Innovation Cooperation – HOW?
CONTENT

1. INTRODUCTION ............................................................................................................. 3

   1.1 Why look at How ........................................................................................................ 3

   1.2 A mapping of Denmark’s and China’s innovation systems reveals areas for... 3

2. Denmark’s innovation system ..................................................................................... 6

   2.1 Denmark is a leading research nation ................................................................. 6

   2.2 R&D means improved productivity and competitiveness .................................. 6

   2.3 Yes, Denmark is innovative .................................................................................. 10

3. China’s innovation system .......................................................................................... 12

   3.1 China as a science nation ..................................................................................... 12

   3.2 Yes, China is innovating ...................................................................................... 13

   3.3 China’s business development attitude is very much ‘just-try-it’ ....................... 15

   3.4 Indigenous innovation ......................................................................................... 16

   3.5 Innovation in China can follow several models, propelled by different needs 18

   3.6 An open approach to innovation ......................................................................... 20

4. The way forward – how to cooperate? ..................................................................... 20

   4.1 How to cooperate on innovation – some final remarks ....................................... 24

5. Conclusion ................................................................................................................... 24
1. INTRODUCTION

Definition for the sake of this report:

**Innovation is the translation of ideas and knowledge into products and processes with societal and commercial value.**

This requires interaction and transfer of knowledge throughout the generic value chain—from basic research to commercialization.

1.1 WHY LOOK AT HOW

China is well under its way to become the largest economy in the world, also overtaking the US\(^1\). Therefore Denmark should take a sincere interest in how it could work more with China, e.g. to create growth and improve its development; within productivity, research and innovation. China is Denmark’s second largest export market outside EU (after the US) and as such increasingly important to the Danish economy. Moreover, China as well as Denmark is a country with few resources\(^2\) and the countries e.g. have in common that research and education are pillars of a sound and solid country of the future. Therefore, it should be expected that areas of mutual interest could inspire to additional cooperation. Moreover, such areas for additional innovation cooperation could pinpoint a direction for where it would be optimal to spend Danish resources for future growth.

It should be noted that this report relates to China and Denmark at an overall level. Especially within China there are differences and variations over quality and ranking on e.g. the universities; whereas some are just established, others have world class divisions and professors within specific fields of research. Especially in Beijing and Shanghai excellent research is taking place, and within some research fields the so-called Tier Two cities start to develop stronger competencies, as a result of China’s policy to upgrade research institutions.

1.2 A MAPPING OF DENMARK’S AND CHINA’S INNOVATION SYSTEMS REVEALS AREAS FOR IMPROVED COOPERATION

In order to identify areas for beneficial innovation cooperation between Denmark and China, as a way for future Danish growth, Innovation Centre Denmark, Shanghai (ICDK) set out to perform a mapping of the innovation systems and value chains in the respective countries of Denmark and China, incl. their strengths and weaknesses. After having mapped the individual innovation systems – from basic research to commercialisation – the two countries’ systems are compared. The outcome is an overview of where the countries could obtain synergies from working closer together.

---

\(^1\) IMF: World Economic Outlook, October 2014. China incl. Hong Kong.

\(^2\) Meaning natural resources
The analysis is to be found in Appendix I in this report. It discusses the way innovation is created, the players involved, and how they are influenced. For the sake of this report, the innovation is only ‘complete’ if we see it developed all the way to the commercialisation stage; so the focus is on how to create outstanding research, put the research to work, secure knowledge transfer, and finally commercialisation including entrepreneurship.

The mappings’ point of departure is a framework that follows the innovation in three phases; from basic research, over applied research & development, to commercialisation.

Within each phase a number of primary players act. In basic research it is e.g. frontier research that is the main activity, performed by the universities and other research institutions, and in some cases private companies. The work is of more experimental or theoretic character with the objective to create new knowledge. Applied R&D is a systematic work to resolve challenges; issues owned by researchers, government, or companies. In this phase the actors are both research institutions and companies. In the third phase the activities evolve around bringing life to the R&D; how to create processes, products, and technologies which can improve productivity and/or competitiveness. In this phase the actors are companies, state owned enterprises, hospitals, networks, clusters, etc.

The activities and players within each phase are influenced – directly and indirectly - by secondary actors. The actors affect the behaviour of the above mentioned primary actors, setting objectives, directing policies, etc. The main secondary actors are governments and institutions, tax systems, culture, funding, customer demands/markets, etc.

Appendix I discusses both quantitatively and qualitatively the three phases, the primary and secondary actors and their activities, how they influence each other in a dynamic way, as well as the strengths and weaknesses within both Denmark and China. The conclusion can be summarized as per the below table.

<table>
<thead>
<tr>
<th>Basic research</th>
<th>Applied R&amp;D</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary actors</strong></td>
<td>+ Denmark (overall, esp. social sciences)</td>
<td>+ China (ICT)</td>
</tr>
<tr>
<td></td>
<td>+ China (natural and technical sciences)</td>
<td>+ Denmark (life sciences, energy and environment)</td>
</tr>
<tr>
<td><strong>Secondary actors</strong></td>
<td>+ Denmark</td>
<td>+ China</td>
</tr>
<tr>
<td><strong>Institutions</strong></td>
<td>+ Denmark</td>
<td>+ Denmark</td>
</tr>
<tr>
<td><strong>Input factors</strong></td>
<td>+ Denmark</td>
<td>+ Denmark</td>
</tr>
<tr>
<td><strong>Knowledge transfers</strong></td>
<td>+ Denmark</td>
<td>+ Both</td>
</tr>
</tbody>
</table>
Output factors

+ Denmark: research  + Denmark (quality)  + China: exports
+ China: graduates  + China (quantity)  + Otherwise mixed

Illustration: summarizing findings from analysis of Denmark’s and China’s innovation systems, and comparing them. Source: Appendix I

The overall findings are - at a generalising level - that Denmark is excellent within basic research, both Denmark and China do well in applied R&D, and China is strongest when it comes to commercialisation.

From the detailed analysis nuances and data can be studied, and some of the findings as well as both input and output factors are discussed below.

The analysis has made us suggest potential areas for cooperation. Some of these areas have an institutional essence, whereas others have more of a commercial character. It is the latter that we have concentrated on in the majority of this report, but a list of question/ issues have been listed, which could serve as inspiration to areas for cooperation; e.g., input and training on IPR, high research integrity, clusters and networks, etc.

One area that could be improved in both countries is ‘knowledge transfer’, as both Denmark and China rank relatively low. The reasons behind this low ranking, however, is likely different in the two countries. It would be interesting to investigate if a certain portion of the knowledge and related patterns stay within universities, and whether it could come to work e.g. in China after it has been utilized for its ‘original purpose’ in Denmark.

China has a need for good research, and could very well be willing to pay for good intellectual property (IP). A knowledge transfer bank or initiative could therefore be looked into. Also, it could spear Danish growth if Danish entrepreneurs and researchers followed the IP to China, as part of an agreement; whether a joint venture or another constellation.

For immediate actions ICDK has reached out to some of the best incubators and science parks in China, to strengthen our relationships and pave the way for incubator agreements and cooperation.

In this way, Danish technology and entrepreneurs can get plugged in to the Chinese market, networks, and other important parts of the commercialisation efforts and eco-system; also as a ‘soft landing’.

One area that could be improved in both countries is ‘knowledge transfer’, as both Denmark and China rank relatively low.

