to some extent Europe, have been the regions of choice. Moreover, there is a tradition of in-house R&D in Japanese companies. This lack of critical mass of commercial partners open to collaboration and bringing university research further to market creates a challenge for universities. Because technology-based SMEs are viewed as important to change the Japanese industrial landscape, there have been recent initiatives to support university start-ups, focusing on quality rather than quantity. The aim is that the spin-offs may become stronger and thereby more attractive domestic partners for the pharmaceutical companies as well as for the university researchers.

When discussing university-industry cooperation in Japan, it is important to keep in mind that there was significant flow of research results and knowledge from university to industry prior to the recent changes in legislation (Pechter, 2002). Companies have participated in industrial consortia, R&D programs or other networking initiatives but also obtained results from university researchers informally. The goal of getting universities more engaged in commercialization efforts has brought with it a transformation: the previous "grey zone" of person-to-person contacts is becoming a more transparent and institutionalized framework of university-linked functions. The performance of those functions is critical to successful interaction between university researchers and commercial actors.

2.3 China

China's modern-day experience with commercialization of scientific research is very recent.[13] Until the late 1970s, research was almost exclusively in the public domain, i.e. funded by the government and carried out at universities and government research institutes: "Until the mid 1990s, most science and technology resources in China were channelled via public research institutions / universities to industry through dissemination of the research results" (Guan et.al., 2005, p 340). Furthermore, science and technology programs were closely linked with, and driven by, defense-oriented policy and needs (Walsh, 2003).

In recent years, the role of the business sector in financing and carrying out R&D has increased significantly. Thus, the business sector's share of total national R&D expenditure has increased from 30 percent in 1987 to 61 percent in 2002 (Guan et.al., 2005). This can be compared with between 68 and 75 percent in the US, Japan, and Sweden. Similarly, the role of the business sector in patenting activity has increased significantly in China in the past decade (ibid.). When seeking to understand commercialization processes in China, however, it is important to remember that both commercialization and university-industry collaboration or linkages are a relatively recent phenomenon.

The impediment of lack of both cooperation and collaboration among research institutions was demonstrated through the refusal of the epidemic center in South China to supply other Chinese institutes with virus samples during the recent outbreak of SARS. This one example demonstrates how lack of trust and fierce competition are preventing cooperation and thus undermining the development of a strong national innovation system (Li et.al., 2005). The Chinese scientists' inability to provide solutions or cures during the SARS outbreak in spite of rapidly increasing funding for life-science research has often been described as a traumatic experience. It served to spur government and university efforts to increase commercialization and thus to ensure economic and societal returns on the rapidly increasing R&D investments. The government has implemented a number of programs aimed at both stimulating basic research in life sciences and promoting the commercialization of R&D.

[13] China has a long tradition of science and utilization of science. Some groundbreaking inventions accredited to ancient China are the wheelbarrow, cast iron, paper, printing, the compass, gunpowder, and the decimal system.

The most important programs in this context are the 863 Program, the Torch Program, and the 973 Program:

- The National High-Tech Development Program, referred to as the 863 Program (1986), was launched with the aim of strengthening China's international competitiveness and high-tech R&D capability by focusing on eight key areas, including biotechnology (Walsh, 2003).[14] By 2002, the number of areas had been reduced to six, with biotechnology and advanced agriculture receiving 33 percent of the total funds (Ministry of Science and Technology, 2003).[15]
- The Torch Program (1988) has focused on the commercialization of research results achieved through the 863 Program. Under this program, 53 state-level High Technology Development Zones, as well as numerous, regional high-tech development zones and business incubation centers have been created.
- The National Basic Research Development Program, or 973 Program (1997), supports multi-disciplinary research, which is linked to China's research needs in a number of different areas, including healthcare.

One important characteristic of Chinese commercialization efforts is that once researchers have received funding from national research programs, such as the 863 Program, their likelihood of receiving funding from other sources, such as banks, regional authorities, and other government sources increases dramatically. Thus, if a researcher gets government funding for his or her research, he or she also has good chances of getting funding for commercialization. As a result, funding received from government research programs has a value that far exceeds the financial amount of the grant. One of the government sources is "Innovation Fund for Technology-Based SMEs" (1999).

The mission of the Innovation Fund, as well as some of the operating principles, is similar to those of the Small Business Innovation Research (SBIR) Program in the United States. The Fund is financed jointly by the Ministry of Science and Technology (MOST) and the Ministry of Finance. In 2003, the Fund had a budget of approximately 60 million USD. In order to qualify, companies must have less than 500 employees, their R&D investments as a percentage of sales must exceed 5 percent, and the share of technological personnel must be at least 30 percent of total employees. The prioritized technological areas are the same as for the 863 Program. Funding can take the form of either grants or loan interest subsidies. Grants must generally be matched by the applicants and complemented by funding from local government. The Innovation Fund is also in the process of developing forms for equity investments, and some pilot projects have been carried out in this area. Between 1999 and 2004, the Fund approved 6410 projects (out of a total of 25,419 applications), and allocated a total funding of 4.29 billion RMB, or 670,000 RMB per project, on average (Innofund, 2005). Eighteen percent of the projects funded were in the field of biotechnology.

Funding is only one aspect in promoting commercialization. Another big question in China, which is beginning to be addressed, relates to the incentive structure for patenting and the ownership of intellectual property rights (IPR). Traditionally, the university owned the intellectual property rights of scientific discoveries made by researchers employed at

---

[14] *Good overviews of China's science and technology policies are found in Walsh (2003) and Sigurdsson (2005).*

[15] *The other areas were information, advanced materials, advanced manufacturing and automation, energy, and resources and environment.*

their institutions. However, in recent years, some universities have started to offer researchers a share of the ownership of their discoveries in an attempt to encourage patenting and commercialization. Aside from the ownership question, there is also a traditional strong bias in favor of publishing, versus – and at the expense of – patenting. Scientific publications bring research funding and prestige, as well as considerable private financial benefits. Patents are not regarded or rewarded in the same way. Thus, they do not have the same benefits and offer no other certain benefits in return, since there is no guarantee that one will make money from a patent. Furthermore, they may mean that the publication process will have to be delayed until the patent is formally registered. Recently, universities and policymakers are recognizing that commercialization must gain higher priority and be promoted more strongly. Thus, scientists are now encouraged to establish their own companies and faculty are permitted to be shareholders while retaining their academic positions (European Molecular Biology Organization, 2003). Funding organizations and universities are also encouraged to give greater recognition to patenting as a criterion for awarding grants and academic titles.

In addition to the question of ownership, a further, more fundamental, problem hampering commercialization efforts in China is the lack of protection of intellectual property. While the basic legislation seems to be in place, lack of sufficient enforcement of intellectual property rights constitutes a significant weakness in the Chinese commercialization system (Asakawa, 2005; DTI Global Watch, 2004; Wu, 2005; van Arnum, 2005). Weak IPR enforcement is often listed as a major deterrent preventing foreign companies from establishing research facilities in China. Fear of idea theft and inadequate legal protection also undermine Chinese scientists' motivation to patent discoveries.

In the 1980s, some universities, primarily in Beijing and Shanghai, began to set up university-owned, technology-based, spin-off companies. The companies were set up, first, as a mechanism for commercializing university research and, second, to provide an additional income source for universities. Based predominantly in one of the national science and technology development zones, some of these have become important players in the Chinese high-tech industry (Sunami, 2002).

The Chinese innovation system is very much characterized by top-down, centralized, and public sector-driven decision-making. Thus, in many cases, the government has a vision of how the innovation system should look and what actors are needed, then proceeds to decree the creation of these according to this vision. An example of this is the venture capital system. The government identified venture capital as one of the fundamental weaknesses of China's innovation system. Its response to this weakness was to create, or delegate to regional authorities the creation of venture capital companies which often are publicly funded and staffed by civil servants.[16] One consequence of this is that, as opposed to the United States, for example, the commercialization process is dominated by official, or at least officially recognized, institutions. As a result, the commercialization landscape tends to be very similar across universities.

In addition to the lack of a functioning venture capital market, or of "intelligent capital," particularly for life sciences, there are no satisfactory exit mechanisms for venture capital in China. Chinese companies and private investors, which could be an important source of capital, tend to have comparatively short-term investment horizons. Thus, whereas commercialization in life sciences can be a very lengthy and risky affair, with many years

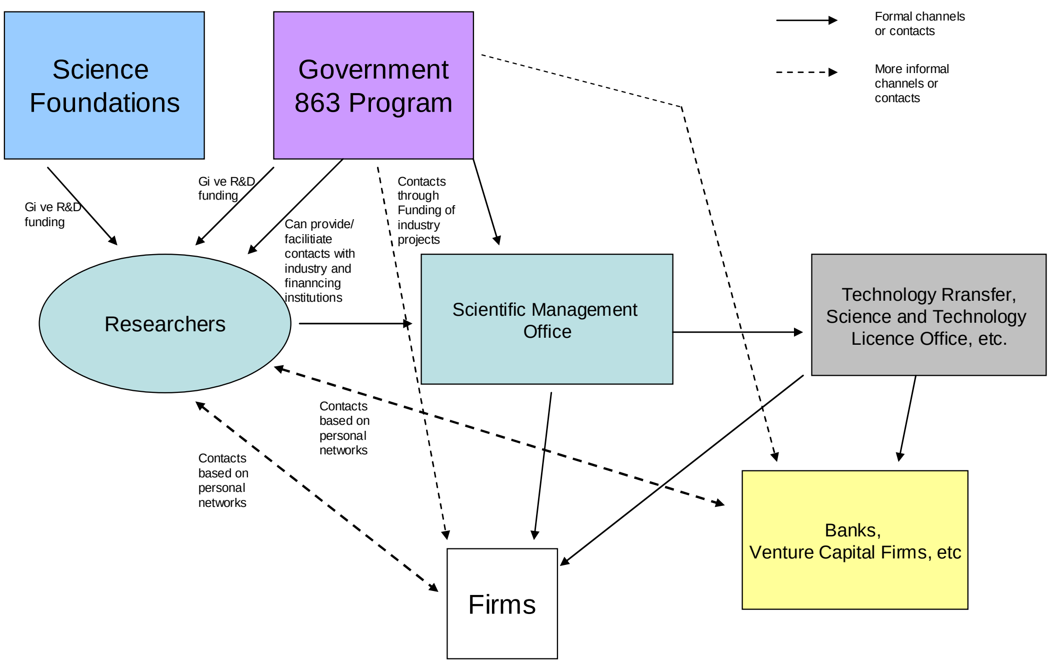
[16] *See White et.al., 2005, for an excellent analysis of China's venture capital system.*

between drug discovery and a marketable product, Chinese investors tend to demand quick returns on their investments (Li et.al., 2004; Red Herring, 2005; European Molecular Biology Organization, 2005).

Figure 1 below attempts to depict this "standard" version of the commercialization system. Researchers receive funding from the university, science foundations or the government through government programs, such as the 973 or 863 Programs. Officially, all research funding coming from outside the university has to be approved by the Scientific Management Office. Its main function is to handle cooperation with other research institutes and universities, cooperation with enterprises, also in regard to technology transfer, patent application, etc. If a researcher makes a discovery with potential commercial value, he or she is expected to take this discovery to the university's Scientific Management Office (sometimes also called Office of Scientific Research Administration). The Scientific Management Office often has a unit dealing with technology transfer or Science and Technology Licensing. In some cases, these functions can also be in a separate office, as, for example, in the case of Peking University. The technology-transfer officers assists the researcher with obtaining patents and licensing. It also establishes contacts with companies, banks, and venture capital organizations. Generally, the Scientific Management and technology-transfer offices are staffed by university officials, that is, not by people with strong commercialization experience.

Science and Technology Industrial Parks and Development Zones, as well as business incubators, play an important role in China's commercialization processes by physically bringing together technology-based companies and research institutes in the same location. Thus, the vast majority of technology-based companies and university spin-offs, both domestic and foreign, are located in these Development Zones, Science Parks or business incubators. Currently, there are 53 nationwide Science Parks or High-Tech Development Zones, which, among other things, can offer preferential tax treatment to foreign technology-based companies wishing to establish themselves in China (White et.al.). An interesting observation is that Science Parks and High-Tech Development Zones are quite frequently not located close to universities. For example Shanghai's Zhangjiang High-Tech Park is located several kilometers away from Fudan University, or any other university carrying out life-science research. The same goes for Beijing's Economic and Technical Development Zone and the Beijing Biological Engineering and Pharmaceutical Industry Base.

Figure 1 Actors in commercialization processes in China



Life science, in particular biomedicine, is a very young, and in many ways, immature field in China. However, there are clear signs of rapidly increasing academic excellence in biology research. This can be seen in a rapid increase in Chinese-authored or co-authored scientific publications in medicine and biology (Li et.al., 2004). China's rapidly growing science and technology resources are strongly concentrated to a few cities and regions in China. Thus, one third of all provinces accounts for 75 percent of all R&D expenditure. By most measures, China is still a developing country with a few more developed geographic or sectoral niches. When it comes to commercialization of life sciences, this means that only a very small minority of China's officially recognized universities are currently carrying out life-science research that is relevant in commercialization terms, and have commercialization activities that would be suitable for comparison in the context of this study. A common trend in recent years has been for universities to "acquire" or merge with medical universities, thus creating stronger life-science platforms. This has also been the case for Peking University and Fudan University, our case studies, see Appendix.[17]

Biotechnology is one of the key priority areas in the government's science and technology policy. This has resulted in strong government support, financial and otherwise, both for research institutions and companies. Official sources estimate public investments in bio-

[17] *The dramatic increase in student enrolment in China in recent years has not been matched by a corresponding increase in government allocations to higher education. As a result, many universities are facing serious financial constraints and have been forced to diversify funding sources towards donations and company endowments, among others. Starting in 1989, for the first time in 40 years, institutions began to experiment with charging tuition and fees from students.*

technology at around 300–600 million USD per year, or 1.25 billion USD between 2001 and 2005 (Jia, 2005; Zhao, 2005; Chervenak, 2005). Currently, the responsibility for allocating public investments in biotechnology is divided between a number of ministries and agencies (Jia, 2004). In addition, the National Development and Reform Commission, based in Beijing, has to approve all biotechnology research appropriations (ibid.). In 2004, in order to improve the coordination of China's national support for biotechnology research, the Minister for Science and Technology, Guanghua Xu, announced the creation of a high-level leadership committee for national biotechnology development. Furthermore, in 2005, Minister Xu announced the creation of the first official nationwide industry association for biotechnology.

There are clear signs of rapid advances in scientific excellence, and leading international pharmaceutical companies are locating parts of their R&D activities to China. Access to large patient populations, low costs, China's domestic market for drugs, and its anticipated rapid growth are the primary, listed reasons why multinational pharmaceutical companies increasingly choose to carry out clinical trials in China, in addition manufacturing (Einhorn and Carey, 2005; Gong, 2005).[18] According to most observers we spoke to in the context of the study, China still has some way to go before it has the systemic, and systematic, ability to carry research through the development phase to the final product. When it comes to commercialization, life science in China is still very much an "academic affair."

The life-science industry is relatively small, and it has no large companies that could take on a role in developing research from universities. Experts assess that there are not more than 100–300 biomedical companies in China today (Chervenak, 2005; Li et.al., 2004). The overwhelming majority of these are small (up to 150 employees). Government policy of regulating the price for drugs, in particular the low ceiling for pharmaceutical products, prevents the development of a large market for drugs that have high development costs (the Economist, 2005; Wu, 2005). While there are a number of large Chinese pharmaceutical companies, they still produce predominantly generic drugs (Cao, 2004).

2.3.1 Key Findings from Case Studies

It is important to remember that commercialization is a very recent phenomenon in China. It makes the significant advances in scientific excellence and the successes in attracting foreign R&D very impressive, but it also partially explains some of the difficulties encumbering commercialization of university research within life sciences. Not all of the challenges can, however, be attributed to the lack of commercialization experience or tradition.

Efforts focus on physical infrastructure, neglecting intangibles

In general, an examination of policies aimed at promoting commercialization of life sciences reveals a tendency, by national and local authorities, to focus on creating the physi-

[18] *China's growing research strength combined with well-equipped laboratories (DTI Global Watch, 2004) and a large supply of relatively inexpensive scientists are increasingly attracting the attention and investments of pharmaceutical companies. According to some rough estimates, the labor cost for a Ph.D. researcher in Shanghai is roughly one-fifth the cost of a Ph.D. researcher in Silicon Valley (interviews). Costs for conducting clinical trials in China are about one-fourth of that in the US (Einhorn and Carey, 2005). As of December 2005, two of the world's largest pharmaceutical companies (according to global market share) had R&D operations in China. AstraZeneca, Roche, Eli Lilly, Ciba, and Novo Nordisk are some of the multinational pharmaceutical companies that have established R&D operations in China. According to some estimates, the Chinese market for Western drugs is expected to quadruple in the next five years, from 15 billion USD in 2005 (ibid.).*

cal infrastructure for commercialization by establishing big buildings or state-of-the-art facilities in big science parks and setting up technology-transfer offices. At the same time, policymakers appear to neglect, or not focus on sufficiently, the more 'intangible' aspects of commercialization and science-industry cooperation, such as: attitudes, culture, communication, and, perhaps most importantly, social capital. A low level of trust, or the absence of social capital, has been identified as one of the strongest challenges to commercialization of university research in life sciences in China (interviews and Li et.al. 2005).

Reluctance to use official channels and to patent abounds

Formally, offices of scientific management and for technology transfer or licensing are identified, and created, as key actors in the commercialization process. In practice, there are important reasons why researchers who make discoveries of potential commercial interest may not seek to commercialize their ideas, or, if they are interested in commercialization, may choose not to go through these official channels. Firstly, when seeking cooperation with the private sector, researchers prefer to seek direct links with companies based on their personal networks and contacts. Secondly, researchers often show reluctance either to patent or, even if they want to patent, they seem skeptical about going through the official channels, such as the office of technology transfer. Reluctance to patent is explained partially by the greater economic and social returns accruing to researchers who choose to publish rather than patent. Publications bring much higher immediate and certain rewards for scientists than patents, both in terms of personal income and prestige. Overall, and for several very different reasons, technology-transfer offices appear to play a minor role in the commercialization process.

Weak enforcement of intellectual property rights and lack of long-term investment hampers commercialization processes

A further challenge appears to be an unwillingness both to pay for and to invest in intangible assets or ideas. According to the experts interviewed, neither researchers nor business people seem to have the long-term investment or planning horizons that are required in the development of new drugs. Lack of IPR enforcement severely impedes the development of an internationally competitive life-science industry (DTI Global Watch, 2004; Wu, 2005).[19] Weak IPR enforcement worsens this problem. Overall, how to share inventions and at the same time protect them from idea theft and piracy is a huge barrier to commercialization. Given these factors, while China has achieved considerable successes in the commercialization of research in other sectors, such as information and telecommunications (ICT), it may take considerably longer to establish a thriving, and internationally competitive, life-science industry based on Chinese research achievements.

System suffers lack of "full-dimension talents"

There is apparent lack of so-called "full-dimension talents," that is, people who possess scientific as well as managerial or commercial capabilities (WU, 2005). In addition, several interviewees identified a lack of people and skills necessary for ensuring the linkage of the various components, from drug discovery to sales, throughout the value chain.

[19] China's decision to revoke Pfizer Inc.'s Viagra patent aroused or confirmed concerns in international pharmaceutical companies about operating in China (van Arnum, 2005).

3 Major Challenges and Efforts to Overcome Them

This chapter is based on findings from the US, Japan, and China. Our statements are supported by the interviews made in conjunction with the case studies, as well as by official documents. We have identified factors that constitute major challenges in the processes of commercialization of university research in each country. The challenges are to some part country specific, but we also identified a number of generic challenges, see Table 1.

Table 1 Challenges in Processes of Commercialization of University Research

	Challenge
Generic	- Lack of seed-financing and human resources - Creating and maintaining top-quality science - Engaging commercial actors early in the processes - Policymakers focus on the structure – rather than the content – of activities, and expect quick returns on investments - University managers are unclear about priorities and goals regarding technology transfer - Informational and cultural barriers exist between universities and companies (lack of trust and respect) - Conflicting goals at universities, including insufficient rewards and/or negative impacts for researchers who participate in commercialization processes
US-specific	- Bayh-Dole is a one-channel system and may become a road-block at universities that do not have sufficient capacity at their TT offices. - Interaction between researchers and companies is limited by the litigation climate and complex negotiation processes with regard to intellectual property rights.
Japan-specific	- Domestic life-science companies focus on internal R&D rather than collaboration with universities - Low entrepreneurial thinking in society *Low mobility between actors *Rigid labor market - Lack of individuals with experience in creating and growing university spin-offs
China-specific	- Government and authorities design commercialization landscape and institutions in top-down processes; actors have little faith in the officially designated institutions - Few domestic life-science companies - Underdeveloped intellectual property and financial system

Through the analysis of the data collected in this study, three main issues emerged as critical to consider regarding commercialization of university research:

- **Critical Mass of Diverse Range of Actors** For commercialization processes to work, there must be a diverse range of institutional actors involved, who can contribute a variety of information, as well as depth and breadth of experience.
- **Efficient Transfer Channels** For commercialization processes to work, there must be time- and cost-effective ways of transferring university research to commercial actors so that development can continue.
- **Interaction** For commercialization processes to work, there must be links between university researchers and commercial actors that enable opportunity-recognition and successful development of research results.

In the following section we compare the challenges and efforts in the three countries, highlighting the generic challenges within the three main issues.

3.1 Critical Mass of Diverse Range of Actors

For commercialization processes to work, there must be a diverse range of institutional actors involved, who can contribute a variety of information as well as depth and breadth of experience. This has previously been highlighted in research by Powell et al (2005).

At the national level in the US, there is already a critical mass of necessary actors. Therefore, the focus is more on getting a smooth system of interaction, given the IP complexity, litigation climate, and cultural barriers between universities and industry. With less history of commercialization of university research, the key for Japan and China is to make sure that there *is* in fact a critical mass of actors enabling these processes.