In the following chapters we comment on the two countries innovation systems and provide a more detailed discussion of the two systems status.
2. DENMARK’S INNOVATION SYSTEM

Denmark’s market share of top research is increasing and the quality is good

As global competition increases, growth is low and societal challenges mounting, the need for excellent research and innovation is obvious. There are many tasks to take on, e.g. within the environment, lack of sustainable resources, aging population and diseases. Some of the challenges are global, others have more of a national character. But common for them all is that Denmark is best positioned to take on the challenges and turn them into commercial opportunities if it has the very best of research and knowledge, and best possibly turn this into solutions - which also could spiral growth.

2.1 DENMARK IS A LEADING RESEARCH NATION

Danish research does well, also on an international scale. In the period 2008-2012 Danish researchers published 60,000 scientific articles which in relation to the Danish population is only topped by Switzerland and Iceland. Moreover, Danish researchers are among the most quoted worldwide; Denmark is ranked as number three when looking at the number of quotes per publication, and this is a positive trend that has increased over the past years. Put differently Denmark’s market share of top research is increasing and the quality is good.

One of the factors often mentioned as vital for excellent research is the close cooperation between companies and research institutions. This is also a factor that works well in Denmark; see e.g. Appendix 1 p. 8, for a discussion on the so-called Triple Helix model, where three parts - universities, companies and government - cooperate.

2.2 R&D MEANS IMPROVED PRODUCTIVITY AN COMPETITIVENESS

The companies have taken on a larger share of the R&D investments, they have hired more highly educated staff and the number of innovative companies has increased.

Research and Development (R&D) is a good investment for companies. An analysis indicates that the return of R&D investments is around an average of 34%

---

3 Research and Innovation Indicators, uf.m.dk
4 Thomson Reuters: InCites database, as per UFM’s Forsknings- og innovationspolitisk redegørelse, October 2014
5 Note: ‘Innovative Companies’ is defined as a company that as a minimum has implemented – or tried to implement – new products, processes, marketing methods and/or organisational structures within the past three years.
6 Forsknings- og innovationspolitisk redegørelse, Danmarks Statistik
an average of 34%\(^7\). Moreover, companies that perform R&D and cooperate with research institutions have a higher productivity\(^8\). It is also believed that such cooperation improves the quality of the research\(^9\). This speaks in favour of research to improve a company’s competitive edge and hence a country’s performance.

There are different types of ‘research’ and some seem more effective when looking at the effects. According to a study in Denmark\(^10\) e.g. a company's own R&D investments, as well as cooperation via innovation consortia and networks, and cooperation with research institutions prove rewarding.

*International cooperation increases the quality of research.* Both when it comes to researchers’ cooperation with other researchers, as well as companies’ cooperation with foreign companies and research institutions\(^11\). Though it already seems good, the quality of the work initiated at Danish research institutions and companies could improve even further if more cooperation was done.

The number of scientists and publications increase on a global scale as more countries do more research. At the same time, digitalisation has eased exchange and sharing of information. Adding up, this opens up for new potential cooperation opportunities. It does, however, also mean challenges in prioritising and verifying information, and assessing the quality of the data.

---

**R&D in Denmark**

The private companies’ role within R&D has increased considerably

- Public R&D investments have grown from 0.75% of GDP in 1997 to 1.11% of GDP in 2014
- Private R&D investments have increased from 1.18% of GDP in 1997 to 2.03% of GDP in 2012
- In 2012 there were around 25,000 privately employed researchers, and around 16,000 publically employed researchers

*Source: Forsknings- og innovationspolitisk redegørelse, Danmarks Statistik*

---

\(^7\) UFM: Economic Impacts of Business Investments in R&D in the Nordic Countries – A microeconomic Analysis

\(^8\) Ministry of Science and Higher Education, UFM, 2010: Produktivitetseffekter af erhvervslivets forskning, udvikling og innovation, and (2011) Økonomiske effekter af erhvervslivets forskningssamarbejde med offentlige vidensinstitutioner

\(^9\) NordForsk 2014, Comparing Research at Nordic Universities using Biometric Indicators, as per UFM’s Forsknings- og innovationspolitisk redegørelse, October 2014

\(^10\) Central Innovationsmanual for Excellente Økonometriske Effektmålinger (CIM) af innovationspolitikken, Forsknings- og Innovationsstyrelsen, 2011, as per ‘Offentlig forskning, - effekter på innovation og økonomisk vækst, Danish Ministry of Science and Higher Education, June 2012, p.47

\(^11\) NordForsk (2014) Comparing Research at Nordic Universities using Biometric Indicators

Forsknings- og innovationspolitisk redegørelse, Okt 2014 and www.ufm.dk: Forsknings- og innovationspolitisk redegørelse, Okt 2014
Looking at the Danish research strongholds in terms of research areas where Denmark enjoys significant international impact already and comparing those to the societal needs of China following areas are noticeable:

- Medicine, General & Internal
- Biodiversity Conservation
- Construction & Building Technology

This does of course not exclude cooperation in many other areas, but from a growth and socio economic point of view the above three areas make good sense for the sake of cooperation, and these are three out of the top four areas measuring Danish research impact on an OECD scale. Moreover, these areas are also in line with the areas that the Danish missions in China work within already; e.g. the Innovation Centre Denmark in Shanghai have consultants working with special knowledge in these areas. The objective of the Innovation Centre Denmark is to bridge the Danish-Chinese interests and e.g. facilitate (Danish) growth based on research and technologies.

Data points in the same direction; yes, Denmark is an innovative nation. The question in focus should probably rather be; does Denmark gain sufficient economic growth based on this capability? Does it create jobs, develop companies, win market shares and generate sufficient revenues?

Danish innovation has long been known world-wide. LEGO, Bang & Olufsen and other companies with proud traditions have proven innovative from the outset, and companies such as Coloplast and Novo Nordisk have long had focus on constant innovation as part of their development. In general terms, Danes believe they are ‘creative’ and when comparing themselves to new growth economies such as China it is one of the qualities often mentioned as a force. Compared to the Chinese system it is believed that the Danish schooling system foster questioning, challenging of the norm, and abstraction, - and hence also creativity.

The number of innovative companies in Denmark has increased. Denmark is ranked as number ten within the OECD measured on the share of innovative companies. But is this sufficient? Denmark’s rankings within research are much stronger – so some-

---

12 Offentlig forskning – effekter på innovation og økonomisk vækst, Ministeriet for Forskning, Innovation og Videregående uddannelser, Juni 2012, p35, e.g. based on Thomson Reumert

13 EU Scoreboard
where it seems Denmark misses out on turning the excellent science into new sustainable companies.

A part of the explanation could be found in the fact that it is primarily the large companies that benefit the most from their R&D investments, as seen from below.

<table>
<thead>
<tr>
<th>Company Size</th>
<th>Business R&amp;D investments as % of total R&amp;D (2010)</th>
<th>Marginal rate of return of business R&amp;D investments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-49 employees</td>
<td>16.6%</td>
<td>12.4%</td>
</tr>
<tr>
<td>50-99 employees</td>
<td>5.5%</td>
<td>15.0%</td>
</tr>
<tr>
<td>100-250 employees</td>
<td>5.8%</td>
<td>37.4%</td>
</tr>
<tr>
<td>&gt; 250 employees</td>
<td>72.1%</td>
<td>63.7%</td>
</tr>
</tbody>
</table>

Source: Analysis of the Danish research and innovation system, a compendium of excellent systemic and econometric impact assessments, Ministry of higher Education and Science

In total, the rate of return on the R&D investments in the companies is 34.2%
It could be suggested that the companies do not hold up the R&D investment level when they go into a growth phase with additional employees, and that it is only as a start-up company or a larger mature company the R&D takes centre stage.