Although Japan has many life-science companies compared to China's few, both countries lack commercial actors that take on the development of university research, which constitutes a major challenge for commercialization efforts at universities. Japan has a significant segment of large life-science companies, both in pharmaceuticals and industrial biotechnology, but the companies have had a tradition of internal research, rather than interacting with domestic universities. There are, however, surveys indicating that, in general, Japanese industry is interacting with university research at levels not significantly lower than in the US, but the forms for this differ and are not always as transparent (Pechter, 2002). Despite efforts to promote biotechnology companies in Japan, the emergence of new companies has, until very recently, been slow. Few scientist-entrepreneurs have shown the way, as of yet. The lack of entrepreneurs is related to an overall low entrepreneurial thinking in society, but a more important factor is probably the rigid labor market that discourages skilled individuals at larger companies from entering into spin-off companies. The number of actors involved in commercialization of university research is comparatively low and these have a shorter history than in the US. Moreover, in the metropolitan areas, opportunities are limited in terms of space that can be provided for new organizations.

For China, the challenge of a lack of life-science companies is accompanied by an underdeveloped financial system, which impairs commercialization efforts. The same holds true for the intellectual property system.

Creating and Maintaining Top-Quality Science

The Japanese and Chinese governments initiate and fund new programs to motivate industrial and academic actors to participate in collaboration programs, to make more money available in the system, not the least for research. The US has large investments in R&D. Due to the last years´ cuts in several fields of science, however, worries about the ability to maintain the scientific leadership have been expressed.

Lack of seed-financing and human resources

Lack of seed-financing and human resources were brought up as challenges by interviewees in all countries. At the regional level the same type of efforts are implemented in the US, Japan, and China. The focus is attracting financial and human resources. There is marketing for the region, focusing on quality of life and career opportunities in order to attract both researchers and entrepreneurs. One difference is that in the US, those efforts are often initiated by regional actors, even on research funding. In Japan and China, even regional initiatives are often closely linked to efforts at the national level. In Japan, most initiatives are centrally funded, but organized and managed by regional/local actors. Many actors are, fully or in part, supported by the government, sometimes in cooperation with private or university-linked venture capital funds. In China, most efforts are initiated by the national government and even if they are not, their legitimacy is dependent on getting government recognition. In Japan, there are initiatives both from public and private actors and their efforts sometimes merge in public-private partnerships. Relatively seen, Japan does not have as many purely private actors as the US, where private and public initiatives mix in the arena, sometimes merging, earning legitimacy through their success.

Interviewees in all countries brought forward “valley of death” as a challenge, although we can generally assume that seed-financing problems are likely to be more serious in China than in the US. There are a number of efforts at national and regional levels to overcome this. Governments support seed-financing of project development and encourage regions to transform into knowledge-based economies. Regional policymakers put money into creating venture capital funds and science parks in all three countries. It only seems to be in the US, however, that the universities themselves take initiatives to attract financing in order to cover proof-of-concept, bring their discoveries further, and thereby gain the interest of companies. Examples of such initiatives are:

- Getting private-market actors to invest in conglomerate seed-funds through the technology-transfer office as a way of offering decreased risk through a larger portfolio.
- Making use of alumni for fund-raising and market contacts.

In the US, one challenge for many states is that their spin-offs move to other states once they start to grow, due primarily to a lack of large venture capital funds in the region. Generally, as venture capitalists consider whether to make deals with universities, part of their risk analyses is related to the relative cost of moving, for example a drug, from inception to market in that specific country. Lower costs will make it easier to form a critical mass of venture capital companies, keeping in mind the other factors that are a part of their risk analyses.

Intermediary actors, whose role it is to support the commercialization processes by increasing the critical mass of various types of actors or the interaction between universities and companies, exist in all countries. One issue is whether there is competition between these actors for resources and influence (political legitimacy) or if they are able to work towards a common goal. One major difference between the countries is that in Japan, for example, direct conflict is often avoided and competition is sometimes masked. In the US, conflicts are not as important to avoid. According to our interviews, traditions of collaboration in a region affect whether intermediary actors collaborate with each other or not. Access to economic resources was also said to matter, as good access creates lower incentives to collaborate, making actors in poorer regions more inclined to collaborate.

3.2 Efficient Transfer Channels

For commercialization processes to work, there must be time- and cost-effective ways of transferring university research to commercial actors so that development can continue.

Engaging Commercial Actors Early in the Processes

Looking at national efforts getting commercial actors to engage in the processes, the current US administration is focused on providing indirect support through tax policies, research funding, and regulations. The assumption is that given the right infrastructure, there will be incentives for companies, non-profit organizations, and universities to engage in commercialization of research. Although such efforts also exist in Japan and China, those two countries are more dependent on direct support through programs initiated at a national level, which create incentives for actors to engage.

Policymakers Seem to Focus on the Structure – Rather than the Content – of Activities, and Expect Quick Returns on Investments

In Japan and China, commercialization has been added as a new responsibility for the universities, while the structures, goals, and missions of universities are focused on education and research. The public Chinese universities follow top-down instructions from national agencies. Policymakers have chosen to build technology-transfer offices at the universities, inspired by the US system, in order to increase commercialization of university research. Japanese policymakers have also been inspired by the Bayh-Dole Act and give universities the right, and encouragement, to establish internal technology-transfer offices, but leave it to the university managers to decide whether to do so or not. Most research-intense universities and institutes have followed the Ministry's recommendation.

The US universities making big profits on commercialization of research are few, and although more technology-transfer offices have become profitable over time, the current picture suggests that profits are not the sole goal of the licensing activities at the universities (Thursby and Thursby, 2003). The official statement of the Association of University Technology Managers is that their goal is "to deliver the benefits of innovative research to society, not to generate revenue" (Crowell, 2005). Also reflected in our interviews, US universities are increasing their investments in technology-transfer offices (Libecap, 2005), offering courses in commercialization of research and broadening the administrative and academic support for technology transfer. One reason, stated by interviewees, is that universities, in persuading governments to provide more funding, argue that they will contribute to economic growth. Universities that have a good track record in technology transfer can use it as a competitive advantage, a service to faculty, when competing over top researchers. In the US there is internal pressure from faculty who want a professional handling of their discoveries and from students who are interested in practical applications of their research, according to technology-transfer officers.

University Managers are Unclear About Priorities and Goals Regarding Technology Transfer

Many universities are still struggling to find an optimal way of designing their commercialization efforts. The US Presidents Council of Advisors on Science and Technology concluded in 2003 that the mechanisms for technology transfer that were in place worked and should not be changed (PCAST, 2003). There are scholars who oppose this and argue that it could be more effective. Florida (2000) argues that the US system, which enables universities to claim ownership of intellectual property, may exacerbate the skewing of the university´s role, and that policymakers instead have to support the university´s role in the broader creation and attraction of talent, a fundament in the knowledge-based society. The Bayh-Dole Act needs to be reevaluated, based on the university as a talent magnet, rather than an innovation engine, according to Florida. He highlights that companies are upset that they are both sponsoring research at universities and then put through "unfavorable negotiations" over IP. Moreover, the time delays caused by complicated negotiations slow the process of getting new things out on the market in a competitive manner.

Technology-transfer officers in all three countries experienced that their resources were insufficient to meet expectations in terms of identifying and patenting research with commercial potential. In China, there is a lack of trust in the capacity of internal technology-transfer offices, which makes faculty even less inclined to disclose their discoveries. The new technology-transfer offices encourage researchers to use their services, but as patents are not prioritized by the researchers, it is not apparent that the researchers would use these offices. It is more likely that they continue to go through their own networks if they interact with industry. In Japan, due to the already existing, external technology-transfer offices, (some of which have been functioning well), the introduction of new internal technology-transfer offices with personnel that do not have the same experience of commercialization processes creates an uncertainty amongst researchers who want to disclose a discovery. New efforts to increase commercialization include university managers scouting the departments for universities. Such scouting is also increasing in the US and dual appointments are created at some universities so that a person gains credibility both in the research department and at the technology-transfer office, which makes it more likely that discoveries will be discussed and disclosed. University managers are also encouraging faculty to disclose more to technology-transfer offices, overall.

3.3 Interaction

For commercialization processes to work, there must be links between university researchers and commercial actors that enable opportunity recognition and successful development of research results.

In the US, efforts to increase interaction exist through programs financed at a national level through government agencies, which promotes commercialization of research through collaboration between universities and industry. The programs are usually proposal-driven, and bottom-up. National and regional efforts to promote collaboration between universities and companies exist in all three countries. Such efforts are mostly focused on joint research ventures, which is an important way in which universities contribute to economic growth, although hard to measure.

Informational and Cultural Barriers Exist Between Universities and Companies (Lack of Trust and Respect)

When it comes to the universities' commercialization efforts, which is where policymakers seem to put the pressure on universities today, the problems of cultural barriers and lack of interaction are evident to the university managers and technology-transfer officers we interviewed in all three countries. Different agendas and ways of working, as well as lack of trust, were mentioned as challenges of interaction. Problems with direct interaction between faculty and commercial actors thus exist in all three countries, partly for different reasons.

In Japan, policymakers and some researchers identified the apparently weak interactions between universities and companies as a challenge. The lack of spin-off companies, which in the US were driving innovation, was seen as a particularly disconcerting. Efforts to increase interaction and promote spin-off creation have improved the situation. However, the system is still in a transitional state. In China, the interviewees considered the insufficient collaboration between industry and universities a main reason to why it is hard for the universities to succeed with commercialization efforts.

In the US, there is a long tradition of research collaboration between universities and industry, but according to economic development officers, the collaboration in many regions is not at the level it should be in order to foster innovation. Successful initiatives to change this are found in, for example, Georgia.[20]

Although university faculties have connectivity to the business community, such activities are not being tracked. It is therefore difficult to make statements about absolute levels of direct interaction. This is true for all three countries studied. In China, long-lasting connections are usually direct and personal, based on private networks rather than just work-related networks. University management encourages interaction, but only very recently. In Japan, researchers within public universities were limited by law in their interactions with commercial actors until 2000. Interaction at an officially-sanctioned level did occur through collaboration projects. Parts of the universities are constructed as research programs, where faculty collaborates with industry researchers. When the universities gained more independence in 2004, the rule is that new connections or new contracts should involve appropriate university functions. Researchers are now encouraged to interact with industry (e.g., through fairs where they can show their results to industry), and to be involved in spin-offs.

In the US, direct contacts between researchers and commercial actors have been legitimate for a long time, within the rules and regulations of the universities. Many universities allow faculty to consult 20 percent of their time. The possibility of efficiently using one day a week for consulting is considered to increase when there is a biotechnology community close at hand and interactions occur naturally, for example, through shared facilities. Faculty may not always, however, be allowed to take a managerial role in a company, and if the interaction is regarding a discovery made at the university, the technology-transfer office must be involved.

Contrary to popular belief, all US universities are not necessarily encouraging their faculty to engage in commercialization processes, apart from disclosing their discoveries to the technology-transfer office. One reason is the complexity of the intellectual property system. Technology-transfer officers may be concerned that researchers' interaction with companies will hamper negotiation processes. A related issue is that lawsuits are becoming more frequent and can be very costly for the universities. That, in turn, may create negative attitudes toward commercialization efforts at universities, amongst faculty. The interaction between universities and industry is likely to be negatively affected by the fact that companies find patent negotiations too complicated and time-consuming, which ties back to the risk evaluation and costs discussed in the introduction of this report. There are, however, efforts at US universities to increase interaction with industry and the university in various ways:

- Making use of alumni to expand network into companies
- Creating offices of economic development & entrepreneurship
- Creating boards where deans are represented along with commercial actors and technology-transfer officers
- Arranging science presentations for commercial actors with networking opportunities.

[20] *Georgia Research Alliance. See www.gra.org for information on methods and impacts.*

The Japanese university system has been built after the "Humboldt University" model and is thus focusing on free, curiosity- and scientist-driven research with a primary goal of building knowledge and educating new researchers. Unlike the US, Japanese national universities have not been subject to competition from strong private, research-intense, universities. Policymakers have only recently articulated the role of the university as innovation engine for the society, and it has been argued that the initiatives in recent time to prioritize life sciences could be seen as means to strengthen the universities role in the innovation system as a whole (Lehrer and Asakawa, 2004). Since gaining more independence in 2004, Japanese universities prioritize the interaction with industry more than previously. Resources and staff are being directed toward facilitating cooperation and technology transfer. Already-existing relations between researchers and industry are seen by university leaders as important channels to build stronger ties. These functions are expected to enhance the cooperation. However, some scholars and researchers are worried that the extra levels imposed actually hampers cooperation.

Conflicting Goals at Universities, Including Insufficient Rewards and/or Negative Impacts for Researchers Who Participate in Commercialization Processes

For interaction to work there needs to be an interest from both parties. Interestingly enough, we learned through our interviews that university researchers in all three countries did not feel that they would be rewarded for engaging in commercialization efforts, even though university management made statements regarding the value of such activities.

Researchers at universities seek to disseminate their ideas and breakthroughs rapidly; the end result being measured in publications, citations, and grants. The acknowledged motives for life-science researchers to interact with commercial actors are: access to platforms for testing, financial support for their projects, potential for licensing a discovery. Professors also revel in their students finding good jobs in companies and interaction gives the researchers connectivity for their graduate students. Lach and Shankerman (2003) show that university researchers´ disclosure is positively related to their share of license revenue – a fact that highlights monetary motivation. Others point out that most researchers have had opportunity to make more money in various ways, but have chosen to stay within universities, demonstrating that they are more driven by research than by money. Surveys show that the involvement of researchers in the processes of commercialization may be quite limited in the US: over 64 percent of faculty never disclosed discoveries, and approximately 15 percent disclosed only once (Thursby and Thursby, 2005)[21]

Bercovitz and Feldman (2004) find that the researchers' decision to disclose discoveries depends on the norms at the institution where the researchers were trained, as well as the disclosure behaviors of their department chair and peers, which corresponds with what we have found in the US case studies. The need for changes in reward system was frequently brought up in the case studies in all countries. In China, changes of the reward system for faculty are on the way as an effort to overcome the interaction challenge. We did not identify similar efforts in the US or Japan. If researchers do not feel rewarded by the processes, efforts to increase interaction are not likely to be successful.

[21] *Survey data set of 3,342 faculty at six major universities over up to 17 years.*

4 Main Issues: Sweden

Through studies of six universities in the US, Japan, and China, we identified current challenges experienced by actors involved in commercialization of university life-science research, along with efforts which have been implemented to overcome those challenges. A number of generic challenges were found and three main issues emerged as critical for policymakers to consider for commercialization processes to work:

- **Critical Mass of Diverse Range of Actors** There must be a diverse range of institutional actors involved, who can contribute a variety of information, as well as depth and breadth of experience.
- **Efficient Transfer Channels** There must be time- and cost-effective ways of transferring university research to commercial actors so that development can continue.
- **Interaction** There must be links between university researchers and commercial actors that enable opportunity-recognition and successful development of research results.

This chapter employs the framework "Policy issues for commercialization of university research" to discuss the Swedish situation.

4.1 Critical Mass of Diverse Range of Actors

Generic challenges

- Lack of seed-financing and human resources

- Creating and maintaining top-quality science

Key efforts[22]

- National initiatives: support research; offer R&D tax credits; support cluster programs (high-development zones); promote technology-based SMEs

- Regional initiatives: support research; create local VC funds; attract large VC funds to the region; create science parks; attract CEOs and top researchers

- University initiatives: attract top researchers

A critical mass of diverse range of actors is required to bring a research discovery to market. Florida (2000) argues that while new knowledge is generated in many places, the only regions that will be able to transform new ideas into economic wealth are those that can absorb and apply those ideas. A region that lacks such infrastructure and commercial actors will not be able to retain talent. We found that Japan and China have numerous efforts at national and regional levels that aim to create a critical mass of diverse actors, as required by the commercialization processes. In the US it is a question of creating critical mass at the regional rather than national level, and there are programs in place to attract both human and financial resources.

[22] *See Table 5 in Appendix for efforts implemented in the US, Japan, and China.*

Sweden has a relatively high number of life-science companies clustered to a few university cities[23], and these range from well-established companies to start-ups. Seed-financing, which was brought up as a challenge in the countries studied, is being addressed by the creation of a public organization that supports commercialization of research-related ideas (Innovationsbron) along with already existing foundations (Teknikbrostiftelserna). It is anticipated that these efforts will increase access to seed funding (VINNOVA, 2005).

There is a growing concern that Swedish discoveries with commercial potential get picked up and exploited abroad, thereby adding more value in another country than in Sweden. The same concern was identified the US case studies; those interviewed pointed to the lack of local, large venture capital companies as one reason why promising spin-offs moved from one state to another. If commercial actors are lacking locally and discoveries are of high quality, it is natural for entrepreneurs to look in other regions for commercial actors to act as investors. To foster a stronger connection between Swedish entrepreneurs and Sweden (not only through the initial research), VINNOVA (2005) proposes creating a Swedish national fund with a long-term perspective and highly professional staff that can match international investments. Similar efforts have been implemented within several states in the US.

In international comparisons, Sweden´s share of the world's total publication volume within life sciences has increased, but the share of most cited articles has not (Sandström and Norgren, 2003). In a recent sector strategy report, concern over the future well-being of Swedish life-science research is expressed (Regeringskansliet, 2005).[24] Securing long-term financing in order to maintain a front-line position in international research is of utmost importance for commercialization of research. A thriving research and innovation climate with good career opportunities is also critical to attracting top researchers from around the world. If that were to exist, the complementary factors of Sweden's clean environment, relatively safe society, rich culture, etc., may also help attract human resources. Such quality-of-life factors create advantages in the international competition for human capital.

The number of PhDs granted within life sciences is expanding in Sweden (Högskoleverket, 2005). The access to human resources, paired with unique databanks and patient registries, provides good incentives for life-science companies to perform work in Sweden. The Swedish government is investigating whether an R&D tax credit should be introduced. In contrast to many other countries, Sweden does not offer companies R&D tax credits, which are thought to stimulate existing companies to invest more in R&D to facilitate the growth of companies, as well as attract companies to Sweden. Special tax-reductions for experts do exist, as a method for attracting human resources, but are currently under investigation (VINNOVA, 2005).

To be able to maintain top-science and attract companies within life science, it is important to have strong clinical research. In Sweden, life-science research is headed by universities, while clinical trials at university hospitals are headed by the Swedish Association of Local Authorities (Landsting). Each Landsting decides on how to engage in clinical research and

[23] *In absolute numbers of biotechnology companies, Sweden ranks fourth in Europe and ninth in the world (VINNOVA, 2005).*

[24] *Sweden's total R&D expenditure in 2003 was approx. 13 billion USD. The proportion of the GDP spent on R&D was reduced from 4.3 percent in 2001 to four percent in 2003, as a result of a rise in GDP that was not matched by increase in R&D funding. Medicine and technology account for half of the R&D resources in Sweden's higher education institutions (Högskoleverket, 2005).*

the variation between them is great. Generally, it is hard to make room for clinical trials, since the Landsting prioritize the everyday health care and the medical doctors are not necessarily rewarded for participating in research (LIF, 2005). The split ownership of these two activities, heavily interlinked in the commercialization processes, constitutes a challenge (Regeringskansliet, 2005; VINNOVA, 2005). Industry representatives suggest changing the ownership entirely, so that one owner is tasked with creating a single, efficient system of these closely interlinked activities. The Swedish Governmental Agency for Innovation Systems suggests implementing incentives for both hospitals and universities to stimulate clinical research, and the government has declared its aim to investigate this issue (VINNOVA, 2005).

4.2 Efficient Transfer Channels

Generic challenges

- Engaging commercial actors early in the processes

- Policymakers focus on the structure – rather than the content – of activities, and expect quick returns on investments

- University managers are unclear about priorities and goals regarding technology transfer

Key efforts[25]

- National initiatives: fund programs for seed-financing; change ownership of research results; establish university technology-transfer programs

- Regional initiatives: create intermediary organizations to support processes in different ways

- University initiatives: attract private actors to invest in seed-phase conglomerates through the TT office; use alumni as financial and network resources; create offices of economic development & entrepreneurship; encourage faculty to disclose research results to TT offices to a larger extent

Incentives for commercial actors to engage at earlier phases than current risk analyses allow (and thereby avoid the “valley of death”) can be created by changing regulations and other framework conditions in different ways. Tax exemption and matching funds are examples of tools that lower risks related to investing in R&D, which create a driving force for companies to engage in the process. Such tools are likely to be more successful if policymakers increase stakeholder inclusion in policy design from the very beginning.

The need to further develop research projects within universities in order to verify commercial potential has been highlighted (VINNOVA, 2005). In response, the new Swedish effort “Innovationsbron” has been created, as mentioned earlier. This organization is, for example, developing a program through which increased business thinking is integrated early in the process of identifying discoveries for commercialization. A “verification program” has recently been prioritized in government-industry talks, and it was suggested that this should be a joint responsibility of Innovationsbron and VINNOVA (Regeringskansliet, 2005). The purpose is to get verification of projects before too many resources have been put into starting companies with insufficient potential.

[25] *See Table 5 in Appendix for efforts implemented in the US, Japan, and China.*

One advantage held by Sweden with regard to efficient transfer channels is that the process of making agreements regarding transfer of university research is less complex in Sweden than in the US, according to company representatives. It is generally felt that deals can be made without risking an unnecessarily long process. Moreover, Sweden's non-litigious culture becomes an advantage in these processes.

Three factors are frequently mentioned as explanations for successful commercialization of research in the US: universities as drivers of economic development, the Bayh-Dole legislation, and venture capital financing. These factors have figured prominently as good practices in debates on the need to improve commercialization, both in the US and other nations (Powell et al, 2005). We have, for example, seen that Japan is copying the Bayh-Dole legislation as transfer channel, but running into some problems in the process. An important policy implication is to consider the specific culture of each country when looking at commercialization efforts. Does a country, for example, have a tradition of interaction between industry and universities?