The reasons could be many; e.g. that the companies with 50-250 employees primarily are focused on growing their business based on existing products and processes. While there could be many excellent reasons for this, it could also be a sign that a stopped innovation process can halt a company’s development. The companies that do hold up the R&D steam clearly benefit from it.

One way to keep innovating could be by being exposed to new customer segments, needs and partners – again, something that could be obtained via an international outlook.

It is interesting to see the diversity across industries; e.g. do R&D investments into Green Technologies yield a return on 33.5% whereas Welfare Technologies return 20.7%. Looking at R&D investments per industries reveals the following:

<table>
<thead>
<tr>
<th>Ranking (year 2010)</th>
<th>R&amp;D in % of total business investments (R&amp;D investments in DK anno 2010)</th>
<th>Top industries with largest share of innovative companies in DK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pharmaceuticals – 20%</td>
<td>Electronics – 75.4%</td>
</tr>
<tr>
<td>2</td>
<td>IT &amp; info services – 13%</td>
<td>Pharmaceuticals – 70.5%</td>
</tr>
<tr>
<td>3</td>
<td>Mechanical Engineering – 13%</td>
<td>Manufacturing of electrical equipment – 69.2%</td>
</tr>
</tbody>
</table>

Source: Analysis of the Danish research and innovation system, a compendium of excellent systemic and econometric impact assessments, Ministry of higher Education and Science
The pharmaceutical industry represents 1/5 of all R&D investments in Denmark and 70.5% of the pharma companies are innovative.

Interestingly ‘Water and Waste’ only holds a 9th place with a share of 51.6% innovative companies. So even though Denmark is proud to have an image as a green nation there could be room for more innovative companies in the industry, it seems. Electronics on the other hand, could be feared dominated by development e.g. in Asia but it seems the Danish companies still keep innovating in this space.

2.3 YES, DENMARK IS INNOVATIVE

The overall ability to be innovative in Denmark off-hand seems sufficient; Denmark ranks top in EU on its scoring of innovation capabilities when looking at turning knowledge and ideas into products and processes\textsuperscript{14}. So how could it improve?

Part of the answer might be in improving the success rate of the new products and/ or companies that are established as results of the research and innovation. Seen from a Danish / Chinese point of view a more considerate Danish interest for the Chinese market could be wished; also from the younger companies and products. It is correct that the Chinese market can seem intimidating and that a founder or product manager might hum ‘if I can make it there I’ll make it...’ and hence rather go for other markets; but a large part of the world’s growth is indisputably in China. And imagine if the entry to China becomes a success...

Denmark does not lack entrepreneurs, actually it ranks well when looking at how many new companies are established compared to the total number of companies. In 2010, Denmark ranked higher than e.g. the UK, the US, Germany and Sweden\textsuperscript{15} – but an insufficient number of the start-up companies keep a high growth rate. In Denmark (in 2009) only three of the 100 largest companies were less than 30 years old – in California 39 out of 100 companies are less than 30 years old\textsuperscript{16}.

\textsuperscript{14} EU’s Innovation Scoreboard
\textsuperscript{15} Produktivitetskommisionen 2013C based on Eurostat and US Census Bureau, as per Innovation Foundation’s publication
\textsuperscript{16} Innovationsfondens Danmarks Vækstfudfordring; Erhvervs- og Byggestyrelsen
As most of the world Denmark was hit by the financial crisis in 2008. Unfortunately, it has not since regained speed of its growth, compared to several other countries. E.g. has Sweden, Germany and the US improved their growth rates better than DK in the aftermath of the crisis. Denmark is not on the same level of BNP growth as before the crisis. It is, however, not only the crisis that is a factor it seems; the Danish productivity growth has been relatively low since mid-1990’s, seen in relation to other comparable countries.

This is a challenge. If Denmark is to keep up its economic growth it needs to either improve products and processes and productivity via innovation, and/or create more jobs. Denmark improved its productivity during 1980’s and almost caught up with US productivity figures in the mid-1990s. But it seems that since then insufficient progress has been made. New technologies are needed to improve the processes.

It seems that the industries that compete on an international playing field have the best productivity rates; when having to compete, one needs to develop. So one of the ways to develop productivity and hence create growth would – not surprisingly - be by enhancing the number of jobs in the internationally competing segments.

The Danish productivity growth has been relatively low since mid-1990’s, seen in relation to other comparable countries.

So Denmark has excellent research, a good ability to innovate, but insufficient productivity, and (hence?) insufficient growth rates. One way that this could be addressed could be to grow the great ideas into longer lasting and larger companies, and by constantly innovating.

To help with the latter Innovation Centre Denmark, Shanghai has developed relationships with innovative hotspots in China. In general, ICDK’s work focuses around ICT, LifeScience and CleanTech. To support fresh ideas relationships have been established with leading science parks, universities and incubators. Services offered include Innovation Camps, Technology Scouting, and introduction to networks, matchmaking and input to Chinese business-models.

---

17 Innovation Foundation, Vækst og beskæftigelse gennem innovationsfonden, January 2015 s. 10

18 see also ICDK report ‘Know Who’ 2013

19 http://icdk.um.dk/en/whatweoffer/
3. CHINA’S INNOVATION SYSTEM

3.1 CHINA AS A SCIENCE NATION

China’s impressive double-digit growth rates and economic miracle were primarily based on government investments and productivity improvements. Other means are now necessary to keep up the growth. The future for a continuous growth for China is – now in the range of 7% p.a. - e.g. via education and research. The Chinese government is well underway to change the economy to one based partially on private consumption, and with a much higher rate of research and technology.

Since 1999 China’s investments into R&D have increased around 20% p.a. and in 2014 China invested 2% of its GDP in R&D. According to OECD that makes China the country in the world with the second highest R&D investments; only overtaken by the US. China’s R&D investments represent 17% of the world’s R&D investments. China’s has an objective of reaching a level of R&D investments of 2.5% by 2020.

China is ranked as number three on the list of countries with most quotations from researchers, and the Chinese researchers contribute with 14% of all scientific publications; a significant increase from the level of 2% which China had only ten years ago. The impact of the research is, however, still relatively low, as there are few citations per scientific publication. This would hint to a relatively low quality.

China has a declared political ambition to be an innovative society by 2020, with much of the innovation taking place within the companies. Almost 75% of the R&D investments are already carried out by the companies. With a proven ability to mobilise resources and implement strategic decisions there is little doubt that China will reach its objective. The challenge that China is facing, however, seems somewhat different from the one in Denmark: basic research deserves more attention. The universities have been favouring more application oriented research (rather the development ‘D’, than the research ‘R’) and so have the companies. It is therefore expected that future investments will focus on the basic research and new technologies. This is also found in the Appendix I analysis (p35). China has a basic research expenditure of 0.09% of its GDP – Denmark’s comparing figure is 0.54%.

Selected technology areas receive special attention, and so do seven strategically appointed industries; biotechnology, new energy, high-end equipment manufacturing, energy conservation & environmental protection, clean energy vehicles, new materials and new generation IT.
3.2 YES, CHINA IS INNOVATING

The Innovation Centre Denmark in Shanghai is often asked about China’s ability to innovate.

If it can be accepted that innovation is ‘a fresh thinking to create value’ then innovation is embraced in a broad sense; one that also very much qualifies China as innovative.

Chinese are innovative. Sometimes arguments are heard against this, almost as if innovation was not a part of the Chinese gene pool. This is of course nonsense; e.g. were around 10% of the people living and working in Silicon Valley of Chinese descent in 2002\(^{20}\). One of the problems is that the Western world does not always get to see and experience Chinese innovation. As Yu Zhou, professor at the faculty for Asian Studies at Vassar College says: “The problem is that the Chinese internet world is not the same as the American internet world (...). Unless you live there, you don’t know what’s going on. It’s like you’re eating American food and you go to China and can’t find it, you say, ‘well, there’s no good food here’\(^{21}\) China as a country has, on the other hand, with its regulated system and firmly structured education not encouraged creative thinking and challenging the norm over several generations.

A career as an entrepreneur has not been favoured until recently; it is only with the latest success stories such as Jack Ma with Alibaba and Ma Huateng with Tencent that entrepreneurs are getting more of a rock star status. Previously, the family planning policies have made family investments of six grownups—parents and grandparents—into one child’s career the normal pattern; expected return on such investments put pressure on the single children to be best in class, get access to top universities, and afterwards land solid well-paid jobs, - more than it encouraged and stimulated entrepreneurial dreams with high risks attached.

The start-up environment is only recently starting to blossom, and somewhat still at its infancy. But numerous private organisations, initiatives and events have emerged over the last few years, and a start-up eco-system is starting to take form. Whereas capital has not been the lacking resource in China the ‘smart money’ has not been in supply; the highly experienced venture capitalists (VCs) and entrepreneurs-gone-angel investors that are important to support the development of great ideas and technologies and that are well-known e.g. in the US, have not been present. But it is arriving. Many Chinese have returned from especially the US with excellent education, VC experience and the gist that comes from having tried and falling in love with the entrepreneurial scene and lifestyle.

So while the venture capital industry is still not comparable to e.g. the US it is certainly developing in a positive direction. In 2014 the total number of new funds raised in China was 258, amounting to $19.02 billion. This is a 29.6% increase from 2013 in number of

---

\(^{20}\) Keynote Speech by George Koo, “Chinese American Contribution to Silicon Valley” at 20th anniversary banquet of the Chinese American Forum

\(^{21}\) Cheung Kong Graduate School of Business article: Will China Overtake Silicon Valley?
new funds raised, and an impressive 147.9% in terms of amounts raised. The number of actual venture capital investments were 1,917, accumulating to a total investment amount of US$16.88 billion dollars. This is respectively a 67% and 155.8% increase year over year. These numbers clearly exemplify the growing venture capital in China\textsuperscript{22}.

And what has so far lacked in governmental and structural encouragement in China the government is attempting to make up for now; at least politically via programs. Innovation is ranking extremely high on the political agenda. E.g. President Xi stated in an article in Shanghai Daily\textsuperscript{23}, that ‘Innovation is the most driving force for development’, referring to a movement towards slower growth where higher profit margins are needed. Xi urged the government to take more active policies to attract innovative professionals from around the world.

The attention that innovation receives from the Chinese government at the moment is rooted in two causes: One is to make sure that China moves from being ‘only’ the production hall of cheap toys and other fairly low-priced goods to a nation where also R&D&I takes place. When the products are actually developed in China the share of the final price and product margin stays within China. China cannot count on a global demand for Chinese products to keep up the growth rate as the world’s economy looks today, and hence the current government’s policy is to spread the wealth internally so that more people can afford more spending, and hence help keep up the purchase power. For the Chinese government it is important that the purchases support China as much as possible; with China expanding its value chain into R&D and innovation more value is created within its own borders.

There is a need for improved technologies and technological development; also the ones that can support the commercialisation of the latest research.

As a result in 2014\textsuperscript{24} the Ministry of Science and Technology (MOST) and Ministry of Finance (MOF) published a strategy to accelerate the shift of the latest research achievements towards more downstream innovation activities. They e.g. set out goals for the Science and Technology (S&T) development plans, and put up a budget of ¥236,468 billion for R&D projects to refine the S&T resources and meet the needs of innovation. Included in these activities are the by now quite well-known program named TORCH which aims at further technology development with a strong focus on technology transfer\textsuperscript{25}.

The limited welfare society has if anything added to the entrepreneurial spirit: the American dream is also Chinese, and with the opportunities that capitalism has created in China individuals with close to zero income and little education self-inject to create businesses. This is whether owning a stand at a market or utilising e.g. the underlying explosion of internet penetration to try out new business models.

\textsuperscript{22} China VC/ PE Market Review 2014 by Zero2IPO Research Center

\textsuperscript{23} Shanghai Daily, 6 March 2015, "President Xi stresses the need for Innovation".

\textsuperscript{24} Ministry of Science and Technology (2014), China Science and Technology – Newsletter, no. 20

\textsuperscript{25} Torch is a Centre under MOST and is responsible for the establishment and management of Technology Transmission Centres. The centres refer to service organisations providing brokerage, technology integration and management, investment and financial services. The main function is hence to facilitate a knowledge flow and technology transfer (ICDK, Shanghai, 2013. \textit{From know-how to know who})
An example of such a business model is the Chinese start-up company Greenapple Health. Jennifer Xu, Chinese by origin and a Harvard MBA graduate, took advantage of the somewhat dysfunctional Chinese healthcare system; in China, there are no primary care doctors so patients flock to the state hospitals in major cities. With so many people to see, physicians can only offer a few minutes of their time to each patient. Moreover, while the Chinese doctors build up solid experience very quickly, they don’t make much money.

After seeing an Uber-like mobile app to summon cabs in Beijing, Xu got the idea to offer a mobile service that would allow patients to schedule follow-up visits with the physicians they only briefly see at the state hospitals. The service should also help doctors to build up a private practice. Xu’s startup, Greenapple Health, has raised several millions of dollars from investors.

So the movement from low-cost manufacturing towards e.g. internet companies is rapidly taking place, as clearly demonstrated by e-commerce giant Alibaba’s $23 billion IPO in September 2014, the largest ever debut on Wall Street. But lesser known to foreigners are perhaps JD.com and Tencent — whose revenues are both larger than those of Facebook, Yahoo and AOL. It could be argued tough, that China’s internet-based success, has been propelled by the government ban of e.g. Facebook, Google and Twitter; this shields home-grown companies from foreign competition, allowing Chinese firms primary or sole access to the country’s enormous market of Internet consumers — which currently is estimated at more than 650 million, and growing. By comparison, the US has about 280 million internet users.

3.3 CHINA’S BUSINESS DEVELOPMENT ATTITUDE IS VERY MUCH ‘JUST-TRY-IT’

Some of China’s large companies such as Haier, Tencent, Xiaomi and Alibaba have grown exponentially the past five to ten years. It is interesting to study their business development behaviour. They, as well as much smaller companies, seem to have that in common that they are happy to bring new versions of a product to market before it is 100% tested. Or rather; before it is at a level where a western company would find it thoroughly tested. By bringing a new product or model to market at a relatively earlier stage the customers’ instant feedback and reactions are taken into account and an updated version released.

Some Chinese companies believe this is the only way they can stay ahead of competition as the market, the customers and their needs move so quickly. In this way the companies stay agile, and can survive on quite small margins.

By following needs so closely the companies also become aware of new segments as they develop. Haier e.g. does this in a very clever way, which have let them to find sub-

segments such as university students living at campus’ with needs for small, cheap and colourful ovens for heating their meals.

As scale matters it should be expected that with a test bed of an increasingly growing massive Chinese market the international scene should be well aware that Chinese companies will become competitive on a global stage within long. Whereas the elite business world wrote and read about ‘lean start-up’ methods the past years it is obvious that exactly this ‘just try it’ spirit with instant customer feedback and quick adaption is what we witness in China in many business development departments. And instead of solely seeing this as increased competition Danish competencies and players should be part of the process and hence the upside. It challenges today’s models for R&D, operation, and company philosophies, but the strategic experiment seems important.