Sweden and Denmark are examples of countries where informal collaborations over many decades have given rise to new companies, as well as channeled discoveries into existing companies for further development. This was a main catalyst for the growth of the life-science industry in those countries. Both countries had systems where the university researcher owned his or her intellectual property. In 2000, Denmark implemented a new law where the rights to intellectual property were transferred from the researcher to the university, in an attempt to increase commercialization of publicly-financed research. A comparison between Sweden (where the researchers still own their IP) and Denmark five years after the new law came into effect, shows that the intended goal of increasing commercialization was not reached. In fact, a study shows a decrease in the contribution of Danish university researchers to inventions patented by dedicated biotechnology companies in Denmark. Meanwhile, there was an increase in the contribution of researchers at non-Danish universities, which finally became larger than the share of domestic university participators. The new law "has induced an erosion of national networks of considerable value for Danish science-based competitiveness" (Valentin & Jensen, 2005, p 18).

Such indications should be seriously considered by Swedish policymakers since the networks that have been created in Sweden most likely constitute a major competitive advantage to commercialization of university research.

An interesting finding arises in the way the studied countries have chosen to set up transfer channels at universities; their actions do not seem beneficial to increasing direct interaction between researchers and commercial actors. One reason for this may be that policymakers tend to simplify the mechanisms of commercialization of university research. By focusing on one aspect (the technology-transfer office) rather than on the whole process, a linear process is implied, which is far removed from the non-linear processes actually occurring. Changing one component may in fact hamper other parts of the process, as experienced in the Danish case. To improve the chances of increasing commercialization of university research, we propose that policymakers need to address the issues of critical mass of diverse range of actors, efficient transfer channels, and interaction collectively.

Mowery (2005) is critical of the current US system and claims that need exists for experimentation with alternative models for technology-transfer management and organization in the US. He emphasizes the importance of having multiple channels between university and industry. There also has to be an acknowledgement of the different technology-transfer challenges across disciplines and different type of patents. A system may serve one scientific discipline well but not another, thus flexibility is required. [26] Mowery´s argument speaks for the Swedish system, where the academic researcher owns the intellectual property rights and is free to turn to whoever seems best qualified to commercialize it. As the university does not own the intellectual property rights, it has no reason to limit direct interaction between commercial actors and researchers, which was identified as a risk in the case studies of other countries.

There is, of course, a risk that the researcher finds the deal-making process too complicated and does not follow through. In accordance with regulations, the Swedish universities do, however, offer support for the researchers in terms of protecting their intellectual property rights, deal-making, etc., which cannot be expected to fall within the researchers´ area of competence. A fundamental difference is that although Swedish universities have technology-transfer offices that the researcher can choose to use, those offices must be competitive and not become bottlenecks in the same ways that some offices in the US do, since the researcher can use other channels to transfer the discoveries as an alternative. Schacht (2003) proposes that technology transfer be handled on a case-by-case basis that considers specific circumstances and involved actors. This also speaks for the present Swedish system.

Universities are set up to serve society with education and creation of new knowledge. They contribute to economic growth as “creators, receptors, and interpreters of innovation and ideas; as sources of human capital; and as key components of social infrastructure and social capital” (Lester, 2005, p 12). Most universities are focusing on patenting, licensing, and spin-offs, with technology-transfer offices as the main instrument. Contributing to innovation through technology transfer is a rather new task for many universities, even in the US. There are still questions on optimal organizational practices with regard to inventor incentives, legal issues, strategic objectives, and how to evaluate the activities. Technology-transfer offices focus on patents and licenses, rather than the overall contribution to economic growth, and are rewarded accordingly. The focus on patents overrides that of social capital, which might have a negative impact on interaction, although in some cases technology-transfer offices also create arenas for interaction.

If a one-channel system is used, universities need financial support to ensure recruitment of enough competent staff to prevent slowing processes. If the university has to take money for commercialization activities from their ordinary budget, it is unlikely that such activities will be prioritized against research and education. The result would be a less-than-optimal, one-channel system at universities. Lester (2005) argues that the focus on technology-transfer offices should be replaced with a more differentiated view: the universities need to be aware of innovation processes in local industries and, along with pursuing front-line research, identify which role to play in those processes.

Several scholars highlight the need for university administrations to adopt a strategic approach for contributing to economic growth, where formulation and implementation are well thought out and transparent (Lester, 2005; Siegel and Phan, 2005). With regard to technology transfer, Mowery (2005) argues that university administrations must be clearer about their priorities. Without this clarity of purpose, they cannot structure activities in a way most suitable achieving their goals. For example, choices must be made regarding allocation of resources, technological emphasis, modes of transfer, information flows, organizational design, and human resource management for technology-transfer positions (Siegel and Phan, 2004).

[26] *Technology Transfer Society Annual Conference, September 28-30, 2005.*

Universities' traditional internal organization does not seem conducive to opportunity-recognition and follow-up; it is often difficult for faculty to work between departments, and there can be issues of ownership of research results between researchers. These difficulties need to be acknowledged and measures to overcome them should be introduced if the goal is to increase commercialization of university research. Examples of such efforts include: creating dual appointments (crossing organizational boundaries), patent education and clarifying rights and regulations. Without a clear institutional strategy, due to the decentralized structure and multiple stakeholders, university efforts related to economic contribution may create internal conflicts because of other institutional goals. Without transparency of goals, the results of the efforts may disappoint external stakeholders.

Because different disciplines and types of patents require different treatment, one suggestion is to use regional, specialized incubators and transfer offices to make the whole process more time- and cost- effective. Such development is already underway. At the transfer office at the Karolinska Institutet (KI) in Stockholm, agreements have been made with other universities both in Sweden and Norway, which allows researchers at those universities to use the services of KIs transfer office if there is mutual interest. The example of KI shows that there are technology-transfer offices that – although they do not automatically own the right to the researchers' discoveries – can stand their ground and compete well with commercial actors. Inherent competitive advantages enjoyed by internal university technology-transfer offices include physical proximity and, provided they are funded well enough to possess competence and capacity, established trust between technology-transfer offices and the researchers. An incentive for university management to support the development of strong offices, apart from the policy-driven goals, is that the professional services of such offices become a competitive advantage in attracting top researchers who are interested in the further development of their research into products.

4.3 Interaction

Generic challenges

- Informational and cultural barriers exist between universities and companies (lack of trust and respect)

- Conflicting goals at universities, including insufficient rewards and/or negative impacts for researchers who participate in commercialization processes

Key efforts[27]

- National initiatives: create collaboration programs (support joint research)

- Regional initiatives: "Connect" and similar network organizations; create collaboration programs (support joint research), issue patent-grants to researchers

- University initiatives: create boards of innovation where deans are represented along with commercial actors and TT officers; change rewards system for faculty

Joint research between universities and industry is no new phenomenon and it is emphasized by the countries studied as a way of getting more university research into practical use. Collaboration programs are ongoing in Sweden as well, and there are proposals of increasing the efforts specifically for biotechnology companies (VINNOVA, 2005).

[27] *See Table 5 in the Appendix for efforts implemented in the US, Japan, and China.*

Not only is this how universities have contributed to society for many years, as explained in the introduction, but it also increases the interaction between researchers in universities and industry. Social capital created in those processes is important for commercialization efforts at the universities as well.

The motives, perspectives, and cultures of the key actors in commercialization processes are disparate; this explains some difficulties experienced with technology transfer and creates an organizational challenge (Siegel and Phan, 2005). Having great research and access to capital is a prerequisite, but these are not enough to make these processes work. The actors must talk to each other. Policymakers thus need to focus on ways to connect the driving forces of both commercial actors and universities in the processes of commercialization. The existence of cultural barriers between university researchers and commercial actors has been evident throughout this report. This is difficult to change because of inherent differences in language and the lack of trust. Even in the US, the most mature country in terms of commercialization of research, barriers still exists. To policymakers, this indicates that mobility between the sectors should be encouraged and facilitated. If Sweden manages to implement a system that allows and encourages mobility, our findings indicate that it would help to decrease the cultural barriers that create roadblocks in the commercialization of university research. Proposals for ways to increase such mobility are presented in a strategic document from the Swedish Governmental Agency for Innovation Systems (VINNOVA, 2005), focusing on programs at post-doctoral and executive levels. The willingness to interact can be seen as a mindset. Encouraging people to interact with each other across sectors and disciplines should perhaps be encouraged also during the education process, much like entrepreneurship.

In all three countries researchers are encouraged to interact, but the reward for faculty who engage in commercialization seems limited to potential financial share. Rewards related to the carrier development seem to remain a challenge. Universities, research foundations and policymakers need to take a serious look at incentives for individual researchers, in terms of status, career development, research funding, and income. If negative effects are found, adjustments need to be made. Although culture is not directly changed by changing a policy, policy communicates what is expected and appreciated, and may in turn lead to a change in culture. University managers in Sweden are generally supporting the idea of researchers engaging in commercialization. There have been a number of initiatives in the way of courses and competitions to facilitate engagement, which is also frequent in the US. There has, for example, been an increase in efforts to promote entrepreneurship through courses in Sweden; the first course specializing in science-based entrepreneurship was established in 1998. Most seem to focus on undergraduate and PhD students, rather than faculty, although the needs of both groups should be addressed. Lack of management skills in new biotechnology companies is still considered to be a challenge, and there is currently a proposal for programs that would help these entrepreneurs develop their companies.

In the US, most universities allow their faculty to spend 20 percent of their time consulting, which allows for knowledge transfer and increased chances for successful product development. Swedish researchers are also allowed to be active outside of their faculty duties. The rules for consulting are presently being discussed, with regard to ethical issues that are of great importance, especially when it comes to publicly financed research within life sciences. It should be remembered that, for knowledge-transfer to occur and to increase chances for successful product development, there should be a transparent framework within which researchers feel comfortable and encouraged to interact with companies as part of their mission. The notion that researchers' contributions and time is put to more efficient use if there are near-by commercial activities has been translated to efforts in the US, as seen in the case of North Carolina. Similar efforts are underway in Sweden (e.g. Stockholm Bio Science). Such efforts are expected to increase interaction between researchers and commercial actors, laying a foundation for trust that can translate into collaboration and increased commercialization.

One way of encouraging researchers to think about commercial opportunities is to offer patent grants. Such efforts are implemented by other countries, as seen in the case studies. Researchers that hold patents gain increased legitimacy for the discovery, which also serves to reduce the uncertainty for commercial actors (see discussion in the introduction). Sweden has a unique competitive advantage in terms of motivating researchers to search for commercial opportunities; by law, researchers maintain the right to the intellectual property related to their research results (Teachers exemption)[28]. This ties back to the present proposal that may change this law in an effort to increase commercialization of university research. Based on this report, it should be considered not to remove the researchers' right to their inventions – an assertion also supported by VINNOVA (2005).

4.4 Moving Toward a Strategy for Commercialization of University Research

The engagement of universities is critical to the processes of commercialization of university research, as they provide the initial ingredient and continued knowledge transfer through collaborations, and it makes sense that university managers should support their researchers' efforts to commercialize. Universities do, however, not have all the means for making necessary changes to overcome the main challenges identified in this report. One reason is that there are regulatory elements that can be used to overcome some of the challenges, but these are outside of universities' authority. Also, universities' financial resources are limited, which makes it difficult for them to prioritize commercialization activities, in competition with research and education. Universities thus cannot be expected to be the sole drivers of commercialization efforts, but their involvement is absolutely vital for regional and national economic development.

While highlighting the importance of universities in these processes, caution should be taken with regard to how much economic contribution to expect from commercialization activities at universities. For example, university spin-offs make up less than 20 percent of the new technology-based companies in Sweden, according to Lindholm Dahlstrand (2000). The majority of technology-based companies are spun-off from another company. Moreover, Lindholm Dahlstrand (2000) shows that company spin-offs have a higher growth-rate than university spin-offs.

According to one of the General Directors at the Council of the European Union, commercialization of research is a prioritized issue at the EU-level. There is no agreement, however, on which instruments that should to be used to promote such processes. Two main questions they work on is how the get companies to invest more in research and how to promote pre-competitive research in order to support collaboration between industry and universities. Questions of innovation are discussed at a general level within the EU and there is a limit to what can be done at an EU-level with regards to commercialization of research, since indirect measures such as tax credits have to be decided upon at a national level. Creating an innovation friendly environment is the responsibility of each country.

---

[28] *Most actors in the biotech innovation system claim that the Teachers Exemption has been an important contributor to the positive development of new companies and an incentive for researchers to engage in the processes. (VINNOVA, 2005)*

One difficulty with innovation is that the relevant questions belong at different ministries; for example, the ministry of finance deals with tax-issues, the ministry of education deals with the role of technology transfer at universities and the ministry of industry deals with seed-financing. All those issues are relevant to commercialization of university research, but it is a challenge to get the ministries to work together in forming policies to create a better environment for these processes.

The Ministry of Education, Research and Culture and the Ministry of Industry, Employment and Communication in Sweden took a step towards collaboration on innovation issues by presenting a strategy for an Innovative Sweden (Regeringskansliet, 2004). It creates an opportunity for Sweden to continue to work across ministries on innovation issues, thereby gaining competitive advantage in creating an environment conducive to economic growth.

This study has highlighted the need to consider a number of mechanisms collectively in order to design policies that will help create opportunities for economic growth through increased commercialization of university research. As seen in other countries, and as predicted by scholars, changing a single factor (such as ownership of intellectual property) is not likely to be a magic bullet. The complexity of these processes demands a strategic plan with a long-term view and we propose that such a plan consider three main issues: critical mass of diverse range of actors, efficient transfer channels, and interaction.

We end this report by showing how the framework “Policy issues for commercialization of university research” developed in this report can be useful for considering all three issues. Table 2 lists a number of competitive advantages that Sweden appears to have in each of the three policy domains. Table 3 lists challenges and related policy implications in the same domains. While we do not claim this list of advantages and challenges to be all-inclusive, and while opportunity exists to further develop our content, we feel that this data represent a first step toward a strategic plan. It is also important to remember that these processes are not static, which means that a strategic plan for commercialization of university research needs be revised from time to time.

Table 2 Advantages for Sweden in the Commercialization of University Research within Life Science

	Competitive Advantages
Critical Mass of Diverse Range of Actors	- High number of life-science companies - Expanding number of PhDs in life sciences - Unique databanks and patient registries - High-quality science - High quality of life
Efficient Transfer Channels	- Agreement processes for technology transfer less complex (e.g., than in the US, according to company representatives) - Not a strong litigation culture (e.g. as compared to the US) - Tradition of direct interaction between university researchers and commercial actors - Multiple channels between university and commercial actors - Flexibility, rather than conformity, in transfer processes
Interaction	- The law provides university researchers with intellectual property rights to research results, which is considered to increase their motivation to engage in commercialization processes - There are a number of initiatives to link university researchers to commercial actors including providing courses for researchers, network arenas, as well as cluster-efforts

Table 3 Challenges Facing Sweden in Commercialization of University Research Within Life Science, and Related Policy Implications

	Challenges => *Related Policy Implications*
Critical Mass of Diverse Range of Actors	- The clinical trial system is hampered since the owners of hospitals often do not prioritize research => *The responsibility for contributing to clinical trials should be clarified, and reward systems for medical doctors who engage in research should be adjusted* *Private organizations working with clinical trials are on the rise and may well play an important role* - Discoveries are being exploited abroad => *Create national, professional long-term fund to match international invest-ments* - It is critical to maintain research excellence => *Secure long-term research funding* - It is critical to attract top researchers and employ the high number of rising PhDs => *Offer competitive career opportunities for researchers*
Efficient Transfer Channels	- Commercial actors need to engage at earlier phases than they presently do => *Increase stake-holder inclusion in policy designs* - University managers are still unclear about priorities and goals regarding technology transfer => *University managers need to adopt a strategic approach where formulation and implementation are well thought out and transparent*
Interaction	- Cultural and informational barriers exist between university researchers and commercial actors => *Implement a system that allows and encourages mobility* - Current career system does not reward researchers who engage in commercial activities => *Adjust system with regard to career development, research funding etc. and create transparent regulatory framework*

References

Interviews

The United States

Case Study: University of Pennsylvania

Richard Bendis, Director, Innovation Philadelphia, May 9, 2005.

Louis P. Berneman, Special Advisor, Office of Strategic Initiatives, University of Pennsylvania, May 9, 2005.

Lawrence J. Botticelli, Interim Managing Director of Commercial Development, University of Pennsylvania, May 10, 2005.

Jennifer H. Hartt, Associate Director, Business Development & Equity, University of Pennsylvania Center for Technology Transfer, May 10, 2005.

Tim Raynor, Director Intellectual Property, University of Pennsylvania Center for Technology Transfer, May 10, 2005.

Don Siegel, Associate Professor & Vice-Chair, Pathology & Laboratory Medicine at University of Pennsylvania and founder of Phenotech, May 9, 2005.

RoseAnn B. Rosenthal,President and CEO, Southeastern PA – SEP Ben Franklin Technology Partners (BFTP), May 10, 2005.

David Counts, Director of Life Sciences, Ben Franklin Technology Partners (BFTP), May 10, 2005.

Lennart Hagegård, Business Angel, located in Philadelphia, phone interview, May 17, 2005.

Case Study: University of North Carolina at Chapel Hill

Ted Abernathy, Executive Vice President, Research Triangle Regional Partnership, August 12, 2005.

Don (Bo) Carson, Director of Research, Research Triangle Regional Partnership, August 12, 2005.

Jeff Cope, Business Development Manager, Center for Technology Application, Research Triangle Institute International, August 11, 2005.

John Craichy, Business Development Director, Business & Technology Development Program, North Carolina Biotechnology Center, August 11, 2005.

Mark Crowell, Associate Vice Chancellor for Economic Development & Director for the Office of Technology Development, The University of North Carolina at Chapel Hill, August 12, 2005.

Seth Harward, Membership Development Manager, Council for Entrepreneurial Development, August 11, 2005.

Robert Lindberg, Technology Development Director, Business & Technology Development Program, North Carolina Biotechnology Center, August 11, 2005.

Peter Pellerito, Consultant to BIO, State Government Relations, September 1, 2005.

Marc Sedam, Vice President of Corporate Development, Qualyst, August 12, 2005.

Japan

Case Study: University of Tokyo

Mr. Tomotaka Goji, University of Tokyo Edge Capital Co. Ltd, May 20, 2005.

Prof. Fumihiko Hasegawa, Vice Director, New Industry Creation Hatchery Center, June 23, 2005.

Dr. Masatoshi Ishikawa, Executive Vice President; Prof. Tomohiro Ohta, Head, Collaborative Research; Prof. Shigeo Kagami, Division of University Corporate Relations, June 9, 2005.

Prof. Kazunori Kataoka, Department of Material Science and Engineering and Division of Clinical Biotechnology, June 13, 2005.

Prof. Robert Kneller, Research Centre for Advanced Science and Technology, May 20, 2005.

Mr. Nakajima, Mr. Funasaki, Mr. Iwakado and Mr. Hashimoto, METI Kanto Bureau, September 9, 2005.

Mr. Takafumi Yamamoto, CEO & President, Toudai TLO, May 20, 2005.

Case Study: Tohoku University

Mr. M. Endo and Mr. K. Endo, Miyagi Prefecture, June 23, 2005.

Prof. Yuko Harayama, Management of Science and Technology Department, Graduate School of Engineering, May 18, 2005.

Prof. Ryuta Kawashima, Graduate School of Medicine, project leader at NICHe, June 23, 2005.

Mr Takashi Kishi, Manager, Technology Licensing Div., Tohoku Techno Arch Co., Ltd, June 23, 2005.

Dr. Eisaku Nishiyama, Mr. Jun Yamamoto, Tohoku Economic Federation, June 23, 2005.

Ms. Aiko Sakai, Mr. Hidetaka Yanatsu, Sendai City, June 23, 2005.

Dr Tomoi Takahashi, Acting Director, Office of Research Promotion & Intellectual Property, June 23, 2005.

Mr. Ichiro Yanbe, METI Tohoku Bureau, June 23, 2005.

Other meetings:

Mr. H. Nakanishi, Mr. I. Miyamoto & Mr. H. Tomita, Industry-University Cooperation Division, METI Head office, Tokyo, June 10, 2005.

China

Chinese expert on commercialization of life sciences (researcher with international experience and founder of biotech service company), Shanghai, September 20, 2005.

Vice President of Asia Office of large multinational pharmaceutical company, Shanghai, September 20, 2005.

Assistant Vice Chancellor, Technology Transfer and Intellectual Property Services, US University, Shanghai, September 20, 2005.

Geoff Dyer, Financial Times, Shanghai, September 19, 2005.

Chinese expert on commercialization of life sciences (researcher with international experience currently setting up foreign subsidiary in China), Beijing, October 5 and 14, 2005.

Ph.D. Student, Peking University, Beijing, October 6, 2005.

Professor, Peking University, Life Science College, Beijing, October 6, 2005.

Director International Affairs, large Chinese Pharmaceutical Company, Shanghai, September 20, 2005.

Deputy General Manager, large Chinese pharmaceutical company, Shanghai, September 20, 2005.

R&D Director, Chinese life science company, Tianjin, November 3, 2005.

Korean Professor of Chemcial and Biological Engineering, Tianjin, November 4, 2005.

Michael Enright, Professor, University of Hong Kong, presentation, TCI conference, Hong Kong, November 9, 2005.

Jinqiu Qian, Administration Center for Innovation Fund for Technology-Based SMEs, Ministry of Science and Technology of the People’s Republic of China, Presentation, Beijing, November 15, 2005.

Wu, Grace Xiaohong, Assistant Professor, University of Hong Kong, presentation, TCI Conference, Hong Kong, November 9, 2005.

Written

AAAS (2006) ”Congress Caps Another Disappointing Year for R&D Funding in 2006”, *AAAS R&D Funding Update*, January 4th

AiF (2005) *Die Medizinbranche in China*, http://www.intec-online.net/uploads/media/-Medizinbranche_in_China.pdf.

Asakawa, K. (2005) “Accelerating R&D investments into India and China,” *Columns Back Issues* 2005/04, Research Institute of Economy, Trade and Industry (RIETI), Japan, http://www.rieti.go.jp/en/columns/a01_0180.html.