3.4 INDIGENOUS INNOVATION

The relatively heavy involvement of government in China’s economic programs is also obvious within innovation. This involvement is different from most other great economies, e.g. where government has decided on investments into areas where they per say want China to have their own solutions, primarily to protect own interests and make sure they would be operational at all times; initiatives such as e.g. the Chinese version of wifi – ‘wapi’ – came at a cost as it handicapped both operators trying to deploy it and consumers adapting it. An example that actually worked, however, is the high-speed trains. Though also hit by set-backs along its development an industry was built on the requirements for high-speed trains. A mix of two policies – encouraging technology transfer from multinationals (in return for market access) and a coordinated R&D-investment effort – has helped create a strong national industry.

On the research side China has created quite impressive results via its governmental policies, by ordering different regions and universities to take on development within specific technology areas. The number of patents and publications has increased, and whereas the number of patents alone is not a sole indicator for rise in quality it certainly indicates a strong trend.

China’s policy work on innovation is following the so-called Medium- to Long Term Plan for the Development of Science and Technology (MLP) from 2006.

Whereas a means to reaching objectives on improved research and technologies was opening up the country, the west could see the campaign as anti-foreign and regressive. China set out to increase its gross expenditure on R&D to 2.5% of GDP by 2020 from 1.3% in 2006, with a target of basic research reaching 15% of R&D spending by 2020.

---


28 Note: The MLP is a second act of Deng Xiaoping’s reforms and opening from 1978
But in his report, ‘China’s Drive for Indigenous Innovation: A Web of Industrial Policies’, senior counsellor of APCO Worldwide James McGregor states that the MLP ‘calls for ’establishing the nation’s credibility and image in international cooperation’ and ’to perfect the nation’s intellectual property rights system’. It also sets goals for expanded cooperation with foreign universities, research centres and corporate R&D centres. The plan does, however, also explicitly state that a key tool for China to obtain its own intellectual property is through tweaking foreign technology. Indeed, the MLP defines so-called indigenous innovation as ’enhancing original innovation as through co-innovation and re-innovation based on the assimilation of imported technologies’. So where the program opens for cooperation on research it also put China’s technology needs very much in focus, perhaps also on account of the inventor of the technologies.

Chinese indigenous innovation has a high level of hands-on micromanagement from the government, which demonstrates that the indigenous innovation program is a strategic economic priority. The objectives of its origin should be kept in mind, and it is therefore encouraged to seek partnerships and opportunities that create true synergies.

With its extraordinary reform and infrastructure plans and continental-sized consumer market that has just begun to really develop, China is a market no multinational should ignore. While the price of admission to the market could increase every day as competition is getting fiercer some children diseases are nice not to catch. Improved legal rights on intellectual property is much welcomed, as China opens its policy toolbox to ensure that foreign technology allowed into China is accessible for ‘co-innovation’ and ’re-innovation’ by Chinese companies. Intellectual Property Rights must be well understood and a strategy for the rights in China a part of any business plan and cooperation.

China is – rightfully or not - known for its reverse engineering, copying and recently also for indigenous innovation for own benefit. Whereas the motives are less beautiful seen from a global perspective they are often part of a maturing phase when looking at a curve for innovative capabilities. Intellectual property rights should never be questioned and when challenged the owners of them pull out of partnerships and markets. Well governed IP rights are a must for flow of ideas and technologies, a propeller for international cooperation and a catalyst for synergies. China’s positive development in new and better IP rights are therefore extremely important; and future good governance, also in favour of foreign developed and ’owned’ but internationally protected rights, bid welcome to encourage future trust in the system.

---

29 James McGregor: “China’s Drive for Indigenous Innovation” – APCO Worldwide

30 [https://hbr.org/2010/12/china-vs-the-world-whose-technology-is-it](https://hbr.org/2010/12/china-vs-the-world-whose-technology-is-it)
3.5 INNOVATION IN CHINA CAN FOLLOW SEVERAL MODELS, PROPELLED BY DIFFERENT NEEDS

Looking back ten and 20 years most of the innovation done in China was at the factories; improving processes, finding relevant cheaper material, and creating simple versions of what was already known products. Whereas *process innovation* still takes place much of the innovation has now been moved elsewhere as well, into the products and the business models.

Innovation driven by new business models are popping up in China these years. The best examples are the by now large internet and mobile companies such as Alibaba and Tencent. Alibaba connected the buyers with the network of small sellers via the internet, gave the customers AliPay to settle in a trustful manner, and grew the model into a huge success.

When Tencent created one of their biggest successes the social platform WeChat, which encompasses both communication, sharing, and now also payment, they did not technically come up with breakthrough technologies; instead they combined *arising well-understood needs and existing tech, and let user-friendliness take centre stage*.

So-called *constraint-driven innovation* can in general be expected to propel an economic move up the value chain as it is a method to meet underserved needs with simple often local means and methods. It is a type of development that focuses much on the solution and perhaps less on the latest technology. Cooperation with foreign companies seems relevant and could mean new use of already existing technologies.

Doing more with less within innovation is often named ‘frugal innovation’. It is traditionally driven by scarce resources and the birthplace of the concept has to a large degree been India. China is on the trend as well. Whereas it also can include elements of reengineering it has a more positive resonance to it and is increasingly serving as inspiration for many large R&D organisations. Using fewer resources to fulfil the same needs is appreciated; from an overall resource perspective as well as from a company’s cost perspective and more complex solutions do not necessarily bring more happy customers.

Innovation is also a question about mind-set; and the most innovative mind-sets are not necessarily found within the largest laboratories and long-term planning organisations.

Siemens realised the need for more ‘basic’ innovative thinking when they invented their SMART strategy, after entries to large emerging markets like China, India and Brazil had yielded poor results. Their previous strategy had relied on two product groups: M1 that were high-end products developed abroad, and M2 that were cheaper low-quality products developed locally. But the new markets found the M1 products too expensive and the M2 products did not meet their needs. Siemens realised that clients in China and India wanted products that were simple to install, use and maintain, and started developing products within the newly invented M3 segment, where customers were quality conscious but still highly price sensitive. Products were made by Siemens’ local R&D departments in these emerging economies with help from a team in Germany, and were noticeably simpler than products in the M1 products. Siemens learned that the technological complexity of their previous products was a hindering factor, and that simplicity was necessary to meet the demands in the emerging markets. The products were more *entry-level* than *low-end*, and were marketed under the Siemens corporate brand even

---

31 *Simple, maintenance-friendly, affordable, reliable, timely-to-market*
though it was a separate product line. They were typically high-quality but with fewer features and functionalities, for example power converters with simpler electronics, that can withstand the high level of dust in China.

By realizing the difference in needs between its regular customers and their new ones and innovating their way to tailor-made solutions that meet the demands of the emerging markets, Siemens managed to increase their revenues in China significantly, and increase brand strength and local presence at the same time 32 33.

Chinese Haier is today known as one of the most innovative companies in the world. They e.g. adapted a standard washing machine to meet the farming consumers’ needs for also using the machine for washing potatoes, and for placing machines outside the houses, so they developed a special plastic model to accommodate the behaviour. The list of special products is longer, and e.g. a result of Haier’s clever detailed segmentation and listening to their customers’ needs.