Association of Campus Bio-Ventures, (2004) *The Campus Bio-Venture* [Kyampasu baio benchaa gaido bukku].

AUTM (Association of University Technology Managers) (2004) *AUTM Licensing Survey: FY 2003*.

Azzone, G. and Maccarrone, P. (1997) "The Emerging Role of Lean Infrastructures in Technology Transfer: The Case of the Innovation Plaza Project," *Technovation*, Vol. 17 (7), pp 391–402.

Battelle, (2004) *Laboratories of Innovation: State Bioscience Initiatives 2004*, June.

Beijing Pharma and Biotech Center (2005) *Sailing: Annual Report on the Development of Beijing Biotechnology and Pharmaceutical Industry.*

Bercovitz, J. and Feldman, M. (2004) "Academic Entrepreneurs: Social Learning and Participation in University Technology Transfer," *Mimeo*, University of Toronto.

Branscomb, L. and Auerswald, P. (2001) *Taking Technical Risks: How Innovators, Executives, and Investors Manage High-Tech Risks*, MIT Press, Cambridge, Mass.

Bok, D. (2003) *Universities in the Marketplace – The Commercialization of Higher Education*, Princeton University Press, Princeton and Oxford.

Borrell, J. (2005), "Asia Has Strong Interest in Biotech, But No Infrastructure," *Venture Capital Journal*, January 1, 2005.

Campbell, E., Koski, G., Zinner, D. and Blumenthal, D. (2005) "Managing the Triple Helix in the Life Sciences," *Issues in Science and Technology*, Vol. XXI, No. 2.

Center for Technology Transfer at UPenn (2005) *A Start-Up Powerhouse*.

Chervenak, M. (2005) "An Emerging Biotech Giant?" *The China Business Review*, Vol. 32, No. 3, May/June, pp 48–60.

Colyvas, J., Crow, M., Gelijns, A., Mazzoleni, R., Nelson, R., Rosenberg, N. and Sampat, N. (2002) "Do University Inventions Get into Practice?" *Management Science*, Vol. 48, No. 1, pp 61–72.

Cong, C. (2004) "Challenges for Technological Development in China´s Industry. Foreign investors are the main providers of technology," *China Perspectives*, No. 54

Cortright, J. and Mayer, H. (2002) "Profile of Biomedical Research and Biotechnology Commercialization, Raleigh-Durham-Chapel Hill," *Signs of Life: The Growth of Biotechnology Centers in the U.S.*, June, The Brookings Institution.

Council on Competitiveness (2005) "Innovate America," *National Innovation Initiative Summit and Report*.

Council of Governmental Relations (1996) *A Review of University Industry Research Relationships*.

Council for Entrepreneurial Development (CED) (2004) *North Carolina Venture Report*.

Crowell, M. (2005) "Letter to the Editor, in response to a September 19 Fortune Magazine article," www.autm.net/news.

Deiaco, E., Giertz, E. and Reitberger, G. (2002) *Teknikparkens roll i det svenska innovationssystemet – historien om kommersialisering av forskningsresultat*, VINNOVA Forum, VFI 2002:3

Di Gregorio and Shane (2003) "Why Do Some Universities Generate More Startups Than Others?" *Research Policy*, Vol 32, pp 209–227.

DTI Global Watch (2004) "Stem Cell Mission to China, Singapore and South Korea," dti *Global Watch Mission Report*, September.

Economist (2005) "Medicine in China," November 19, 2005, p. 29.

Einhorn, B. and Carey, J. (2005) "A New Lab Partner for the US?" with Neil Gross, *Business Week*, August 22, Issue 3928.

Eisenberg, R. (1996) "Public research and private development," *Virginia Law Review*, 82, pp 1663–1727.

Elfenbein, D. (2005) "Publications, Patents, and the Market for University Inventions," *NBER conference* April 1, 2005, Santa Fe, New Mexico.

Eliasson, K. (2004) *American Science – the Envy of the World? An Overview of the Science System and Policies in the United States*, ITPS A2004:004.

Ernst & Young LLP (2004) *American Biotechnology Report: Resurgence*.

Ernst & Young (2004) *On the Threshold – The Asia-Pacific Perspective Global Biotechnology Report 2004*.

European Molecular Biology Organization (EMBO) (2003) "China's Leap Forward in Biotechnology," interview with Zhu Chen, Director of the Chinese National Human Genome Centre of Shanghai and Vice President of the Chinese Academy of Sciences, *EMBO report*, Vol. 4, No. 2, pp 111–113.

Ewalt, David (2004) "America's Most Entrepreneurial Campuses," Special Report, *Forbes*, October 22.

Ewing Marion Kauffman Foundation (2003) "Accelerating Technology Transfer & Commercialization in the Life and Health Sciences," *Final Report of the Panel of Advisors on the Life Sciences*.

Florida, R. (2000) "The Role of the University: Leveraging Talent, Not Technology," in *AAAS Science and Technology Policy Yearbook*.

Goldstein, J. (2004) "Region´s Biotechs Poised for Growth," *Philadelphia Inquirer*, November 28.

Gong, Yidong (2005) "Pharma Moves Ahead Cautiously in China," *Science*, Vol. 309, July 29, p.735.

Guan, Jian Cheng, Richard C.M. Yam and Chiu Kam Mok (2005) "Collaboration Between Industry and Research Institutes/Universities on Industrial Innovation in Beijing, China," *Technology Analysis and Strategic Management*, Vol. 17, No. 3, pp.339–353, September 2005.

Hall, Edward T. (1976) *Beyond Culture*, Anchor Press/Doubleday, New York.

Harayama, Y. (2004) "Japanese technology policy on technology transfer," *Tech Monitor*, Mar-April 2004. http://www.techmonitor.net/techmon/04mar_apr/tm/pdf/04mar_-apr_sf3. pdf.

Holmes, E. (2005) UCSD Statement at Paneldebate at the International Biosummit, Berkeley, June 1.

Högskoleverket (2005) "Swedish Universities – Short Version of Annual Report," *Högskoleverkets rapportserie* 2005:37 R.

Innovation Fund (2005) “Government Promotion and Support to Innovation: Innovation Fund for Technology-Based SMEs,” Presentation, Beijing, November 15.

Innovation Philadelphia (2002) *Innovation & Entrepreneurial Index – Is Our Glass Half-Empty or Half-Full?*

ITAC Information Technology Association of Canada (2003) *Case Studies in Technology Cluster Formation*, July.

Japan Bioindustry Association (2004) *Bioventure Statistical Survey Report*, 2004.

Jensen, R. and Thursby, M (2001) “Proofs and Prototypes for Sale: The Licensing of University Inventions,” *American Economic Review*, Vol. 91, No. 1, pp 240–259.

Jia, H. (2004) “China Moves to Reform Biotech Policies,” *Nature Biotechnology*, Vol. 22, No. 10, pp 1197.

Karlsson, M. (2004) *Commercialization of Research Results in the United States – an Overview of Federal and Academic Technology Transfer*, ITPS A2004:007.

Key, P. (2004) ”Penn Hits High Note with Tech,” *Philadelphia Business Journal*, January 16.

Kneller RW, (2003) “Autarkic Drug Discovery in Japanese Pharmaceutical Companies: Insights into National Differences in Industrial Innovation,” *Research Policy*, Vol 32, pp 1805–1827.

Kneller, RW, (2004) “Transformation of Japan's National Universities Into Administratively Independent Corporations,” *les Nouvelles*, March 2004, pp 1–5.

Lach, S and Shankerman, M. (2003) “Incentives and Innovation in Universities,” *NBER working paper* 9727.

Lehrer, M. and Asakawa, K. (2004) “Rethinking the Public Sector: Idiosyncrasies of Biotechnology Commercialization as Motors of National R&D Reform in Germany and Japan,” *Research Policy* 33, pp 921–938.

Lester, R. (2005) “Universities, Innovation, and the Competitiveness of Local Economies,” *MIT Industrial Performance Center Working Paper* 05–010, December 13.

Li, Zhenzhen, Zhang Jiuchun, Wen Ke, Halla Thorsteinsdottir, Uyen Quach, Peter A. Singer and Abdallah S. Daar (2004) “Health Biotechnology in China – Reawakening of a Giant,,” *Nature Biotechnology*, Vol. 22, Supplement, December, pp 13–18.

Libecap, G. (2005) “Introduction,” *University Entrepreneurship and Technology Transfer: Process Design, and Intellectual Property*, Edit. Libecap, Gary Elsevier, Oxford, UK.

LIF (2005) *Finansieringen av den medicinska forskningen i Sverige*, Läkemedelsföreningen, September, 2005:2

Lindholm Dahlstrand, Å. (2000) ”Entrepreneurial Origin and Spin-Off Performance,” *Paper presented at the 20th Annual Entrepreneurship Research Conference, Babson College*, June 8–10

Mannervik, U. and Arvidsson, N. (2005) ”Värdeskapande innovationsmiljöer,” *Vinnova Rapport* VR 2005:15.

Ministry of Economy, Trade and Industry (2005) Presentation by Industry-University Cooperation Promotion Division for Swedish Delegation, November 2005.

Ministry of Science and Technology (MOST) (2003) *Annual Report 2002. The National High Technology Research and Development Program of China (863 Program).*

Motohashi, K. (2003) "Recent Developments in Research and Innovation Policy in Japan," *Hitotsubashi University IIR Working Paper Series*, No. 03–03, 2003.

Motohashi, K. (2004) "Economic Analysis of University-Industry Collaborations: The Role of New Technology Based Firms in Japanese National Innovation Reform," *RIETI Discussion Paper Series* 04-E-001.

Mowery, D. (2005) Presentation at the Technology Transfer Society Annual Conference, Kansas City, September 28–30.

Mowery, D., Nelson, R. Sampat, B. and Ziedonis, A. (2004) *Ivory Tower and Industrial Innovation*, Stanford University Press, Stanford, CA.

Mowery, D. (2005) "The Bayh-Dole Act and High-Technology Entrepreneurship in US Universities: Chicken, Egg or Something Else?" *University Entrepreneurship and Technology Transfer: Process Design, and Intellectual Property*, Edit. Libecap, Gary, Elsevier, Oxford, UK.

National Dialogue on Entrepreneurship (2005) August 8–12.

National Institute of Science and Technology Policy (NISTEP) (2005) "Study for Evaluating the Achievements of the S&T Basic Plans in Japan, Achievements and Issues of Major Policies for Industry-Academia-Government Cooperation and Regional Innovation" [Shuyo na sangakurenkei chiiki innovation shinko no tasseikouka oyobi mondaiten] *NISTEP Report No. 87*.

National Science Foundation (NSF) (2005) *Academic Research and Development Expenditures: Fiscal Year 2003*, August.

Nightingale, P. and Martin, P. (2004) "The Myth of the Biotech Revolution," *TRENDS in Biotechnology*, Vol. 22, No. 11, pp 564–569.

Nilsson, A. (2001) *Interaction Between Researchers, Firm Managers and Venture Capitalists: The Essence of Biotechnology Business*, PhD thesis, Karolinska Institutet, Stockholm.

North Carolina Biotechnology Center (NCBC) (2004) *New Jobs Across North Carolina – A Strategy Plan for Growing the Economy Statewide Through Biotechnology.*

North Carolina Biotechnology Center (NCBC) (2002) *Moving Biotechnology from the Mind to the Marketplace*.

Office of Institutional Research and Assessment (2005) *Fact Book 2004–2005*.

PCAST (President´s Council of Advisors on Science and Technology) (2003) *Report on Technology Transfer of Federally Funded R&D.*

Pechter, K., (2002) "Comparative Policy Analysis Under Innovation-Driven Change: Assessment of the University-Industry Linkage in Japan and the United States," Glocom Platform, Colloquium #10, http://www.glocom.org/special_topics/ colloquium/200201_ pechter_ comparative/.

Philadelphia Business Journal (2004) "Penn Tech Transfer Center Launched 14 Companies in Year," October.

Powell, W., Owen-Smith, J. and Colyvas, J. (2005) "Innovation and Emulation: Lessons from the Experiences of US Universities in Selling Private Rights to Public Knowledge," For Minerva, October.

Putnam, R. (2000) *Bowling Alone: The Collapse and Revival of American Community*, Simon and Schuster, New York.

Red Herring (2005) "Big Pharma Back in China," August 1.

Regeringskansliet (2004) *Innovativa Sverige*, Näringsdepartementet och Utbildningsdepartementet, Ds 2004:36

Regeringskansliet (2005) *Läkemedel, bioteknik och medicinteknik – en del av Innovativa Sverige*, Näringsdepartementet, December.

Rosenberg, N. & Hagén, H-O. (2003) *The responsiveness of the universities*, ITPS A2003–019

RTR Research Triangle Region (RTRP) (2003) *A Blueprint for Lifesciences Industry Growth in the Research Triangle Region*, February.

RTR Research Triangle Region (RTRP) (2005) *State of the Research Triangle Region*.

Sampson, D. (2005) Speech at the Conference on Regional Innovation, Washington DC, April 22.

Sandström, A. and Norgren, L. (2003) *Swedish Biotechnology – scientific publications, patenting and industrial development*, IVA & VINNOVA VA2003:2

Schacht, W. (2005) "Technology Transfer: Use of Federally Funded Research and Development," *CRS Issue Brief for Congress*, April 1.

Schacht, W. (2003a) "Technology Transfer: Use of Federally Funded Research and Development," *Congressional Research Service*, The Library of Congress.

Schacht, W. (2003b) "The Bayh-Dole Act: Selected Issues in Patent Policy and the Commercialization of Technology," *CRS Report for Congress*, Penny Hill Press, September 5.

Sellenthin, M. (2004) *Who should own university research? An exploratory study of the impact of patent rights regimes in Sweden and Germany on the incentives to patent research results*, ITPS A2004:013

Shane, S. (2004) "Encouraging University Entrepreneurship? The Effect of the Bayh-Dole Act on University Patenting in the United States," *Journal of Business Venturing*, Vol. 19, pp 127–151.

Shane, S. and Stuart, T. (2002) "Organizational Endowments and the Performance of University Start-Ups," *Management Science*, Vol. 48, No.2, pp 151–170.

Siegel, D. and Phan, P. (2005) "Analyzing the Effectiveness of University Technology Transfer," *University Entrepreneurship and Technology Transfer: Process Design, and Intellectual Property*, Edit. Libecap, Gary, Elsevier, Oxford, UK.

Siegel, D., Waldman, D., Atwater, L. and Link, A. (2004) "Toward a Model of the Effective Transfer of Scientific Knowledge from Academicians to Practitioners; Qualitative Evidence from the Commercialization of University Technologies," *Journal of Engineering and Technology Management*, Vol. 21, No. 1–2, pp 115–142.

Sigurdsson, J. (2005) *Technological Superpower China*, Edward Elgar, Cheltenham.

Sine, W., Shane, S. and DiGregorio, D. (2003) "The Halo Effect and Technology Licensing: The Influence of Institutional Prestige on the Licensing of University Inventions," *Management Science*, Vol. 49, No. 4, pp 478–496.

SSTI (2005) "North Carolina Crates SBIR/STTR Incentive," August 29.

SSTI (2005) "Weekly Digest," August 29.

Stenberg, L. (2004) *Government Research and Innovation Policies in Japan*, ITPS A2004:001.

Sunami, A. (2002) "Industry-University Cooperation and University-Affiliated Enterprises in China, a Country Aspiring for Growth on Science and Education – Building New System for Technological Innovation," *Research and Review* 2002/05, Research Institute of Economy, Trade and Industry (RIETI), Japan. http://www.rieti.go.jp/en/-papers/research-review/001.html

Thursby, G. and Thursby M. (2002) "Who is Selling the Ivory Tower? Sources of Growth in University Licensing," *Management Science*, Vol. 48, No. 1, pp 90–104.

Thursby, J. and Thursby, M. (2003) "University Licensing and the Bayh-Dole Act," *Science*, Vol. 301, pp 1052.

Thursby, G. and Thursby, M. (2003) "Are Faculty Critical? Their Role in University-Industry Licensing," *NBER working paper* 9991.

Thursby, J. and Thursby, M. (2005) "Pros and Cons of Faculty Participation in Licensing," in *University Entrepreneurship and Technology Transfer: Process Design, and Intellectual Property*, Edit. Libecap, Gary Elsevier, Oxford, UK.

Thursby, M. (2005) "The Entrepreneurial University?" *Understanding Entrepreneurship, A Research and Policy Report*, Kauffman Foundation, Kansas City.

Toole, A. and Czarnitzki, D. (2005) "Biomedical Academic Entrepreneurship Through the SBIR Program," NBER conference April 1, 2005, Santa Fe, New Mexico.

Van Arnum, P. (2005) "Demand for Innovative Drugs Rises in China," *Chemical Market Reporter*, Vol. 267, No. 3, Jan. 17.

Valentin, F. and Jensen, R. (2005) "Effects on Academia-Industry Collaboration of Extending University Property Rights," *Biotech Business working paper 2005–01*, October, Research Center on Biotech Business, Copenhagen Business School.

Vinnova (2005) *Strategi för tillväxt – Bioteknik*, VP 2005:02.

Viola, P. (2004) "International Benchmarking of Biotech Research Centers," *Nature Biotechnology*, Vol. 22 (5).

Walsh, K. (2003) *Foreign High-Tech R&D in China. Risks, Rewards, and Implications for U.S.-China Relations*, The Henry L. Stimson Center, Washington DC.

Walshok, M. (2005) “The Need for More Integrative University Strategies to Advance Innovation and Entrepreneurship,” Presentation at the Technology Transfer Society Annual Conference, Kansas City, September 28–30.

White, S., Gao, J. and Zhang, W. (2005) “Financing New Ventures in China: System Antecedents and Institutionalization,” *Research Policy*, Vol. 34, pp 894–913.

Wu, Grace Xiaohong (2005) “Biomedical Industry in China: from Academic Affair to Commercialization,” Presentation at the 8th Annual Conference of the Competitiveness Institute (TCI), November 10, Hong Kong.

Y. Tsukamoto (2005) *Present State and Issues of the Industrial Cluster Policy of Japan*, METI, http://www.nistep.go.jp//seminar/017/017_e.pdf.

Zhao, G. (2005) “Biotechnology in China: From Genomics Research to BioTech Development,” presentation on May 12, Seoul, Korea.

Zucker, L., Darby, M. and Armstrong, J. (1998a) “Geographically Localized Knowledge: Spillovers or Markets?” *Economic Inquiry* Vol.36, No.1, pp 65–86.

Zucker, L., Darby, M. and Brewer, M. (1998b) “Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises,” *The American Economic Review*, Vol. 88, No.1, pp 290–306.

Zucker, L., Darby, M. and Armstrong, J. (2002) "Commercializing Knowledge: University Science, Knowledge Capture, and Firm Performance in Biotechnology," *Management Science*, Vol. 48, No. 1, pp 138–153.

Appendix

Case Studies

The following case studies provide an insight into how six universities, top recipients of federal funding for life-science research, work with commercialization efforts. To put the university efforts in context, each case begins with an overview of initiatives at the state and regional levels. Two cases each are presented from the United States, Japan and China, in that order.

University of Pennsylvania

The State of Pennsylvania

The Pennsylvania General Assembly created the Ben Franklin Technology Development Authority – an economic development organization – in order to promote innovation and increase the commercialization of research. This development organization was established in 1982 with four, regional partners named Ben Franklin Technology Partners (BFTP). Each partner is structured as an independent, non-profit corporation that receives annual funding from the Commonwealth. The funding is currently 27.6 million USD for the four partners. In 2001 the partnership was incorporated into Ben Franklin Technology Development Authority, which administers and operates several other programs in addition to the four partners. All in all, the budget is 55 million USD. BFTP eventually established a unit dedicated to life sciences.

In a 1998 court settlement with the tobacco industry, the State of Pennsylvania received money, part of which has been used to establish venture funds and create Keystone Innovation Zones in which technological development is promoted through tax credits. The state government decided in 2001 to use tobacco settlement money in one-time outlays for research and commercialization of life science technologies (160 million USD). One hundred million dollars of the larger sum was distributed to three Life Science Greenhouses, based at research universities in Philadelphia, Pittsburgh, and Central Pennsylvania. The program is coordinated with a parallel incentive that invests in three life science venture capital funds in the state (SSTI, 2005).

One major advantage in the region is the presence of big pharmaceutical companies. Pennsylvania employed 51,882 people in the areas of research and testing, medical device and equipment and drugs and pharmaceuticals in 2002 (Battelle, 2004). In terms of number of biotechnology companies, Pennsylvania ranked twelfth in the U.S. in 2004, with 63 companies (Ernst & Young, 2004). Pennsylvania ranked eighth among the states in total venture capital invested in 2004, with the biotechnology sector receiving more than all other sectors (65.9%). In 2004, venture capital companies invested 526.07 million USD in Pennsylvania companies (CED, 2004); eighty-four percent of those investments were made in the Philadelphia metro region.[29] There is now considered to be significant seed-capital available for companies in Philadelphia, especially when including business angels and other investors, from New York City to Washington DC, who are only a train ride away[30]. For later stage investments, non-local investors are said to be more active than local.

[29] *www.ventureeconomics.com*
[30] *Total seed/early stage funding raised in 2004 was 123.57 million USD (CED North Carolina Venture report)*

The Philadelphia Region

- Patents: 11,395 during 1997–2001, 137 patents per 1000 scientist/engineer
- Start-ups based on university research: 56 from 1995–2000
- SBIR/STTR Awards Phase I: 4.7 in 1995, 6.2 in 1999 (million USD)
- SBIR/STTR Awards Phase II: 9 in 1995, 18 in 1999 (million USD)

Source: Innovation Philadelphia, 2002

The Mayor of Philadelphia created Innovation Philadelphia in 2001, with the goal of strengthening the knowledge-based economy in the region (Goldstein, 2004). Innovation Philadelphia performed a study to identify what was needed to reach that goal and concluded that Philadelphia had many of the key ingredients to grow a knowledge-based economy, but the entrepreneurial image and climate had to be improved (Innovation Philadelphia, 2002). The way to accomplish this would be by having the actors from academia and industry at state and regional levels join forces. The recommendations and related actions were to:

- Take action to obtain more federal research money such as SBIR, STTR and ATP.
  - × Research Dollars Program: online program providing technical, research and financial assistance to researchers and entrepreneurs. Companies have more success in getting SBIR grants when they have had the help of research dollars. (www.IPphila.com/researchdollars)
  - × Innovation Partnership: state initiative that helps researchers and early stage companies attain federal grants for proof-of-concept work (SBIR & STTR Phase I grants).[31] (www.innovationpartnership.net)
- Engage the corporate community in collaborative initiatives to generate and spin-out discoveries with commercial potential.
  - × Mid Atlantic Commercialization Corporation: hands-on managerial services (now supported by state funds, but aims to achieve self-reliance based on return on equity by participating businesses. Increase pre-seed and seed capital).
  - × Economic Stimulus Fund (ESF): a fund that has been successful in creating groups of investors who would not invest on their own. ESF takes equity in a company and has a person on the board who is a former venture capitalist (VC). This person has a high standing in the VC community and through him, the ESF is able to better communicate with potential VCs to participate in the fund. ESF stimulates co-investment by providing loans, convertible debentures, straight equity, etc. (www.IPphila.com/bizplan)
  - × Mid Atlantic Angel Group (MAG): member-managed private equity investment fund consisting of angel investors who remain actively involved in their companies throughout Southeastern Pennsylvania, New Jersey and Delaware. (www.magfund.com)

[31] *Pennsylvania TechFormation – A status report and growth strategies for technology-based economic development, 2005*

- Create a lifelong learning environment for knowledge workers and entrepreneurs to change the “brain drain” into “brain gain.”
  - × www.careerphilly.com
- Increase entrepreneurial resources.
  - × Entrepreneurial resource guide, innovation index and local and regional cluster analysis. www.IPphila.com

University of Pennsylvania (UPenn)

Private university (member of the Ivy League)
Number of graduate students: 10,000; Researchers: 2200
Yearly research and development budget: 704.5 million USD (FY 2003), 80% is federally funded, 65% of that is from the NIH
Life sciences R&D: 451. 1 million USD, of which 346.6 million is federally financed (FY 2003)
Top-three recipient of NIH funding of all US institutions in absolute numbers (2004)
The Center of Technology Transfer (CTT) at UPenn:
Employees: 20 (2005)
Spin-offs: 47 in the last five years.[32]
Licensing agreements: 108 (2004), increase of 30 % from 2003
Licensing income: 12 million USD (2004)
Patents issued: 92 (2004), approximately half of which are foreign

Sources: NSF, 2005; CTT, 2005

Main Actors: Bringing a Project from Discovery to Further Commercialization

UPenn

Recently, the Vice Provost for Research at UPenn was charged with the task of commercializing the University's research. The purpose is to better capture and maximize value from all stages of the research enterprise, and is recognition that the commercialization of research is a process that should actually begin at project inception as opposed to being carried out only at the later stages of development.

Patents are an institutional responsibility, and at UPenn, the Center of Technology Transfer (CTT) deals with intellectual property issues. CTT licenses the right to use IP to companies; it never assigns the rights to the company. This way, if something unforeseen should happen, the rights come back to CTT and can then be licensed to another company. CTT is financed by the licensing income and, as income exceeds expenses, portions are also distributed back to research.

[32] *Total of 84 since 1991, 50 of which are still active.(Philadelphia Business Journal, 8 Oct 2004)*

CTT not only arranges licensing deals, but also creates companies based on university discoveries. In 2002 the only two single-campus universities in the US that created more companies based on university research than UPenn were Stanford and Massachusetts Institute of Technology (AUTM, 2004). UPenn itself does not have seed financing, but CTT coordinates with outside seed funding sources to get SBIR's into a spin-off to do proof-of-concept work. CTT also works with BFTP, business-angel groups and other commercial actors. Working with spin-offs rather than licensing to existing companies does, however, prolong the process of generating revenue, since established companies that license discoveries usually can commercialize them faster. The equity that the university takes in the spin-offs is expected to make up for that loss in the long run. The officers emphasize that CTT is not an incubator, and their focus is not necessarily on starting new companies.

Several years ago the state of Pennsylvania concluded that not enough of the university research was being commercialized and decided to change the model from being driven by university needs to being more driven by the private sector. BFTP was and still is one of the major tools ensuring that there are multiple players that are active in these processes.

Benjamin Franklin Technology Partners (BFTP)

BFTP created the opportunity for multiple commercialization entities to exist in the region. It focuses on capital, knowledge and networks, and the activities ultimately have to benefit technology-based regional growth. The starting points for each activity are therefore the needs of the technology-based enterprise, defined precisely or more broadly. There are a vast number of activities being initiated through BFTP.[33] BFTP creates partnerships that have not occurred naturally before, bringing together actors that might not find each other but for the help of BFTP (with both networking and funding). They also get involved in venture deals or funds that may be difficult to pull through (such as high technology banking), but are really important in terms of regional needs.

> *We still have a lot of community building to do, but we are beginning to see players at all stages of the spectrum. We are viewed as an organization that thinks with the other actors, which is what we want. (BFTP officer)*

BFTP has regional subdivisions, including BFTP of Southeastern Pennsylvania (SEP) which is based in Philadelphia. BFTP/SEP offers investment capital[34], coaching, connections to various service providers and help to establish strategic alliances for researchers and entrepreneurs. One-third of the portfolio is dedicated to life sciences. (www.sep.benfranklin.org)

Innovation Philadelphia

Innovation Philadelphia, financed by the City of Philadelphia, is a consortium of approximately a dozen organizations. The numerous action programs described earlier encourage interaction between those organizations as well as interaction between researchers and entrepreneurs. It is difficult to get non-profit and profit organizations to collaborate.

[33] *One example of the organization's catalyst role is that they started an activity which provides researchers or entrepreneurs with a review of the application concept, as well as money to help them get that application written. This activity was successful and eventually became a part of "Innovation Partnership."*

[34] *(100 000–500 000 USD as part of larger funding funds of 200 000–3 000 000 USD involving other sources such as SBIR, angel investments etc.)*

What makes it possible for Innovation Philadelphia is that they are not within the academic world, so they can act commercially. It is easier to work together with commercial actors when incentives are comparable. (www.IPphila.com)

BioAdvance

BioAdvance is one of three life science greenhouses in Pennsylvania, active in the Philadelphia region. BioAdvance provides early-stage financing and is supported by the State of Pennsylvania (33 million USD over five years, from the state´s tobacco settlement). BioAdvance is also a business development resource for companies both in and out of their portfolio.[35] (www.bioadvance.org)

Science Center

This incubator is independent, although UPenn owns 40 percent of it. It has gone from being a landlord to being involved in creating companies, but this is a fairly new role. CTT increasingly encourages spin-offs to locate there. (www.sciencecenter.org)

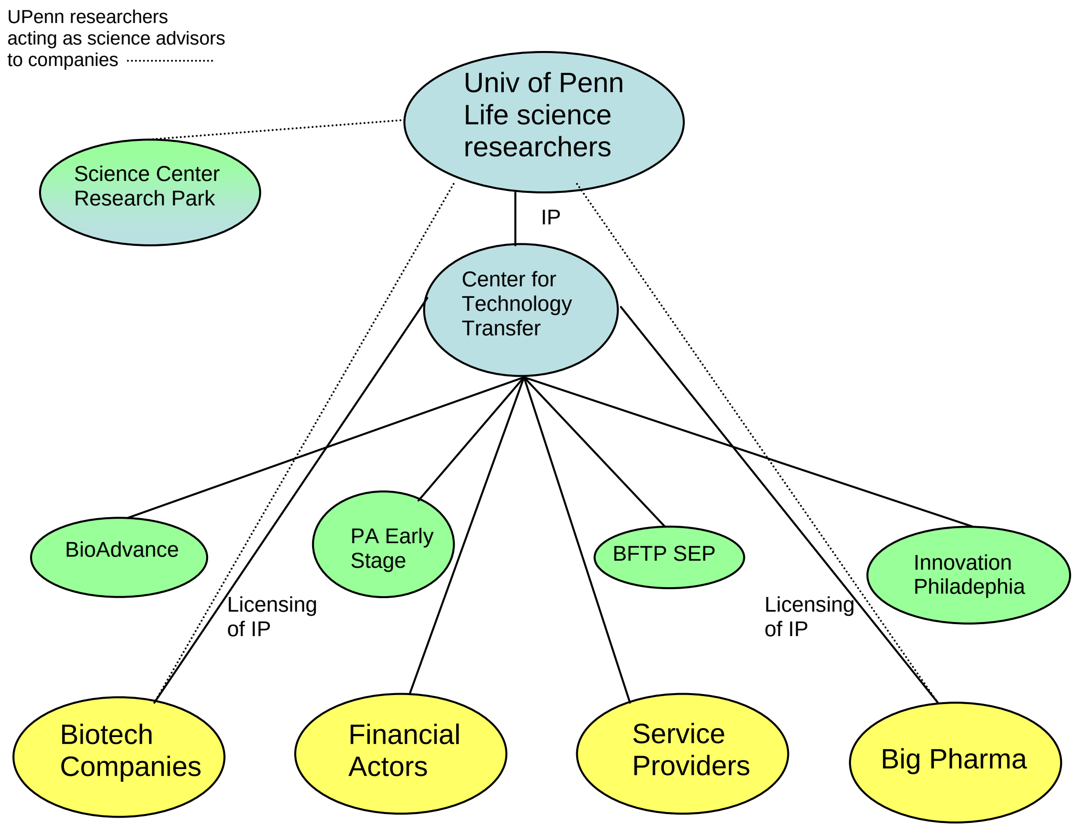
Several organizations are active in more than one investment phase and they co-invest with each other. The advantage to having several organizations is that they attract funding from difference sources (some from the state, some from the city, etc.) and contribute different expertise. Making optimal use of the money is, however, considered to be a question of coordination.

The connection between researchers and commercial actors

The University, due to the Bayh-Dohle Act, is by default the researchers´ first formal partner in commercialization efforts. This direct connection is illustrated by a line between UPenn researchers and CTT (below).

[35] *Battelle, (2004) "Laboratories of Innovation: State Bioscence Initiatives 2004, June*

Figure 2 Connection between UPenn researchers and commercial actors



The extent of the involvement after a researcher has disclosed a discovery to CTT varies:

> *"Some researchers have no business experience at all and then it is not helpful that they get involved in the process. But it is good if they help with a patent application and with relating the opportunity to commercial actors. They also lend credibility to the project through their titles and scientific accomplishments."* (CTT officer)

CTT in turn has direct contact with commercial actors in the private sector and also with regional technology based economic development organizations. Depending on the extent to which the researchers get involved in the transfer of IP, they connect to those actors through CTT, as the full lines in the diagram show. Researchers may serve as science advisors to new companies in science parks, to more established biotechnology companies, as well as to big pharmaceutical companies, without going through the CTT, but only if it is not with regards to intellectual property belonging to UPenn. Such engagement is limited to an advisory role, illustrated by the dotted lines in the map.

The design of the commercialization efforts at UPenn is driven by the methods for gaining access to funding for proof-of-concept work. The CTT at UPenn wants to increase revenue, some of which goes back into the University research. They can file for patents and then license these to companies, which is what technology-transfer offices traditionally have done. At UPenn there has recently been a push on creating more value within the University before licensing it out. The first step is to perform proof-of-concept work, but the University does not have the money to cover such activities. The focus is therefore on getting SBIR or STTR grants to finance that work. These grants, however, are only given if there is a company involved. The state and local funds that match SBIR grants, or finance application work to get grants, are also mainly geared towards companies. CTT engages in creating companies, so that there is a legitimate actor through which the grants can be sought. The grant money basically goes to the researcher's lab so that the proof-of-concept work is done – if it turns out well, it can then be licensed out to a higher value, or investors may be more willing to support a company that will develop the technology further.

There are new initiatives at UPenn to create funds, based on industry money, which will invest in proof-of-concept work without having to create companies.[36] This way more value can be created within UPenn and less effort must be expended applying for several small grants from different organizations. In short, the official design of UPenn's commercialization efforts are set up through a centralized unit, that in turn is increasing its relationships with commercial actors to get them more involved in the commercialization efforts at UPenn without engaging the researchers more than before. But entrepreneurial researchers may well be making their own contacts with companies, as an officer at BFTP explains:

> *"Just because there is a tech transfer office at the university doesn´t mean there isn´t direct contact between university people and commercial entities. That is going to occur and there is no way that universities are ever going to be able to regulate that. But at the time of a business deal, they have to come to the tech transfer office."*

Motives for Researchers to Get Involved in Commercialization

There is a push at UPenn to increase the identification of research with commercial potential, and researchers are encouraged to keep CTT informed of those. To improve identification of discoveries with commercial potential, new structures are being created. Many CTT officers have dual-appointments in academic departments, which facilitate the identification of discoveries with commercial potential. UPenn shares potential incomes from IP with the inventor, who receives 30 percent, but the University does not encourage researchers to get involved in commercialization itself. A faculty member at UPenn is allowed to spend one day out of seven doing something apart from the faculty job. They can not take a management role in a company, but may serve on a scientific advisory board.

Major Challenges Experienced by Actors Involved in Commercialization Processes

Creating spin-offs is not enough; the new companies need to be in an environment conducive to growth. In 2003, UPenn found that of 51 companies reviewed, 24 were succeeding. The issue, however, was that most of the ones succeeding were companies that had moved to California or other parts of the country: *"Our entrepreneurs are constantly on airplanes out to Boston and California."* (former CEO of CTT, 2004)[37]

---

[36] *CTT is creating agreements with large pharmaceutical companies, in which the company funds proof-of-concept work in a field and gets the right to look at results before any other company.*

[37] *Key, P. (2004) "Penn hits high note with tech," Philadelphia Business Journal, January 16.*

Growing a Local Biotechnology Industry

Although Philadelphia is well-positioned in terms of research, pharmaceutical companies, and recently, availability of seed-capital, the lack of local dedicated life science VCs remains a challenge. The VCs that invest in later rounds are primarily from California, Massachusetts and New York City. By making limited partnership investments, the State of Pennsylvania has prioritized the creation of new, in-state venture-capital funds. The investments are financed by the Benjamin Franklin program, public pension funds and direct appropriations in the state budget. There is also concern regarding access to experienced managers, a BFTP officer explains: "*What we mainly need to do is recruit CEOs who can create and lead new companies. There is great competition for these people, so the question becomes: Can you attract them?*"

The interviewees consider quality of life in Philadelphia to be high, which is a major factor in order to attract those CEOs. When it comes to generating their own biotech-entrepreneurs, the challenge for Philadelphia is considered to be the lack of large innovation companies, such as Genentech & Hybritech, which generate spin-offs and managerial competence. Another issue that arises in areas with stronger biotechnology clusters, is the abundance of other work opportunities for entrepreneurs who do not succeed with their venture. These "back up" opportunities are not so readily available in Philadelphia, which is another factor making people more hesitant to start companies.

Structuring the Support System

The interviewees all agree that political systems have an inherited short-term view, which makes it difficult to create structures for commercial processes and regional growth, where results take time. Even if evaluations may prove the activities to have positive impact, there is always the risk that they will get cut.

The political short-term view creates insecurity. Basic issues in the collaboration between various organizations become: Who gets the cash? Who gets the credit? Who gets the control? The actors have recently started to meet monthly to see how they can work together, but some are of the opinion that it would be better to have an umbrella organization to pool resources. The organization could be used to recruit professionals and give them proper incentives to ensure that activities such as proof-of-concepts and creation of companies are performed well.

University of North Carolina at Chapel Hill

The State of North Carolina

A public/private strategy group within the Department of Commerce, The North Carolina Board of Science and Technology, created The North Carolina Biotechnology Center (NCBC) in 1981. NCBC was established as a private, non-profit corporation in 1984, supported by the state. As a neutral player, NCBC works as a catalyst for interactions between industry, universities and government (NCBC, 2002). The initial strategic focus was to strengthen the university life-science research by investing in educational programs, basic research projects and research faculty recruitment. Later, the NCBC expanded its activities to include programs and pre-seed funding to support emerging life-science companies. An updated strategy was presented in 2004, including support to the researcher/entrepreneur through sabbatical rewards and adjustment of the traditional promotion system. (Cortright and Mayer, 2002; Battelle, 2004; NCBC, 2004)

Although some large multinational pharmaceutical, agricultural and industrial biotechnology companies are located in North Carolina, the trademark of this region has been the ability to build its own biotechnology industry, based on university research. North Carolina employed 31,000 workers in drugs/pharmaceuticals and agricultural feedstock/chemicals in 2002. Including medical devices and equipment and research and testing, the total number of employees was about 40,000 (Battelle, 2004). North Carolina ranks fifth in the US with its 88 biotechnology companies, 70 of which are located in Research Technology Park (RTP) (Ernst & Young, 2004).

There has been a decline of nearly nine percent in venture capital investment in North Carolina since 2003. The state still ranks twelfth in the US in total venture capital invested in 2004 (335.31 million USD)[38]. Biotechnology received more than any other sector (40.5%). The State of North Carolina put together a Bioscience Investment Fund in 1998, through the NCBC, to provide financing for start-ups. The 10 million USD appropriations from the State of North Carolina were complemented with 16 million USD in additional investments by several North Carolina corporations and foundations. The fund provided financing in the range of 60,000 to 2.6 million USD (Cortright and Mayer, 2002), but this will not be reinvested. It is difficult to get political support to raise a new fund, since there are now more similar actors on the market and the need is not considered as big as before. There are about six VCs that target seed-stage in the area[39]. The North Carolina Board of Science and Technology has recently created a fund to be used to create incentives for applying for SBIR/STTR and to match awards when won.[40]

The Research Triangle

The Research Triangle is defined by three cities and three universities: Raleigh, State capital and home of North Carolina State University (NCSU); Durham, home of Duke University; and Chapel Hill, home of University of North Carolina (UNC-CH). The shared goal to get ahead enabled leaders from universities, industry and city councils to come together and establish Research Triangle Park (RTP) in the 1950s. It is seen today as the key to the success of the region. Raleigh-Durham attracted major investments from the federal government and from multinational pharmaceutical companies. Eventually the region became a center for biotechnology spin-offs and contract research companies. Over 60 percent of the total VC investments in NC were made in RTP (CED, 2004). That region has attracted more than 379 million USD in venture capital since 1995, through investments in 54 biotechnology companies. RTP is now the largest university-related research park in the United States. (ITAC, 2003).

- Patents: 5,500 during 1997–2001, 120 patents per 1,000 researchers/engineers
- Start-ups based on university research: 50 during 1995–2000
- SBIR/STTR Awards Phase I: 2.3 in 1995, 3 in 1999 (million USD)
- SBIR/STTR Awards Phase II: 5 in 1995, 7.5 in 1999 (million USD)

Source: Innovation Philadephia, 2002

[38] *Total seed/early stage financing raised in 2004 was, according to CED, 124.64 million USD*
[39] *One example is the new 'NC Idea' that provide grants, loans and traditional venture capital to high technology companies. They also offer mentoring. www.ncidea.org*
[40] *One North Carolina Small Business Fund (special revenue fund of up to 3 million USD) Source: SSTI (2005) Aug 29*

The population in the three counties is about 1 million, and approximately 44,000 people work in the RTP – over 900 of whom are life scientists. 95 major research and development organizations are located there, along with three biology institutions granting life science PhDs.

Within the RTP region, integration efforts between universities and industry continue on a more local basis. NCSU built their Centennial Park 20 years ago. It is about 1,200 acres and an extension of the University`s main campus. Schools, businesses and incubation labs are all in the same place. The state government has implemented an act which supports the adoption of NCSU´s Centennial campus model by other universities across the state, as a part of a strategy to grow the biotechnology industry (NCBC, 2004). UNC has developed plans for a similar campus, focusing on the idea that a physical location is necessary for integration between business and researchers.

The main challenges facing the growth of the biotechnology industry in the RTP region have been identified as: 1) Budget strains on public programs that support small company development (including NCBC and the UNC-system) due to economic downturn, 2) VC funding in the region is decreasing, 3) Public infrastructure continues to slow development of commercialization opportunities (RTR, 2003). Recommendations for overcoming those challenges include: increase venture capital funding; base grants to new and expanding companies on the companies´ withholdings of state income tax for employees; promote and support expanded technology transfer from universities; and, engage university leaders to announce their support for commercialization of university research publicly. (Cortright and Mayer, 2002; www.cednc.org; Battelle, 2004)

University of North Carolina, Chapel Hill

Public university

Number of graduate students: 8008, full time faculty: 3,161 (total employees 10,163)

Yearly research and development budget: 1442.5 million USD (FY 2004), 30% is federally funded, 20 % of that is from the NIH

Life sciences R&D: 304.6 million USD, of which 219 million is federally financed (FY 2003)

Sixteenth-highest recipient of funding from NIH of all US institutions in absolute numbers (2004)

The Office of Technology Development (CTT) at UNC at Chapel Hill:
Employees: 11 (2005)

Spin-offs: 23 in the last five years

Licensing agreements: 34 (2004), decrease of 37% from 2003

Licensing income: 3.9 million USD (2004)

Patents issued: 28 US (2004)

Sources: NSF, 2005; Office of Institutional Research and Assessment, 2005

The triangle universities licensing consortium (TULCO) was started in 1988 by Duke University, UNC and NCSU. Every time something patentable came out from the universities, they would give it to TULCO to market it. Eventually NCS spun out and started their own technology-transfer office. Then Duke spun out, leaving UNC to start their own office too.

UNC was, compared to the other institutions, slow to embrace tech transfer. Duke and NCS both had technology-transfer directors in the early 1980s. The first technology-transfer director at UNC came in 1995. During this period, technologies were pulled out of the university by industrialists who, for example, had read about discoveries in articles. In 2000, when a new director came in, the office started to actively push technology to the private sector. In practice that meant telling faculty that technology transfer is important and that they were expected to engage in it.