Having customers take centre-stage seems something the Chinese companies do well when developing new products and models. A study called Global Innovation 1,000 34 finds that the majority (38%) of Chinese companies are so-called ‘Need Seekers’ which is comparably more than the world average with 27%. The study separated innovative companies into three categories 1) Need seekers 2) Market Readers and 3) Technology Drivers and measured their groupings regarding Chinese companies in China, world average and so-called multi-national companies (MNC’s) in China. The study highlights their findings regarding these types of seekers, as Need Seekers seem to be the most powerful of the three types of innovators because they consistently outperform Market Readers and Technology Drivers in both profitability and enterprise value. This might be an underlying reason for why disruptive technologies and business models rise from the most unexpectedly arenas and presently e.g. AliPay and Apple are challenging the traditional private consumer bank services and 3D printing the traditional manufacturing practice, like e.g. PCs disrupted mainframes, and cellular phones the fixed lines.

Though Danish companies might not need to develop a frugal approach, inspiration can certainly be found. Does a new product really need new generation technology, or could it ‘simply’ be different by combining existing factors to meet emerging needs? And who is closest to the market to understand these needs, and test the new applications and products?

---
32 “Siemens in China – Accelerating our Succes” presentation by Mei-Wei Cheng, CEO of Siemens Ltd., China and CEO of Siemens North East Asia, 2011
33 “Siemens gets SMART” – ChinaDaily article, 2013
3.6 AN OPEN APPROACH TO INNOVATION

Chinese firms are no strangers to ‘open innovation’ in a broad term and they have perhaps a lesser need of developing everything in-house as opposed to many western companies. Innovation and tech has been achieved in several ways, both via tech purchases and more recently also via overseas R&D efforts. In Denmark this development can e.g. be witnessed by the biotech company Longlive which got acquired by CSIC, the Clean-Tech company Haizhuang Windpower Equipment and the ICT company Third Wave Denmark R&D A/S acquired by Appa Sound35. This is a trend that is expected to be enforced, as large Chinese companies seek to grow their markets internationally and needs to compete outside own turfs comes constant and higher demands for development; also technically.

As seen in the figure to the right, most of the Chinese companies plan to expand their business abroad. Additionally, almost 70 % of the Chinese companies plan to expand their R&D abroad36

Other Chinese models for innovation include efforts to work with overseas students and universities; in Denmark e.g. a corporate/university cooperation where Huawei offers selected ten students from DTU and AAU a three weeks long trip to Huawei’s Chinese organisation under the program they have named ‘Telecom Seeds for the Future’. Huawei expects to double the number of people in Europe working with innovation within three years37

4. THE WAY FORWARD – HOW TO COOPERATE?

In some ways it seems that innovation in China is becoming more open; universities and companies alike are as mentioned above increasingly looking for inspiration also across borders in order to prepare for and act in a global economy. How they obtain the much needed tech and R&D differs though and the indigenous innovation must be balanced. The trend could, however, hopefully foster an improved cooperation with Danish innovators.

Our study shows that whereas China could improve on basic research, Denmark could improve on the ability to turn research into products in companies in solid growing com-

35 The Chinese name of the company is Jiangsu Nju Electronic information Technology Company
37 http://www.dtu.dk/Nyheder/2014/07/Fem-DTU-studerende-udvalgt-til-prestigefyldt-studietur
panies. Based on this it seems optimal to match the Danish R&D and tech development skills with the growing Chinese market and demand.\textsuperscript{38}

The higher level of risk embracing and the Chinese fast commercialisation attitudes, which are based very much on a trial-and-error approach, could be interesting pillars in an accelerated cooperation where Danish technologies at a relatively early stage were presented to the Chinese market. Either where the early stage company settle in China or via partnerships.

Without sounding too much like an echo the world is getting more global. With that comes high-speed travel of ideas and concepts, and so what is developed in e.g. Denmark does not only stay in Denmark. People, ideas, and businesses go abroad. And though behaviour can have cultural aspects the respective pieces of a sound business plan puzzle can come from many origins. As Greenapple Health is inspired by a transport app, high penetration of the internet and a health system with unmet needs, a future business in China could e.g. be based on other health demands in China, a Danish tech component and design, and mobile connectivity. As a matter of fact e.g. both Danish Acarix and B&O Medicom are at the moment putting together their plans for China. Acarix to help predict the risk of suffering from coronary artery disease in an efficient manner and at an early stage, and B&O Medicom by designing and developing innovative drug devices for pharma companies to increase the effect of the drugs, and hence the pharmaceutical companies’ competitiveness.

As Denmark is among the standard setting research nations within several segments that has China’s utmost interest – health, energy and environment – and since the Chinese market measured on almost any factor is already substantial or expected to be so within a foreseeable future, it would seem relevant to find more efficient ways to bring the parties together to obtain synergies across the borders, in everyone’s interest. With lack of resources, enormous areas of land and water to clean after years’ early industrialisation, and President Xi Jinping recent quote where he asked Chinese people to protect the environment like ‘caring for one’s own eyes and life’ focus seems present.\textsuperscript{39} Denmark should be well positioned to create partnerships and commercial opportunities based on already well-established technologies and image as ‘a green nation’. China’s health reform is as ambitious as the problems it is facing with an aging population, changing life styles, new and more (also chronic) diseases that needs treatment, and an increasing understanding that prevention is an important parameter of a modern effective social & health society system.

\textsuperscript{38} Appendix I, p.39

\textsuperscript{39} \url{http://www.chinadaily.com.cn/china/2015twosession/2015-03/08/content_19748890.htm}
As discussed above, Denmark possesses strong research and innovative skills, but often lacks the ability to turn the excellent technologies and ideas into great businesses. With China’s demand for technology advancement and its easy-going approach to testing new products and versions, potential partnerships could be established. At the same time, products or specific versions developed in and with China could find additional markets elsewhere, where similar needs may demand solutions that are either made as ‘just-good-enough’ and hence in a sustainable way produced to such a level of needs (only); or with a large more high-end market in mind that could be reached if combining the best of Danish R&D, and the best of Chinese R&D, with the best commercialisation and production.

In general terms, it could be suggested that innovating in/ with China has developed in the following way:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>Danish developed research and products</td>
<td>R&amp;D in DK. (Produced in China.) Sold in DK/ the west</td>
<td></td>
<td>Best of DK and Chinese R&amp;D is pooled -&gt; commercialized jointly -&gt; produced -&gt; sold globally</td>
</tr>
<tr>
<td>China</td>
<td>Produced and Sold in China</td>
<td>Produced what was developed in DK</td>
<td>End-to-end local innovation, production and market in China</td>
<td></td>
</tr>
</tbody>
</table>

*Illustration inspired from The Economist/ N. Radjou ‘A pioneering strategy from the south’*

An interesting example of how western countries have succeeded in bringing innovation into China without losing a competitive advantage, and how China has increased its innovation level by leveraging global assets is a joint venture between General Motors and Shanghai Automotive Industry Corporation. They adapted a US minivan (the Buick GL8) for use in the Chinese market and later introduced a version developed in China, for China. The model is very popular, especially among western expats.\(^{40}\)

The market for vehicles powered by internal-combustion engines remains dominated by multinationals, despite significant incentives from the Chinese government, which had

\(^{40}\) McKinsey Quarterly ‘A CEO’s guide to innovation in China, Feb 2012
hoped that domestic automakers would emerge as leaders earlier on. This could indicate that competitive advantages and research strongholds developed over a long period of time are not easy to beat; and that IP is only one piece of a larger puzzle where mentorship and culture also are significant players in developing leading standards and processes. Another example is Volvo; when the Chinese company Geely acquired the passenger car unit of Volvo they moved out a large group of Swedish senior staff to China to make sure the necessary knowledge and skills were in place to run the unit.
4.1 HOW TO COOPERATE ON INNOVATION – SOME FINAL REMARKS

The so far tested cooperation models should soon be scrutinised. Acknowledging that neither development nor production can be done in silos and are somewhat interdependent in the longer run, the recipe for ‘de-featuring’ western developed products in China to suit the Chinese market and lower price level is not the only way of doing things. Entering the Chinese market with simple versions of Danish developed products leaves the Chinese potential untapped. Instead it should be investigated how the Chinese capabilities could be used to develop new applications and products which could be sold not only in China, but on international markets - following a concept which could be named ‘China for the World’.