> *"It was a lot of work talking to faculty about this, specifically department chairs. Cultivate good relationships with them, say that the university heads think that it is important to do. It was really just pure effort. It was harder than doing a start-up because you are changing 206 years of culture and trying to do something new."* (Entrepreneur and former OTD officer)

Main Actors: Bringing a Project From Discovery to Further Commercialization

University of North Carolina, Office of Technology Development (OTD)
At UNC, the Office of Technology Development (OTD) is responsible for the intellectual property developed by the researchers and the licensing thereof. With a total staff of eleven, OTD provides patent assistance and helps faculty to obtain research support from corporate sponsors and negotiate and create agreements. OTD helps spin-offs get the initial contacts they need, straighten out the concepts and prepare presentations, which includes making sure expectations are realistic to enable useful meetings with commercial actors.[41] (http://research.unc.edu/otd/)

University of North Carolina, Office of Economic and Business Development (OEBD)
The Office of Economic and Business Development (OEBD) was launched April 1, 2004, reflecting the expanding efforts of UNC to address economic development issues facing North Carolina. The mission of OEBD is to help North Carolina communities and businesses access the resources of UNC. The director of OTD is also the Associate Vice Chancellor for economic development, thus connecting the strategies of the two units. (http://research.unc.edu/otd/)

Research Triangle Institute (RTI)
RTI was funded by the three universities in Research Technology Park. It was the first entity to be set up in the park, and the mission was to continue to develop research from the universities that seemed to have commercial potential. The universities still provide governance, but RTI now operates independently. As of 2005, it is the second largest private, non-profit research institute in the US. It has a focus on applied research and is an intermediate between industry, university and various support organizations. (www.rti.org)

North Carolina Biotechnology Center (NCBC)
With a staff of 50, the center supports spin-offs and growing companies by providing grants and seed money for biotechnology research, helping recruit faculty to the State´s university system and encouraging collaboration among university and industry researchers (Cortright and Mayer, 2002). Their programs are presented at www.ncbiotech.org

[41] *In order to enhance their productivity, OTD has developed an electronic management system. They have an application at the NSF for a major grant to enhance it further and to work with four universities to help data-test it. The Kauffman foundation has pledged a significant amount of money to help accelerate the system. The aim is to make it available through open source and help develop a standard.*

Research Triangle Regional Partnership (RTRP)

In 1990, the Raleigh and Durham chambers of commerce created Research Triangle Regional Partnership (RTRP) to market the Research Triangle Region in order to attract business investments**.** One of the five key strategies in RTRP's plan[42] was to integrate the region's higher education resources into all economic development efforts. One of their officers explains that *"Universities are integrated in everything we do. When we did our strategic plan, we had the presidents from each university sitting at the table, helping us design the strategies."* One example of this joint work is the Precision Marketing Initiative, which identifies businesses that collaborate with researchers at the universities and then tries to attract those companies to the region. (www.rtrp.org)

Council for Entrepreneurial Development (CED)

CED is a private, non-profit organization, funded in 1984 by local service providers to stimulate growth of companies in the RTP-region. Activities include educating and mentoring. More than 8000 entrepreneurs, VCs and service providers participate in the programs each year. CED acts as an interactive forum for policymakers, entrepreneurs, investors and researchers. CED is financed through membership fees, program fees and sponsorships and benefit from the pro-bono work done by lecturers and mentors. (www.cednc.org)

Small Business and Technology Development Center (SBTDC)

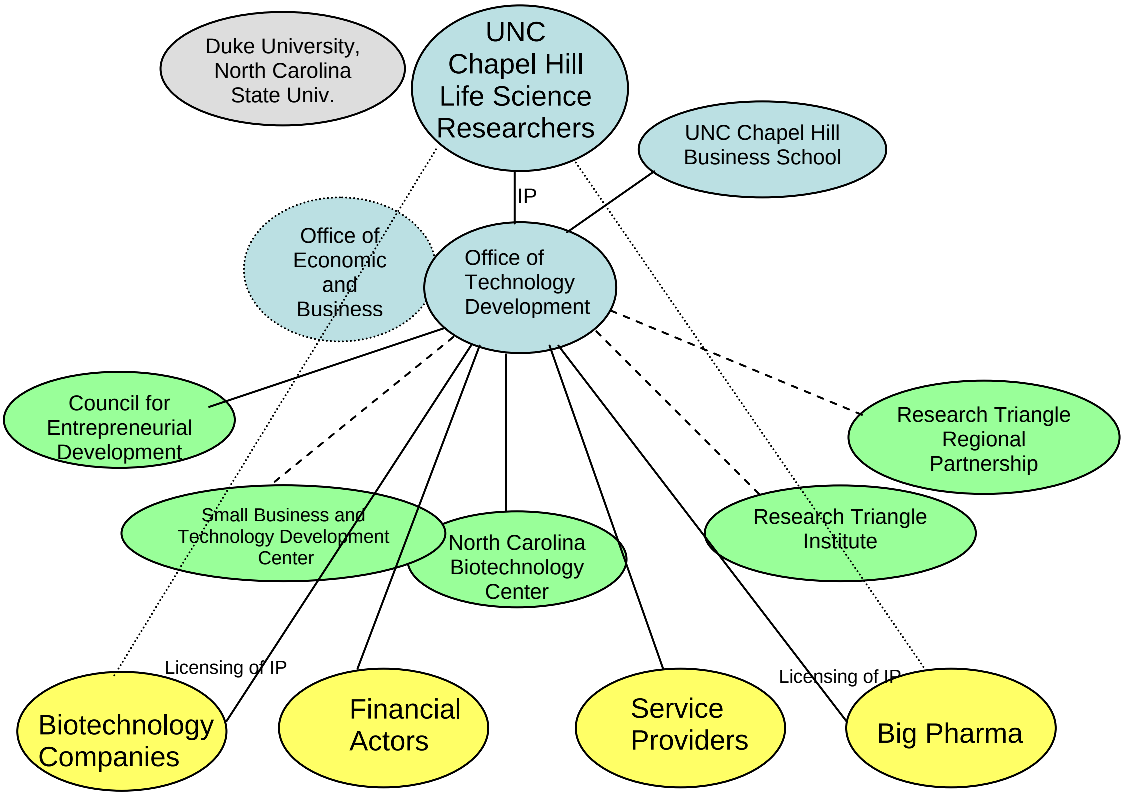
SBTDC is statewide, and provides management consulting and educational services free of charge to entrepreneurs in North Carolina. Their 17 offices are each affiliated with a college or university. SBTDC has a specific service for technology commercialization counseling and SBIR outreach. (www.sbtdc.org)

The Connection Between Researchers and Commercial Actors

The University, due to the Bayh-Dohle Act, is by default the researchers´ first formal partner in commercialization efforts. This direct connection is illustrated by a line between UNC researchers and OTD (below).

[42] *"The staying on top plan won the US Commerce Department´s 2004 Regional Competitiveness Excellence in Economic Development Award. The award recognizes RTRP´s commitment to sound, research-based, market-driven economic development in helping grow the local economy." (State of the Research Triangle Region, 2005, RTRP)*

Figure 3 Connection between UNC Chapel Hill researchers and commercial actors



OTD has direct contact with commercial actors in the private sector and also with regional technology-based economic development organizations. Depending on the extent to which researchers get involved in the transfer of IP, they connect to those actors through OTD, as the full lines in the map show. There are interactions between the local biotechnology companies and the researchers, but not so much with local pharmaceutical companies since the divisions in RTP focus on manufacturing rather than research. Researchers may serve as science advisors to companies, without going through the OTD, if not advising about IP developed within UNC, illustrated by the dotted lines in the map.

The director of OTD is increasing the relationships between the unit and commercial actors, but also sees a need for direct connection between the researchers and industry:

> *"A lot of tech transfer directors are a bit worried by the thought of having people from the outside having direct access to faculty. Faculty is capable of thinking that they have more authority to do a deal than they do. They can get themselves and us in trouble. This entrepreneurially rich area is full of people who know how to deal with the university, and that makes it easier. Our faculty is well educated in how to protect their patent rights, which means that the barriers for letting direct interaction happen are lower."*

In order to increase the direct interaction, OTD implemented a monthly seminar series four years ago: *The Technology Commercialization Seminar Series*. It is geared toward the needs of faculty, post-docs and graduate students, but the business community is also invited.

The intermediary actors go through the OTD in their efforts to increase the University's contribution to economic growth in the region. OTD, in turn, is working hard on increasing their relationships with venture capital companies. But, since most venture capitalists are not interested in early phases, they do not actively look for interaction with researchers or technology-transfer offices. Several universities are therefore focusing on business angels who may be more interested in investing in the early phases.

In 2004, UNC was ranked the number one entrepreneurial campus by Forbes and researchers at Princeton (Ewalt, 2004). A five-year grant from the Kauffman foundation enabled the creation of the Carolina Entrepreneurial Initiative, which focuses on undergraduate students. This grant was spearheaded by OTD who viewed the business school at UNC as a resource for OTD efforts in helping researchers move forward with discoveries with commercial potential. There are a number of initiatives[43] and the activities have a positive effect on the interaction between students, faculty and entrepreneurs.

Motives for Researchers to Get Involved in Commercialization

The researchers at UNC have not been known for interacting very much with commercial actors, according to the OTD director:

> *"Being the oldest public university in the country is an honor, but also a burden because there is a sense amongst the faculty that we have a responsibility to uphold staying true to academic ideals and not getting too much in bed with industry."*

Although senior management at the University supports increased technology transfer, it has been harder to convince some deans. OTD officers do not think that the researchers are so worried about what management of their university will say, but more worried about what their colleagues think about them spending time with technology transfer. That is harder for the OTD officers to influence. Once more researchers have done it, the Director of OTD expects that it will become easier for others to follow.

Major Challenges Experienced by Actors Involved in Commercialization Processes

According to their comparisons with peer universities, OTD is first on the list in terms of the percentage of licensed inventions, yet last on the list in terms of staff size. The officers argue that if they had more people they could take better advantage of the large research base at UNC; but they conclude that the university is still trying to figure out what it takes to do technology transfer.

The common view seems to be that money for proof-of-concept is still a problem. As a response to the decline in funds available from NCBC, universities are also trying to set up their own funds. The Director of OTD has received preliminary approval to raise funds:

> *"I will go to alumni. If you look at the big business around here, you'll find that 80 percent of them have CEOs that graduated from here. We'll start informally with a kind of angel network that we would formalize later on."*

Another challenge is space. There are laboratories available for lease within RTP by different entities, but these are often too expensive for spin-offs and the leases are too long. There is no huge demand, partly because Centennial Campus helped alleviate the problem. But, with regards to UNC, only one of 25 companies created the last five years is still in

[43] *Carolina Entrepreneurial Initiative, the Carolina Entrepreneurship Club, Students in Free Enterprise, The Carolina Launch Program.*

Chapel Hill. The others are in Durham or at the Centennial campus.[44] Private universities, such as Duke, can allow spin-offs to use lab space on campus. That does not work at public universities such as UNC, due to public perception that only academic research should take place within the university walls.

It is not only a question of space, but also of the support that so-called "accelerators" are offering companies in other parts of the US, and which still seems to be missing around Chapel Hill. The OTD Director expects a new park to have several positive effects:

> *"If new companies could stay closer to UNC Chapel Hill, it would help formal and informal interaction with the research community that actually drove the initial science that led to the technology. Researchers could then play a more hands-on roll at the companies. The scientists have a one-day a week rule regarding consulting, but if they are close to the companies, they could drop by one hour a day for example. I think that would help."*

Growing a Local Biotechnology Industry

There is concern in the region that not enough companies, based on local research, stay and grow. Large VC groups that focus on later stages and can put in enough money to accelerate growth are more common in MA, NY and CA, than in NC. CED and NCBIO have joined forces to attract some of the large VC companies to open offices in NC. Another factor that influences whether companies relocate is the availability of experienced managers. Some interviewees expressed concern over a lack of CEOs who can grow spin-offs in North Carolina. But there is also another reason as to why some of the new promising companies "disappear" from the region:

> *"The spin-offs that grow tend to get bought. Biotechs in general are very high risk and many fail. The ones who don´t fail are so good that everybody wants them. There are a lot of big companies in the world that look at us and other high technology regions all the time, trying to buy companies. So we loose our share and we buy our share."* (RTRP officer)

The RTP region is focused on IT and life sciences, industries where acquisition of new companies in order to obtain certain IP is frequent. Acknowledging those dynamics, the actors whose mission it is to create growth in NC focus on quality of life as a way to attract and retain knowledge workers and the companies who want to hire those people.[45]

University of Tokyo

The Greater Tokyo area ranks as one of the largest cities in the world with a population of around 27 million – and it accounts for a significant share of Japan's GDP. Its role as the political and economic center of Japan gives it a unique position among Japanese regions. The area holds a number of prominent universities, public and private, as well as leading public research institutes, many with internationally competitive life science research. Due to its size, geographic spread and diverse research base, it is difficult to discuss the area as one region; rather it is an agglomeration of functional regions and innovation systems. Some of the leading Japanese pharmaceutical companies and larger corporations involved in drug discovery are headquartered in Tokyo, and so are also leading financial actors and banks.

---

[44] *22 of the 25 are still alive and some have raised significant funding, Some are not in such a good shape, but still operating.*

[45] *The cities of Raleigh – Durham – Chapel Hill captured the No. 1 spot in the 2002 America´s Best Places to Live & Work rankings (ITAC, 2003).*

Although Tokyo is considered the most prosperous part of Japan, regional policymakers have identified a need for economic revival. Regional industrial development activities are focused on manufacturing, biotechnology and ICT. The goal is to develop the clusters, strengthen the existing industrial base, and develop the industry of the future. The projects are run both by regional actors, in this case METI Kanto Bureau, and local city councils, all in cooperation with universities and industry. A main project in life sciences focuses on "cultivation of biotechnologyrelated start-ups, "aiming to link" research seeds with industrial needs." This is briefly described later in the case study.

On the city level, the cities/prefectures of Tokyo, Yokohama/Kanagawa and Chiba also support local development programs for the life science industry. These initiatives include support of incubators, research parks, networking and marketing.

Although the existence of life-science SMEs is rather new to Japan, the Tokyo area hosts the largest number of biotechnology start-ups, or "ventures," in Japan. The latest figures from Japan Bioindustry Association puts the figure to about 230.[3] Some of these originate from university research; others come from large corporations or have other corporate/technological backgrounds.

So far, the total number of companies that have emerged from University of Tokyo is limited, considering the size of the university (see fact box). Our guess is that the number with significant business activity is less than 20. Of these, one company focusing on cancer diagnostics made a successful IPO last year.

University of Tokyo

National University, founded 1877 as the first university in Japan

Number of graduate students: 12 000 (6000 Ph.D. and 6000 Masters Degree)

Number of faculty: approximately 2,800 (professors, associate professors, lecturers)

External funding (2003): USD 200 M in projects grants for "scientific research" in all areas and from joint research with private enterprise USD185 M (incl. publicly funded cooperation). No specific figures available for Life Sciences

Number of spin-offs in all fields: 65 (source METI)

Main Actors: Bringing a Project from Discovery to Further Commercialization

Division of University-Corporate Relations (DUCR)

Division of University-Corporate Relations (DUCR), started in 2004, is a unit directly under the President and is assigned to manage the university's contacts with industry, society and other external actors. DUCR summarizes their activities as:

- Consultation – a one-stop advisory service to researchers and entrepreneurs
- Plaza and Communication – offers a "market place" for collaborative research and business generation
- IP Management – develop mechanisms to manage IP rights created at UT
- Policies and Legal Strategies – creation of university-wide policies, including conflict of interest issues
- Contract and Confidentiality Management – Create university-wide rules and guidelines (research contracts, materials transfer agreements, non-disclosure agreements and others)

- Education – Seminars and educational programs for researchers and entrepreneurs
- Development of new university corporate relations models – to improve U-C cooperation.

DUCR is organized into three offices: Office for Intellectual Property (OIP), Office for Collaborative Research (OCR), and Office of Science Entrepreneurship & Enterprise Development (SEED). Each office has a specific task and functions to address these; OCR manages the "Proprius 21" program – Innovation in Collaborative Research with Private Sector; OIP handles IP generated within UT in close cooperation with Toudai TLO; SEED oversees the VC fund University of Tokyo Edge-Capital (UTEC), set up to promote start-up companies. Theses actors and programs, created in 2004, are described below.

- The Office of Intellectual Property has the main responsibility to handle and secure IP generated at UT. A five-year grant from MEXT and funding from "Super TLO" program (also from MEXT) finance the operations. The funding is estimated to be around JPY 30 M /year. This allows for the office of the Director and two full-time Professors. The remaining Professor level staff at DUCR is hired on project funding ("Project Professors"). The university funds the administrators at OIP. Some of the faculties, larger departments and institutes within UT also have staff handling IP issues.
- The Office for Collaborative Research (OCR) manages the Proprius 21 program, initiated in 2004. The purpose of the program was to take advantage of the strong and broad research base at University of Tokyo in collaborative research with industry. Proprius 21 functions as the "plaza,," or meeting place, for university professors and industry, and as a project office with project coordination, preparation of contracts, etc. The program makes it easier to build interdisciplinary teams within the university, as the projects often have a more goal-oriented approach. Proprius 21 funds the project-planning period, which can be up to one year. Projects under the Proprius 21 program are usually funded from METI/NEDO programs, or other government sources. In some sense, the program acts as a virtual institute within the university. It is not clear whether any biomedical projects have yet come out from the program.
- The Office of Science Entrepreneurship & Enterprise Development (SEED) oversees UTEC, University of Tokyo Edge Capital. UTEC was established by the university in 2004. The purpose is to invest in new science-based companies, and the main business of UTEC concerns commercialization of research and investments in science-based companies and university spin-offs. A number of institutional investors have invested in the VC fund. UTEC works in close cooperation with Toudai TLO in the creation of new companies. So far, the financing has mainly been of UT-related companies, but in practice, UTEC is not limited to those projects. UTEC is moving toward seed and early-phase financing but can invest in later stages (before IPO) as well as to commit to investment before a company is formed. As of June 2005, ten investments have been made (no specific details available).

Toudai TLO

Individuals associated with the University of Tokyo, mainly faculty, established the Toudai TLO in 1998[46]. The aim was to help secure and market inventions from research at the university. The TLO is thus not an integral part of the University organization, but has a very close working relation with the university through DUCR. Toudai TLO has a strong partnership with Stanford University OTL and its former head Niels Reimers who has acted as

[46] *Previously called CASTI*

consultant in establishing the TLO. In a recent quantitative study done by the National Institute for Science and Technology Policy (NISTEP), it was ranked as the number one TLO in Japan[47].

Because it was formed prior to the incorporation of the University in 2004, the founding partners set up Toudai TLO as a company, organizationally outside the University of Tokyo. Following the incorporation of the universities, Toudai TLO has been exclusively entrusted by the University of Tokyo (DUCR) to perform patent investigations/ applications, licensing, and related business. The number of staff is 16 and the majority has science/engineering and industrial/business backgrounds. During the years of operation, the TLO has filed around 900 patents (granted domestic and international) and has managed to license out over 280 of them to businesses.

The TLO receives a minor share of the license fees paid to the University and the remaining is split between inventor and university. The net income was 25 million USD in 2004. This was an unusually high figure and was due to income from an IPO of a biotechnology company in which the TLO held shares. The income in previous years has been around 2.5 million USD.

The University-linked actors described above are, since last year, located in the same building on University of Tokyo's main campus in the Hongo district of Tokyo. The building also harbors a small "incubator," mainly with office space.

An additional TLO, the Foundation for the Promotion of Industrial Science, is linked to the Institute of Industrial Science – an institution within University of Tokyo. Its focus is on promoting technology transfer for this Institute and will not be described in detail.

METI Kanto Bureau (Regional Office)

The Ministry of Economy, Trade and Industry (METI) local bureau in the Kanto area (mainly Greater Tokyo) runs a promotion project for biotechnology start-ups, within the framework of the nationwide "Industrial Cluster Program." The project started in 2002. At present, around 290 companies, several local governments, TLOs and 13 universities and research institutions are members of the "Metropolitan Biotechnology-related Start-up Network." The activities of the project include:

- Meetings and networking – yearly "Forum" to present seeds and companies to investors and industry. Smaller "Bio Business Salon" meetings four-to-five times per year on specific issues.
- Bio Business Coordinators – experts that can be dispatched to start-ups to assist in solving specific problems (ten at present "matching seeds with needs").
- Regional promotion through business fairs.
- Matchmaking between universities and industry, investors.

Of the member companies, some are university spin-outs and some are spin-offs from larger corporations. Nine regional incubators also participate in the program.

Japan Bioindustry Association (JBA), headquartered in Tokyo, does the administration of the project and it is believed that this gives better national perspective to the activities.

[47] *NISTEP; Study for the Evaluation of Achievements of the S&T Basic Plan, Achievements of Basic Policies for Industry-Academia-Gov. Cooperation and Regional Innovation (March 2005)*

The project is financed 100 percent from the national government with a budget of around 900,000 USD for 2005. The plan is to run the project 5+5+5 years with evaluation at the end of each period.

Connection between researchers and commercial actors

Since the University reform in 2004, the mode for interaction between researchers and commercial actors has changed because after the incorporation of universities, the ownership of inventions and IP in most cases resides with the university.

For the life science researcher at University of Tokyo, the first contact is made to the the Office of Intellectual Property (OIP) or, a local Intellectual Property Officer for larger departments or institutes, to whom the initial "invention disclosure" is made. A first evaluation is made at this stage by university staff.

Next, OIP asks Toudai TLO to do a marketability evaluation where an estimate of the "value" of the invention is made, including novelty/patent evaluation. In the process, Toudai TLO also performs interviews with the researcher(s) in order to get more in-depth information on the invention and possible usage. The evaluation report is presented to OIP, which decides on whether the invention is of interest to the university or if it could be assigned to the researcher. In 2004, around one-third of the inventions (85 total) were claimed by the University and the remaining were returned to the researchers.

In cases where it is important not to lose momentum, the TLO can proceed with patent application without sending back the report to OIP ("rapid treatment"). If the invention is assigned to the University, Toudai TLO prepares the patent application and handles the practicalities involved.

- TLO will suggest the IPR and marketing strategy for each case
- Cost connected to patenting is covered by the University
- In almost all cases so far, the University has followed the proposals made by the TLO
- For the process, there is a maximum time of one month to decide whether to patent the invention by the university, after which it goes back to the researcher. This is said to make the process run quicker

Toudai TLO normally markets the invention and negotiates the licensing deals. This is usually done by direct contacts to possible customers, approaching identified key persons in their large external network. It does not appear as if they use "Innovation Fairs" to any larger extent in marketing.

Practicalities in the licensing of the IPR to companies – established or start-ups – including negotiations and contracts, are in most cases handled by the TLO. A percentage of the license fee goes to the TLO. The inventor(s), university and the department split the remainder.

Motives for researchers to get involved in commercialization

The official view at University of Tokyo (and in Japan in general) on cooperation between scientists and commercial actors have changed dramatically in the last decade; once considered inappropriate or outside the law, it is now fully supported and promoted. Before the policy change which opened up for official business cooperation, many university researchers had direct interaction with companies one way or another. At the University of Tokyo, representatives of DUCR acknowledge the fact that some university professors already have well established, long term, contacts with industry and view this as positive. These contacts are vital to the university in identifying potential partners among companies.

Seeing one's research used in practice for the benefit of society seems to be as important for the researcher as the possible financial gains. One should possibly take such statements with some caution and view it in the societal and cultural perspective.

The funding provided by the government for commercialization of research has apparently been a strong incentive and motivation to cooperate with commercial actors, for both the universities and individual researchers.

Major challenges experienced by actors involved in commercialization processes

The present system for handling university inventions has only been operational since April 2004. In the case of the University of Tokyo, the cooperation between the strong Toudai TLO and the newly established OIP appears to be working.

From the interviews, it appears as if most of the competence in commercialization issues resides within the TLO. Where previously, the individual researcher could choose between pursuing IP protections by him/herself or take it to the TLO for consultation and handling, the new route via the OIP appears to a more cumbersome process.

One factor brought up by some interviewees was the lack of a science park/incubator close to campus, suitable for biomedical spin-off companies. There are several science parks run by municipal governments in the Tokyo area but the location of these is quite far from the U. of Tokyo campuses, where life science research is conducted. Efforts are now on the way to facilitate the use of university labs as on-campus incubators for early phase start-up companies.

An often-mentioned hurdle is the lack of experienced managers and business experts to staff the new companies. Few people with appropriate skills are available on the job market, also in a large Metropolitan area as Tokyo. The initiatives by METI Kanto Bureau (through Japan Bioindustry Association) to dispatch experts to small biotechnology companies may in some way alleviate the problem, but is not a long-term solution. Many also look to retired managers from pharmaceutical industry to fill the gaps in new companies. Several of the large Japanese companies are located in the Tokyo area. These have an extensive network but may lack some experience in developing start-up companies.

The move of the university to set up UTEC may indicate a lack of seed and early financing for university spin-offs, however we cannot say this with certainty. The major VC actors in Japan are located in Tokyo and this should give companies in the Tokyo area an advantage when searching for funding. The Japanese government also provides different sorts of financial support for university spin-offs such as an SBIR-like scheme and other small business support measures or from JST and NEDO.

Tohoku University

Tohoku University was chosen as a subject for this study for several reasons: a high ranking among Japanese Universities for technology transfer and cooperation with industry and local government, a relatively small and peripheral region similar to many Swedish regions, and initiatives to merge medicine and technology, two strong fields at Tohoku U. It should be noted that molecular and cell biology are not strong fields here.

Tohoku, Miyagi Prefecture and Sendai City

The Tohoku region is mostly rural with a limited industrial base, compared to other regions of Japan. It comprises the northern quarter of Japan's main island of Honshu. Manufacturing industry, agriculture and agriculture-based sectors dominate the business landscape. For some decades, the electronics industry has been important in the regional industrial development but this sector has since the early 21st century been losing ground due to increased competition from other regions in Japan and abroad. Recent policies therefore focus on broadening the industrial base into knowledge-intensive areas, such as life sciences. The region lacks a developed life science-based industry and much effort is now put into attracting companies from other parts of Japan.

Sendai is the largest city in Tohoku, with around one million inhabitants and Miyagi prefecture, where Sendai is located, holds about 2.6 million. Local governments, both on the prefecture and city levels, actively promote the economic development and industrial renewal under a number of initiatives. The local business association also has very strong links to government and university, and coordinates many of the initiatives.

The Economic Bureau of Sendai City manages two local R&D projects:

- MEMS – focusing on the micro-electromechanical systems areas.
- Finland Well-Being Center – elderly care equipment and services. This project has several partners – national, regional, local governments and universities in the area plus a number of Finnish partners, incl. TEKES.

The city is also promoting new companies and ventures. Previously, this was done by subsidies but they are now more and more going towards "soft support" (services, expertise, etc.). Plans are on the way to create a new Science Park and incubator, in cooperation with Tohoku U.

The basic strategy for the regional development here is called the "Double Engine." The idea of the "Double Engine" is to use two university nodes as engines to pursue two goals. The one node is Tohoku University and the other is group of technical colleges in this area. The goals for this are: (1) the advancement of basic industrial technology in regional manufacturing and (2) the establishment of world-leading technologies in the region, such as nanotechnology and materials.

Since Sendai is located quite far from Tokyo where the investors are, there has been an effort by several actors to establish a local venture fund to invest in start-up companies.

One advantage for Sendai is the quality of life and the availability of land for development. The latter factor especially is taken advantage of in developing science parks and industrial zones. The availability of land to develop for new science parks and incubators sets Tohoku University apart from the universities in, for example, the Tokyo area. Recently, a joint project involving Sendai City and Tohoku University is set up to plan for a new campus in Sendai (Aoba Hill Plan) with a new "science park" in association with the campus. This development also includes a new incubation facility for science-based start-up companies.

Tohoku University

Number of students in total: 17,538
Number of Ph.D. students: 2,925
Academic Staff: 4,917 (1430 professors)
External funding (2003): Around USD 130 M; USD 60 M for industrial cooperation and USD 70 M as project grants
Number of university-born venture companies: 40 (source METI)

Tohoku University is one of the major national universities in Japan. The main campus is in Sendai, around 350 km north of Tokyo. It is ranked among the best academic institutions in the country and has for some time been active in setting up cooperation with industry. A very strong research area for Tohoku University has been materials science and semiconductors. In the life sciences fields, Tohoku University is receiving significant external funding from the Japanese government but so far little industrial development has followed. Since engineering and medicine are considered strong research fields, the university is setting up infrastructure and functions to merge these fields. The intramural "institute" TUBERO is the key to these efforts. One goal is to get results into practical use, thereby developing a new industrial base.

Main Actors: Bringing a Project From Discovery to Further Commercialization

Tohoku U. Office of Research Promotion and IP – TURIP

TURIP is the university's main function for handling IP and promoting commercialization and industry cooperation. It was created in 2003 in anticipation of the 2004 University reform 2004. The staff is 19, including IP and legal/contract functions.

TURIP are using four ways to market the research:

1 Through the TLO

2 University representatives (TURIP) visiting management at major companies

3 Tohoku U. "Technology Fair," where professors present their research results to companies, last year held in Tokyo.

4 National technology fairs held by METI and MEXT

TURIP visits departments and talks to professors to see what they are up to, gathering ideas of potential commercial value. The TLO (Tohoku Techno Arch) judges the market potential and patent situation. The university, through TURIP, is trying to be more active in outward promotion to companies, through direct meetings and networking. From our interviews, it was not clear how successful the marketing was. The activities of TURIP are financed by MEXT from the IP headquarters program, and from Tohoku University. The annual budget is around 1.3 million USD.

Tohoku Techno Arch Co., Ltd (TTA)

Tohoku Techno Arch is the TLO linked to Tohuko U. It was founded in 1998 by faculty from Tohoku University. The TTA also serves a number of other universities and regional technical colleges in the Tohoku region. It is ranked second in performance in a recent evaluation by NISTEP (after Toudai TLO). The staff is 12, covering all aspects of handling inventions. The main activities are evaluation of inventions for the academic partners, to help securing IP and marketing/licensing to companies. The major sources of income are:

- Income from licenses (split 1/3 TLO, university, researcher)
- University commissions TLO for IP evaluation and marketing
- METI "Super TLO" program

In total, TTA had around 285 patents granted by 2004 of which 160 were domestic and 125 international. No figures were given on the proportion for life science among those. TTA has the largest proportion of out-licensed patents among Japanese TLO:s – 75 percent – most of which are generating income (184 in total). For marketing of inventions, TTA first interviews the scientist to hear if they have any idea which company may be interested. If there are no suggestions, TTA identifies key persons at possible "customer" companies and approaches them with basic, non-confidential information. If there is interest, a confidentiality agreement is signed and meetings between scientists and companies are organized. Marketing to larger pharmaceutical companies, of which most are located in Tokyo or Osaka, were previously considered a problem. TTA now has an experienced former manager from a pharmaceutical company working half time to market biomedical/biotechnology inventions to companies in Tokyo area and Osaka.

New Industry Creation Hatchery Center – NICHe

The campus-based NICHe is one of 62 university-based "Centers for Cooperative Research". As such, NICHe has evolved to become a key player in the university's cooperation with commercial and public actors. Founded in 1998, the organization promotes cooperation between industry and university researchers putting to use the competencies at the university in the society. The goal is to enhance the international competitiveness of the industry, especially in the Tohoku region. NICHe develops technology and serves as a bridge between universities and business.

It is organized into two sections – Liaison Office for Development and Industry Creation Section.

Liaison Office for Development acts the bridge between the R&D needs of industry and the research capacity of the university. The organization is responsible for establishing new university-industry cooperation, planning and coordinating strategic research, participate in the creation of new companies (with TTA), develop personnel skilled in innovation (inside and outside of Tohoku U.), and creating opportunities for the practical use of research results.

Industry Creation Section manages a number of university-industry cooperation projects run within NICHe facilities. In these projects, leading researchers at Tohoku U. are leading more-or-less applied R&D projects in close cooperation with industrial partners, but outside of their regular university setting.

As the infrastructure for these activities, NICHe has three buildings on campus; The "Main Building" for large-size cooperation projects (USD 1 M /project); the "Fluctuation Free Facility (FFF) for New Information Industry" for semiconductor industry related research (total USD 9 M/year); and the "Hatchery Square," an incubator and support facility for University spin-offs.

The projects in the main building are usually three-to-seven years in duration, funded by external sources (mostly industry and METI). The professors involved are freed from the usual administration requirements. Initially, there were seven industry cooperation projects and now there are 13 ongoing. Within the projects run by NICHe, four are in the biomedical/life science fields. One project is NICHes own research on how to manage university-industry joint projects. An important part of the R&D program is the possibility for companies to locate their own researchers and presently, about 12 researchers from companies are dispatched to projects at NICHe. NICHe doesn't actively promote university spin-off creation. NICHe project financing amounted to USD 21 M in 2004 (METI 9.6 M, MEXT 0.9 M, funding from companies 4.3 M, donations companies 7.0 M).

An important role for NICHe is to educate scientists to become good project leaders, and local/regional public officers to become better in managing and promoting development initiatives for high tech industry. For the latter, NICHe has personnel exchange system with Sendai City, Miyagi Prefecture and METI Tohoku Bureau. Younger public officers from City and Prefectural Governments can work at NICHe for up to two years, in close contact with both researchers and companies. In this set-up, the University may send researchers to work at local/regional governments as "Regional Fellows."

Tohoku Economic Federation – Tokeiren
Tokeiren is the regional "Keidanren" or business federation. They work to promote the business climate in Tohoku and initiates and coordinates activities at several levels. One important role is to stimulate industry/university/government cooperation in the region where Tokeiren has assumed a role to coordinate the different regional actors in order to strengthen cooperation. One measure is to initiate the "Industry, Academy and Local Government Roundtable" under which the Tohoku Incubation Fund was launched, as well as the exchange program of personnel between University, City and Prefecture. In addition, Tokeiren does some marketing of the region.

Tohoku Incubation Fund
The establishment of a local independent VC fund, focusing on investing in companies in Tohoku, is seen as critical for the region. The ex-president of Nikko Securities (and graduate from Tohoku U.) was "head-hunted" to run the company managing the fund: TOHOKU Innovation Capitals Co Ltd (TICC). The fund's capital is 30 million USD and the main investors are regional banks, companies, business organizations and regional governments, making it among the largest local VC funds in Japan. The Tohoku Incubation Fund has recently teamed up with Bio-Frontier Partner, one of Japan's leading specialized VC firms in the biotechnology field. So far, Tohoku Incubation Fund has invested in at least two life science-related companies – one in research tools/analysis and one in medical devices.

METI Tohoku Bureau
The Tohoku bureau of METI is very much involved in the regional activities to strengthen university-industry cooperation. The most obvious examples are two projects within the Industrial Cluster Program:

- IT, Bio and Manufacturing
- Recycle-Based Society

Both projects involve cooperation between local industry and Tohoku U, as well as other regional academic institutions.

METI Tohoku Bureau is also involved in marketing the region to companies from other parts of Japan.

Connection between researchers and commercial actors

Formal scheme for cooperation between researchers and commercial actors and IP issues looks very much like that set up by other Japanese universities after incorporation. What is different from the University of Tokyo case is that there are already facilities and functions set up to handle larger-scale cooperation and spin-off creation, for example NICHe and Hatchery Square. The system at Tohoku University promotes the establishment on direct contact between researcher and companies, facilitated by the university-linked functions. The TLO often uses the researcher's network in order to find business opportunities and in the NICHe-managed projects, companies can dispatch researchers to work in the university setting. There does not seem to be any limit put on by the university preventing cooperation, but issues regarding contracts and possible conflicts of interest should be handled in a more formal way, according to the official University policy.

The creation of the intra-university institute TUBERO, merging engineering and medicine into a new organization, was mentioned as a future opportunity for cooperation with industry.

Motives for Researchers to Get Involved in Commercialization

Despite the measures and infrastructures put in place for interaction with commercial actors, at present there seems not to be a huge interest from medical scientists at Tohoku University to enter into activities relating to commercialization of their research. This situation was mentioned in several interviews ("Tohoku is not an entrepreneurial region").

A project leader for a cooperation project at NICHe we interviewed explained the contact points for the interaction. In this case, his research draws the attention from commercial actors who contacted him for cooperation. NICHe helped set up the contract and get funding. The research, focusing on using imaging technologies to understand how the brain is affected in dementia and to use this knowledge to develop training methods, was performed at NICHe separately from his ordinary research activities at the medical faculty. The motivation for this researcher to enter the cooperation was mostly personal – "to pay back society" – and he was not interested in starting his own company. In addition, the cooperation may help him to get other funding for his research.

According to the NICHe representative, the main motives for the university's researchers to cooperate with industry are: the opportunity to demonstrate the added value of employing research in society and the opportunity to realize financial benefits from licenses or spin-off companies.

Major challenges experienced by actors involved in commercialization processes

For Tohoku University, the challenges seem more in line with what you may see elsewhere in Japan. The main challenges mentioned by university staff (TURIP) were:

- Lack of cooperation between faculties and departments makes it difficult to show what Tohoku U. has to offer to the companies.
- Difficulty motivating scientists to collaborate with industry.

From the University's side, measures to overcome this are:

- Tohoku Techno Arch assumes some coordination role within the university and with other regional universities.
- A special fund to support younger University researchers was set up in April, for stimulating University-industry cooperation.

One problem mentioned is that the TLO has problems generating enough income to be financially self-sustained. They still need public financial support to some extent.

Marketing of inventions and research to larger pharmaceutical companies, which are located in Tokyo or Osaka, were seen as problematic by TTA. A former pharmaceutical company manager is now marketing directly to these companies.

As a region in the less industrialized parts of Japan, Sendai faces some real challenges. The VC situation was seen as a problem, since most actors are located in Tokyo. A local venture incubation fund (Tohoku Incubation Fund) has been started and the manager, having a large network among investors in Tokyo, invited larger VC companies to co-invest in new companies. Thanks to this more active approach, the VC situation has improved in recent years. Also, spin-off "showcase" events run by the Prefecture (Miyagi Business Market) is regularly held to attract investors to regional companies.

The Tohoku region is not known for entrepreneurship, so experienced entrepreneurs and managers with industry experience are still scarce. One measure by Tohoku University to tackle this problem is the establishment of graduate program in Management of Science and Technology (MOST)[48]. The MOST program, under the school of Engineering, is providing theoretical and practical training in subjects such as intellectual property, project management, risk assessment, strategic technology management, etc. Students come from industry, government, academic institutions and other organizations, where such knowledge is essential. Programs like this have been set up at other universities.

Peking University

For this study we have selected two universities which rank among the top in terms of academic excellence in China, Peking University (also sometimes referred to as Beida) and Fudan University in Shanghai. Both universities are among the top 100 universities who benefit from special government funding under the 211 Programme. The 211 Programme is aimed at promoting high-quality, higher-education institutions. Universities funded under the 211 Programme generally have the most prestige, the best students and the most government funding. Peking University incorporated the former Beijing Medical University in 2000, while Fudan University merged with the former Shanghai Second Medical University in 2001, resulting in the founding of the Shanghai Medical College Fudan University.

Beijing, the capital of China, has a population of approximately 15 million inhabitants, accounting for approximately one percent of the total population of China. It is one of the wealthiest regions, with the second highest GDP per capita. In 2003, there were 73 institutions of higher education in Beijing, corresponding to five percent of the total number of regular institutions of higher education in China. Beijing has one of the strongest concentrations of science and technology resources in China. Thus, it accounts for around 16 percent of total R&D expenditure and houses a cluster of renowned national research institutions which are increasingly becoming internationally recognized.[49] In 2003, 20 percent of all granted invention patents came from Beijing. Foreign pharmaceutical companies appear

[48] *http://www.most.tohoku.ac.jp/*

[49] Examples of such institutions located in Beijing are the Chinese Academy of Sciences (CAS), Chinese Academy of Medical Sciences, the Academy for Military Sciences, Chinese Academy for Agricultural Sciences, Peking University, Tsinghua University, Peking University for Traditional Chinese Medicine, Chinese University for Agriculture, and the Beijing Genomics Institute. A recent study of China's medical sector found 203 biology or medical research-related institutions in the Beijing area (AiF, 2004).

to prefer Shanghai or other cities or provinces to Beijing when it comes to establishing R&D facilities. One exception is Novo Nordisk, which has an R&D facility with 40–60 scientists in Zhongguan Village Life Science Park.

There are three science parks in the Beijing area which specialize in life sciences: Beijing Economic and Technical Development Zone, Beijing Biological Engineering and Pharmaceutical Industry Base, and Zhongguan Village Life Science Park.

While Beijing's life science sector benefits from significant and often unique assets in terms of being close to central government decision-making, a critical mass of important research institutions, and government funding, the life science industry in Beijing appears to be comparatively small. According to a recent report by the Beijing Pharma and Biotech Center, Beijing ranks eighth in the country in terms of both sales revenue and profit (Beijing Pharma and Biotech Center, 2005).

Peking University

Public university (founded 1898, originally named Imperial University of Peking)

Number of Students: 46,000; graduate students: 13,000; doctoral students: 4,000

Staff: 4,574 teachers, 2,691 of whom are full or associate professors

Funding: Approximately half from national and local public funding, the rest from profits from University-owned enterprises, donations and endowments (from foundations, individuals and companies), and student tuition.

Formerly a 'national key school', now a receiver of 211 Project Funding (government funding for top 100 universities in China)

College of Life Science with biology, biochemistry, ecology, and biotechnology departments.

Incorporation of Beijing Medical University in 2000. Peking University Health Science Center (PUHSC) offers courses in basic medical sciences, clinical medicine, preventive medicine, stomatology, pharmacy, nursing, medical laboratory diagnosis and biomedical English among others. PUHSC now has enrolment of 10,112 students, including 927 doctoral students, 1,036 master program students, 3,196 undergraduates, 696 junior college students, 3,994 adult learning program students, and 388 international students. PUHSC has 1 national key laboratory, ten ministry-level key laboratories, 23 joint research centers, and 20 research institutes at university level. PUHSC has 11 schools, one institute and one division. In addition, 15 hospitals in Beijing serve as teaching hospitals.

Main Actors: Bringing a Project from Discovery to Further Commercialization

Officially, the Patent and Prize Division of the Office of Scientific Research Administration and the Peking University Office of Technology Transfer and Licensing are important actors in the commercialization process.

The Connection Between Researchers and Commercial Actors

The Office of Scientific Research Administration and the Office of Technology Transfer and Licensing are the principal official intermediaries intended to connect researchers who make a discovery with potential commercial value with commercial actors.

Motives for Researchers to Get Involved in Commercialization Issues

In recent years, Beijing University has sought to increase the commercialization of academic research. In addition to officially encouraging researchers to patent, it is trying to make it more attractive for researchers to patent their ideas by offering them a share in the property rights of their inventions or discoveries. It is also working to increase the professional and status-related returns on patenting. Thus, the University is starting to move away from basing career advancement solely on the number of publications or research grants a researcher can produce or obtain, and towards recognizing patenting as a basis for academic recognition.

However, researchers pointed out that the ability to secure research grants, which bring considerable prestige but also personal wealth, is still strongly based on the publications record of an individual researchers. Since patenting a discovery often means delaying its publications by two years or more, research foundations' selection criteria can act as a powerful deterrent against commercialization.

The Beijing government offers limited financial assistance (150–2000 RMB) for people wishing to apply for a patent. This money is intended to cover the cost for a patent application or annual patent fee.

Major Challenges Experienced by Actors Involved in Commercialization Processes

Actors list a number of challenges to commercialization. The first is fear of idea theft and lack of faith in the system's ability to protect one's intellectual property rights. Thus, rather than seeing patents as a way of protecting their property rights, researchers see patenting as a threat. As one researcher said, *"Professor X didn't apply for a patent because he was afraid to be copied."* Another researcher with international commercial experience described the problem as the following: *"Before you buy my idea I need to tell you what I have, but once I tell you what I have, you don't need to buy it anymore."*

The fear of somebody stealing or counterfeiting one's invention is only partially explained by weaknesses in China's IPR enforcement. A related obstacle appears to be a fundamental lack of trust between partners.