Around 2/3 of the global customer base is expected to live in Asia-Pacific by 2030 so multinational companies (MNCs) are bound to take interest in what this market wants. In the before mentioned study, Global Innovation 1,000, 86% of the interviewed Chinese companies agree that their company will extend overall presence abroad within the next ten years. And according to the China Innovation Survey more MNC’s will put greater efforts in using China as a base for producing goods for other developing markets, developed markets in Asia, and Western Markets. This indicates that China is going from being a production hall to a fast-growing global R&D base.

It would be interesting to pursue a cooperation structure where the penny-wise Chinese innovators and the Danish R&D capabilities work together; tapping into the best of science and tech, with a mind-set of simplicity and ‘just-try-it’ approach new synergies could be released: innovation networks that integrate Chinese low-cost ingenuity with cutting-edge western technologies to develop affordable high-value solutions for a Chinese but also global customer base. In this way new innovation cooperation could leverage the comparable skills of each country.

5. CONCLUSION

Next month we are celebrating 65 years anniversary of the Danish-Chinese diplomatic relationship. It is cementing the already strong ties between the two countries, and it is agreeable to witness how the corporation between the countries enlarges. In the midst of China’s reforms and willingness to look out for inspiration it is aspired that the cooperation within innovation will also become more frequent and multifaceted.

Several Danish companies already have innovation centres and/ or R&D set-up in China. FOSS, Novo Nordisk, Novozymes, Lundbeck, Grundfos, Chr. Hansen and Danfoss to name some. With excellent people on the ground they are well positioned to follow and live the development in the most positive way. The companies’ R&D strategies vary somewhat. In general it could be said that the longer the companies have performed R&D in China, they move away from ‘only’ doing the D towards more R.
To allow smaller companies to dip a toe in the waters by coming to China and learn about their market and meet potential partners and customers Innovation Centre Denmark, Shanghai (ICDK) has developed a network of selected experts, networks and boot camps that would welcome the start-ups.

Moreover, ICDK has for a number of years worked with the leading research institutions and science parks in China within especially ICT, LifeSciences and CleanTech. As such ICDK is eager to bridge the Danish science and technologies and creativity with the Chinese go-to-market efforts and just-try-it business development attitude.

There are especially two findings within this report that ICDK would like to stress the improvement within two areas:

- Knowledge transfer; ‘tech transfer’, and
- Commercialisation, also as continued/ international growth of early innovation.

*Technology transfer* is an important element of knowledge transfer, and as mentioned earlier in this report an area where Denmark (and China) could do better, compared to international standards. As China is very much on the lookout for technologies it could be assumed that Danish technologies in the format of patents and licenses could be both interesting and relevant for Chinese players; primarily for commercial interests. Several Danish universities work with tech transfer already, and it is therefore recommended to strengthen the dialogue around this issue. This could likely be a way to get Danish technologies ‘out and work’ in an active manner.

With regards to the strengthening of the *commercialisation* phase, ICDK is already involved in the work, especially for the smaller sized companies. ICDK will continuously focus on supporting the smaller companies by e.g. offering

- ‘Innovation Camps’ - for groups of companies that in a week-long program receive the input needed for considering China and for their Chinese business model,
- ‘Innovation Growth’ - where a company works closely with ICDK over a longer period of time to prepare and tailor-make its strategy, and match with proper network and partners,
- ‘Incubation’ - assist especially entrepreneurs to hit the ground running and plug them into the Chinese eco-system.

The larger companies require most often quite narrow and deep services, e.g. technology scouting, and identification of application areas and potential partners; within both research and commercialisation.

The cooperation between Denmark and China within research is to a large degree institutionalised; Memorandums of Understanding and agreements within ministries, government entities and research institutions form structures where units and individuals (e.g. professors) can use these agreements and engage via these with their counterparts.

With the companies this is somewhat different; the majority of the work done by ICDK for the companies is on a 1:1 basis. Whereas the service and value delivered is relevant
it would be desirable to increase the volume of companies going through commercialisation and internationalisation in and with China, and in such way create growth around the good research that Denmark generates.

Therefore, ICDK is presently engaged in setting up a number of agreements with some of the best incubators across China’s geography and segments so that an infrastructure is prepared to better support the growth of more such companies. It is our hope that by offering access to a highly relevant eco-system, tailor made support and by opening doors to a China that is very intensely working on the innovation agenda more Danish companies will innovate and grow with China.
Appendix 1
## CONTENTS

**PART I:** .......................................................................................................................... 4

1. INTRODUCTION ............................................................................................................. 4

1.1 PROBLEM STATEMENT .............................................................................................. 5
1.2 PROJECT DELIMITATION ............................................................................................ 5

2. METHODOLOGY AND THEORETICAL BACKGROUND .............................................. 6

2.1 METHODOLOGY ......................................................................................................... 6
2.2 THEORETICAL BACKGROUND .................................................................................. 7
2.2.1. QUALITATIVE FACTORS .................................................................................... 7
2.2.2. QUANTITATIVE FACTORS ............................................................................... 10
2.3 NATIONAL INNOVATION SYSTEM CLASSIFICATION MODEL ............................. 16

3. DANISH AND CHINESE INNOVATION SYSTEM ....................................................... 20

3.1 3.1. DENMARK’S INNOVATION SYSTEM ................................................................. 20
3.1.1. DENMARK’S PRIMARY ACTORS ....................................................................... 20
3.1.2. DENMARK’S SECONDARY ACTORS ................................................................ 22
3.1.3. DENMARK’S INSTITUTIONS ............................................................................. 25
3.2 CHINA’S INNOVATION SYSTEM .............................................................................. 26
3.2.1. CHINA’S PRIMARY ACTORS ............................................................................ 26
3.2.2. CHINA’S SECONDARY ACTORS .................................................................... 28
3.2.3. CHINA’S INSTITUTIONS .................................................................................. 31
3.3 3.3. SINO-DANISH INNOVATION SYSTEM ............................................................ 33
3.3.1. SINO-DANISH PRIMARY ACTORS .................................................................... 33
3.3.2. SINO-DANISH SECONDARY ACTORS ............................................................ 34
3.3.3. SINO-DANISH INNOVATION INSTITUTIONS ............................................... 35
3.4 INNOVATION INPUT FACTORS .............................................................................. 35
3.5 KNOWLEDGE TRANSFERS ....................................................................................... 36
3.6 INNOVATION OUTPUT FACTORS ........................................................................... 38
3.7 SUMMARY .................................................................................................................. 39

4. DISCUSSION AND CONCLUSION .............................................................................. 40

4.1 QUESTIONS AND OPPORTUNITIES ........................................................................... 41
4.2 CONCLUSION .............................................................................................................44

5. LIST OF REFERENCES .................................................................................................45

5.1 APPENDIX 2: DISTRIBUTION OF DANISH AND CHINESE UNIVERSITY STUDENTS ..........48
5.2 APPENDIX 3: KEY CHINESE POLICIES RELATED TO S&T&I ...........................................49
5.3 APPENDIX 4: SELECTED PATENT DATA FOR DENMARK AND CHINA ..........................51
PART I:

1. INTRODUCTION

"We help you navigate China by opening doors to research and innovation opportunities"

Innovation Centre Denmark Shanghai (ICDK) is your entry point to growth in China, being one of the fastest developing markets in the world. The purpose of ICDK is to promote R&D and innovation collaboration between Denmark and China, and ultimately to create Danish growth.