The second challenge identified by experts relates to financing the commercialization of life science research. There is a clear lack of intelligent capital. Additionally, according to the experts interviewed, neither researchers nor business people seem to have the long-term investment or planning horizons that are required in the development of new drugs.

Fudan University

Shanghai's citizens are, on average, the wealthiest in China with the highest Gross Regional Product per capita. It is also one of the top centers of science and technology in China, although it has less science and technology resources than Beijing. While its population is slightly larger than that of Beijing, with 17 million inhabitants, it has less officially recognized institutions of higher education: 56 compared to 73 in Beijing. It accounted for approximately eight percent of China's total invention patents, compared with close to 20 percent for Beijing, and eight percent of total R&D expenditure. Similar to Beijing, Shanghai is home to a large number of nationally, and increasingly internationally, renowned research institutions. Foreign pharmaceutical companies appear to prefer Shanghai or other cities or provinces to Beijing when it comes to establishing R&D facilities.

Shanghai's biotechnology industry is larger than Beijing both in terms of turnover and profits (Beijing Pharma and Biotech Center, 2005). Shanghai's Zhangjiang High-Tech Park in Pudong is the base for a number of national research centers and houses a growing number of national and international pharmaceutical companies.

In addition to Zhangjiang High-Tech Park, research institutions and a number of international and domestic pharmaceutical companies, some important actors in the commercialization process in the Shanghai area are the Science and Technology Commissions of Shanghai Municipality and of Shanghai Pudong New Area, and the Fund of Biotechnology and Pharmaceutical Industry of Shanghai Municipality.

Fudan University

Public university (established 1905)

Number of students: 36,000; doctoral students: 3,500

Staff: 2,400 full-time teachers and researchers, including 1,350 professors or associate professors

Funded by a combination of national and local public funding, donations and endowments (from foundations, individuals and companies), tuition and other income.

Receiver of 211 Project funding (government funding for top 100 universities in China)

College of Life Science with biology, biochemistry, ecology, and biotechnology departments

Also, Fudan University has eight teaching hospitals, such as Zhongshan Hospital and Huashan Hospital, integrating medical service, medicine education and research with 900 staff. The original Fudan University and Shanghai Medical University united to become a more comprehensive university. Thus Shanghai Medical College Fudan University was founded on July 27, 2001.

There are three so-called Fudan industrialization funds aimed at enabling commercialization of the University's research in the fields of biotechnology, Fudan-Jia Hua Venture Capital, Fudan-Zhangjiang Venture Capital, and the New Material Fund. In addition Fudan University has established "Shanghai Fudan Side Venture Capital Company Ltd."

Main Actors: Bringing a Project from Discovery to Further Commercialization

Fudan University has developed an interesting concept whereby it will continuously screen and evaluate research projects going on in the various departments to find projects it considers to have commercialization potential. The University will then invest between 500,000 RMB and one million RMB in those that it deems to have the most commercialization perspective. In this way, Fudan University seeks to support projects in the very beginning to let an idea grow up to a project.

The second step is to attract venture capital and develop the technology together with investors instead of selling the technology. Fudan usually takes a share of 10–20 percent (with 10percent for use the name of Fudan). When the project is fully commercialized, Fudan will consider selling its share and use the money to incubate more projects. The concept is considered to have been a success at Fudan, and is increasingly being copied in a number of other universities.

The Connection Between Researchers and Commercial Actors

The more well-known professors and/or those carrying out research of interest to industry tend to be approached by companies directly. They have good connections with industry and discuss cooperation directly – that is, without necessarily using intermediaries.

In recent years, a trend witnessed at Fudan, as well as some other universities with research strength in life sciences, is for companies to co-finance laboratories within the university. Thus, large companies, both domestic and international, may donate money to or finance equipment in university labs. In return, in addition to getting visibility – an increasing number of university laboratories will display the logos of the companies that are sponsoring them – companies will be informed first of any interesting research that might come out of these so-called co-labs. Thus, companies provide non-earmarked funding in return for getting a 'first shot' at new discoveries.

Motives for Researchers to Get Involved in Commercialization

This is similar to Beijing University, although Fudan University is considered to have a stronger commercial focus than Beijing University.

Major Challenges Experienced by Actors Involved in Commercialization Processes

One challenge identified by experts was organizational structures within universities that hinder effective drug development and commercialization. Different departments are responsible for different aspects of the drug development process (e.g. department of chemistry and medicine department). The problem is the lack of coordination between departments, and the lack of an overall commitment to the process that transcends departmental boundaries and politics.

Challenges and efforts

Table 4 Major Challenges Experienced by Actors Involved in Commercialization Processes

	Regional level	University management	Specific for TT office	Specific for researchers
USA[50]	- Lack of seed-finance - Lack of local large-fund capital => spin-offs move to where bigger investers are located - Lack of CEOs	-Informational and cultural barriers between university and industry	-Insufficient resources in TT offices	- Poor reward system for faculty who engage in the process
Japan	-Lack of CEOs -Lack of seed finance -Lack of space (in the big cities) -Insufficient interest from domestic pharmaceutical companies -Low entrepreneurial thinking in society	- Informational and cultural barriers between university and industry - Insufficient collaboration between industry and university -No overall mapping of research to showcase	-Insufficient resources in TT offices	- Poor reward system for faculty who engage in the process -Inexperienced internal TT officers
China	-Lack of intelligent venture capital -Lack of domestic pharmaceutical companies -Underdeveloped financial system - Poor IPR enforcement	- Informational and cultural barriers between university and industry -Lack of patent awareness amongst faculty - Insufficient collaboration between industry and university	-Insufficient resources in TT offices	- Poor reward system for faculty who engage in the process -Do not see the use of TT office -Lack of trust hampers interaction with industry

[50] *Source: interviews and Siegel and Phan, 2005.*

Table 5 Examples of Efforts That Have Been Implemented to Overcome Challenges of Commercialization of Research

	National level	Regional level	University level
USA	- Support research - Tax policies - Funding programs (e g SBIR, STTR) - Collaboration programs	- Support research - Improve TT through intermediary actors - Create in-state VC funds - Create science parks - Attract large VC funds to locate in State - Attract CEOs and top researchers (quality of life)	- Get private market to invest in seed-funds (proof-of-concept) through the TT office, use of alumni - Create offices of economic development (including entrepreneurship) - Encourage faculty to disclose more to TT offices (one tool is dual appointments) - Create boards where deans are represented along with commercial actors and TT officers
Japan	- New legislation regarding ownership of IP - Cluster programs - Collaboration programs - TT programs - IP center programs	- Create VC funds - Create science parks - Market the region - Increase collaboration with industry	- Adopt national initiatives - Participate in cluster programs - Direct and indirect marketing
China	-Promotion of technology-based SMEs -High-tech development zones -Research funding (863-program)	– Patent grants to researchers - Create VC funds - Create science parks - Attract CEOs and top researchers (overseas Chinese)	- Changing of reward system for faculty (both academic and commercial) -Creation of TT offices - Attract top researchers (overseas Chinese)

Statistics on R&D

To put the discussion into perspective, we provide some statistical comparisons between the US, Japan, China and Sweden in the following section. The statistics are from the OECD statistics Science and Technology Indicators (OLIS database) which was last updated in May 2005. This database, published twice a year, provides a set of indicators that reflect the level and structure of the efforts undertaken by OECD Member countries and nine non-member economies in the field of Science and Technology as available from 1981 onward. It includes final or provisional results as well as forecasts established by government authorities.

Overall Research Expenditure

Figure 4

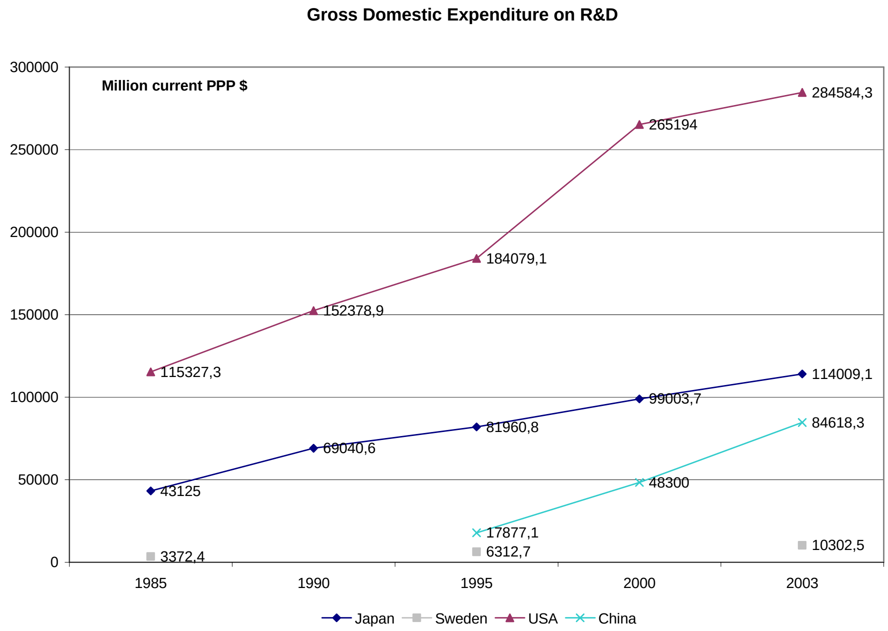


Figure 5

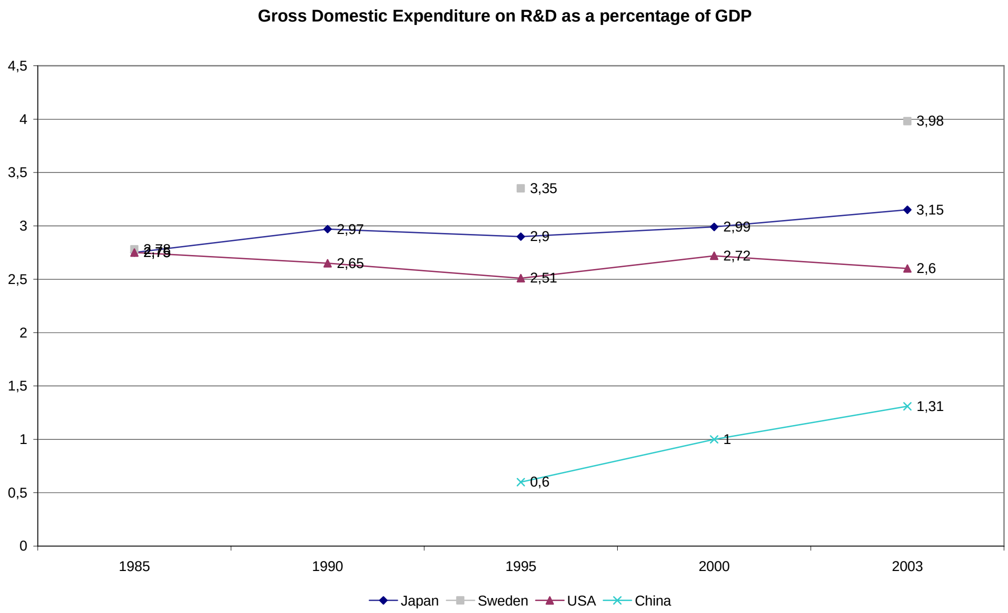


Figure 6

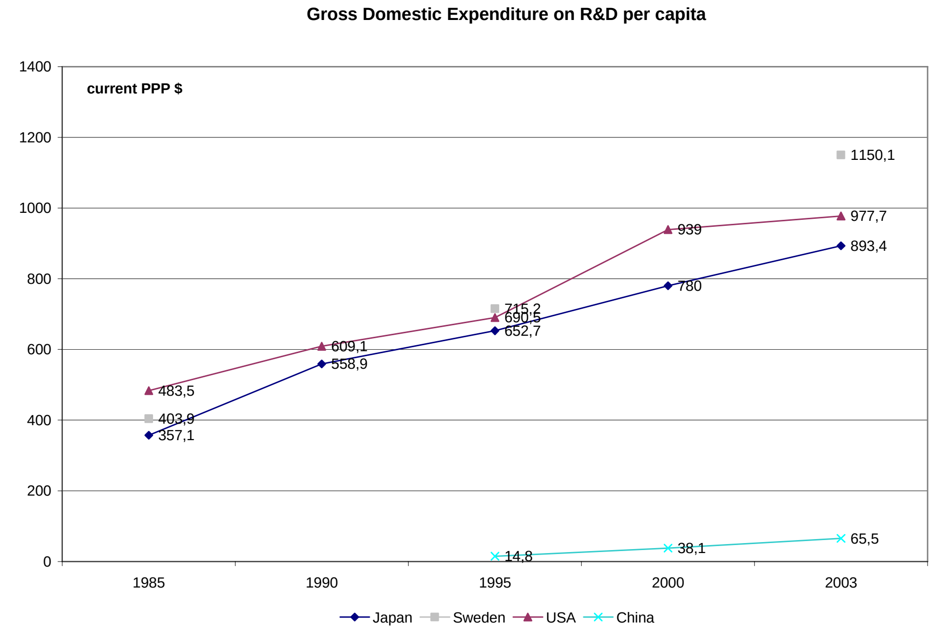
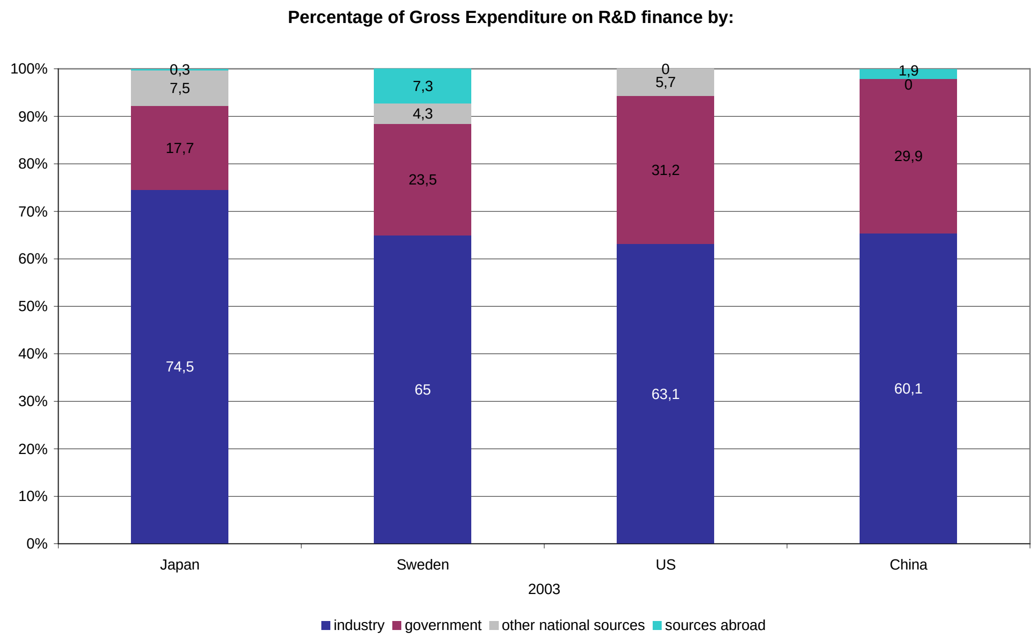


Figure 7



Research performers

Figure 8

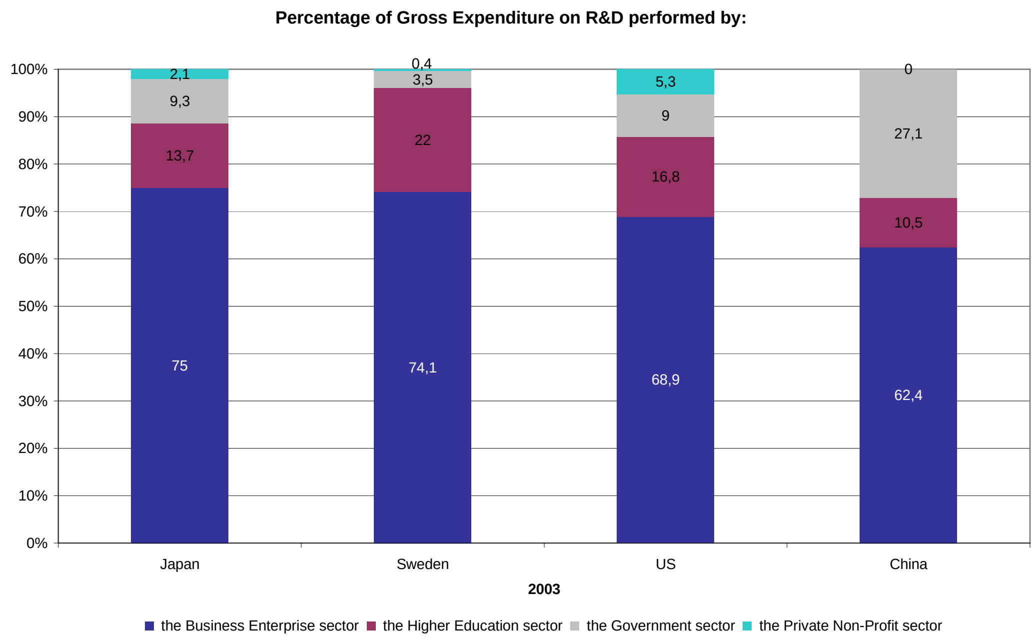
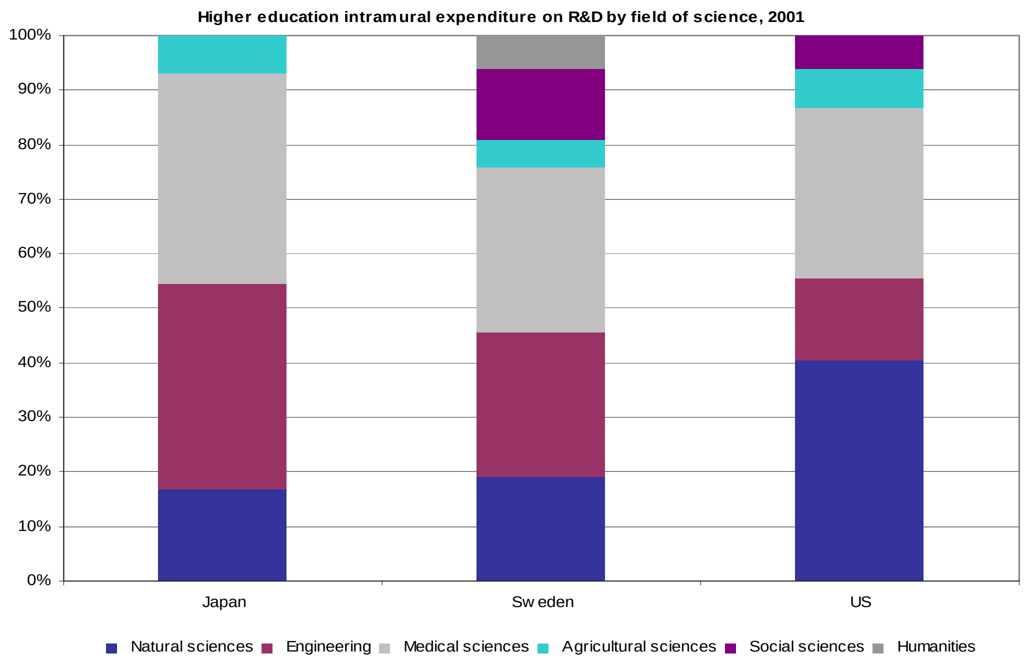


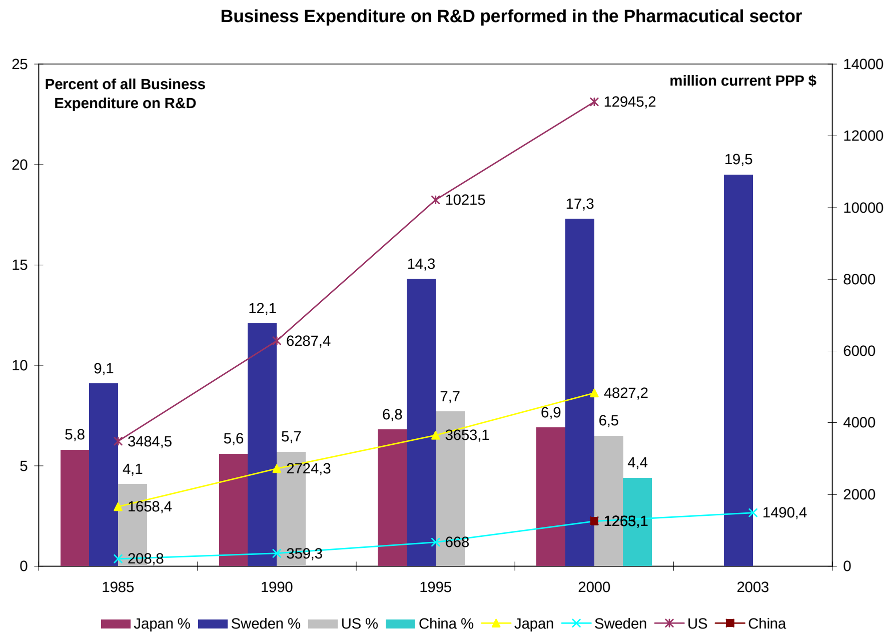
Figure 9



The chart above reflects how the different countries prioritized different science fields in 2001. However, the data for expenditure on humanities and social sciences is not available for Japan, and the data for expenditure on humanities is not available for the USA in this OECD comparison, so the picture is incomplete.

Business Research in the Pharmaceutical Sector

Figure 10



ITPS, Swedish Institute for Growth Policy Studies
Studentplan 3, 831 40 Östersund, Sweden
Telephone: +46 (0)63 16 66 00
Fax: +46 (0)63 16 66 01
info@itps.se
www.itps.se
ISSN 1652-0483

SWEDISH INSTITUTE FOR GROWTH POLICY STUDIES