ICDK’s strong team of specialised consultants have a deep understanding of research, science, technology, and commercial innovation. Through their extensive network ICDK provides services such as creating valuable connections, develop business cases with a global perspective, and give access to international knowledge and research.

While ICDK e.g. assists with input to strategies, business model innovation and has knowledge and experience about what Denmark can offer China, and vice versa, ICDK is looking for a fresh angle to identify opportunities to pursue more and improved innovation cooperation. Taking a different approach to identify such opportunities for this report will begin by analyzing structural differences in the following innovation systems: the primary and secondary actors, the institutions, the input and output factors, and knowledge transfer mechanisms related to basic research, applied R&D, and commercialization. By considering these structural differences, new ideas on how to promote R&D and innovation collaboration between Denmark and China could be identified, e.g. within research collaboration or by developing or selling new technology.

It has not been possible to find an existing model for this analysis. The model should be a generic tool to assess national innovation capabilities, which should ultimately lead to an objective understanding of what each nation has
to offer each other for bilateral commercial and research benefits. The following report attempts to develop such a model, which is subsequently tested using data for Denmark and China.

### 1.1 PROBLEM STATEMENT

- Develop a model for comparing the innovation systems of two nations, which can identify similarities and disparities that may inspire new ideas for ICDK to promote R&D and innovation collaboration between Denmark and China.

This will be achieved by:

1) Identify potentially interesting parameters related to innovation (input factors, output factors and knowledge transfer mechanisms) and order them according to the generic innovation value chain (basic research, applied R&D, and commercialization)

2) Identify structurally the composition of primary actors, secondary actors and institutions in the observed countries

3) Studying the findings from the bilateral comparison, interesting ideas for how ICDK can fulfill its purpose cooperation could be beneficial and hence how ICDK could promote R&D and innovation between Denmark and China

4) Analyzing one or more such ideas in depth to generate more specific knowledge that could be useful for creating Danish-Chinese collaboration on e.g. research, technology development or selling new technology.

### 1.2 PROJECT DELIMITATION

This paper proposes a model named the Generic innovation value chain, and consists of three steps: Basic research, Applied R&D, and Commercialization. The model is presented in-depth in Chapter 2.
The two national innovation systems that will be compared are first qualitatively described by identifying primary actors, secondary actors, and institutions. Then, using available statistics from—among others—the Global Innovation Index and OECD, we are able to compare relevant innovation input and output indicators and knowledge transfer indicators related to each of the steps in the generic innovation value chain.

Conducting a systematic comparison of indicators across the generic innovation value chain gives general insights into how two nations compare on different innovation activities. This may result in potentially interesting research questions that can be explored further, such as "Why do Danish researchers produce higher-quality research output than Chinese researchers do?"

As ICDK Shanghai’s purpose is to promote R&D and innovation collaboration between Denmark and China data on Denmark and China will be used to test the model.

2. METHODOLOGY AND THEORETICAL BACKGROUND

2.1 METHODOLOGY

Our aim is to develop a model for comparing two nations’ innovation systems at the three distinct stages of the generic innovation value chain: basic research, applied research and development, and commercialization.

In order to achieve unbiased comparisons, we will draw on theoretical literature related to each of these stages. We will use Xielin and White’s (2001) generic framework for describing innovation systems by mapping its primary actors, secondary actors and institutions related to each of the three stages. Furthermore, the mapping should contain observable indicators on innovation input factors, knowledge transfer mechanisms, and innovation output factors. These indicators draw attention to how well innovation is being created and diffused throughout the generic innovation value chain.
By qualitatively analyzing the different actors as well as considering quantitative indicators related to innovation, we hope to find both differences and similarities worth exploring further in order to get inspiration for optimal innovation cooperation between two countries.

The stages of the generic innovation value chain are defined here as:

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition</td>
<td>Applied R&amp;D is systematic work with the primary objective to resolve specific problems for—among others—researchers, state, business, or clients. Draws upon knowledge obtained through e.g. research or practical experience with the objective to develop new solutions such as products, processes, services, materials, or systems.</td>
<td>The commercial aspect of innovation refers to the national and international competitiveness of innovative solutions, such as IPR, products and services, and application of innovative processes and systems to deliver those products and services.</td>
</tr>
</tbody>
</table>

2.2 THEORETICAL BACKGROUND

A nation’s ability to produce and commercialize new innovative technology over the long term is dependent on a strong common innovation infrastructure, the innovation environment in the nation’s industrial clusters, and strong linkages between the two (Furman, Porter, Stern, 2002). A good classification of the national innovation systems allows for better comparison and analysis of them. Hence, the proposed model includes both qualitative and quantitative factors that relates to a nation’s ability to produce and commercialize innovative technology over the long term. Qualitative factors provide a context that quantitative data can objectively assess and verify. This provides a good foundation for comparison and analysis, which may generate new insights and questions.

2.2.1. Qualitative Factors

Qualitative factors provide a context that may enrich the data provided by the quantitative factors in the analysis. Here, qualitative factors relate to a classi-
fication of the national innovation system by considering the different actors and institutions that support and shape them.

Xielen and White (2001) proposed this generic framework for analyzing innovation systems, and it considers two types of actors: primary and secondary.

The primary actors undertake fundamental activities that relate to basic research, applied R&D, and commercialization: namely R&D, implementation, end-use, education, and linkage.

The secondary actors affect the behaviours of primary actors either directly by, for instance, dictating operational plans or setting goals and objectives, or indirectly by—as an example—using policies to create incentive structures such as tax systems that reward or discourage certain types of behavior.

There are three main types of actors: business sectors/companies, universities and public research institutions, and government. These are also referred to as triple helix actors (Etzkowitz and Leydesdorff, 2002). The business sectors are the most likely to turn ideas into economic value, and are hence seen as the main drivers of innovation. Universities and public research institutes provide new knowledge, especially in areas with less certain and immediate economic value. Governments are not only a consumer of innovation in terms of delivering services, but are also using a mix of policies, re-
search funding, and tax incentives to shape the research landscapes (OECD, 2014).

Primary and secondary actors are affected by institutions, which are the set of practices, rules, and other organizations that influence the actors’ behaviors. This generic framework serves as a relevant reminder that innovation systems are shaped by dynamic interrelations between different actors and institutions. The following sections outline which actors, institutions, and interrelations are important for successful innovation systems.

### 2.2.1.1. Primary Actors

The primary actors in three stages of the generic value chain are defined in the table below:

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary actors</strong></td>
<td>Undertake fundamental activities related to basic research, such as education and research activities. Includes universities, research institutions and, in some cases, private companies. Identify knowledge clusters, networks, science parks and hotspots.</td>
<td>Undertake fundamental activities related to applied R&amp;D, for example by developing new technologies, products, services, processes, and systems. Includes R&amp;D departments, consultancies, research institutions, start-up companies, etc. Identify clusters, networks, science parks and hotspots.</td>
</tr>
<tr>
<td></td>
<td>Undertake fundamental activities related to commercialization of innovation, for instance by licensing of IPR, sales of innovative products and services, application of innovative processes and systems in manufacturing, etc.</td>
<td>Includes private companies, state-owned enterprises, hospitals, etc. Identify clusters, networks, science parks and hotspots.</td>
</tr>
</tbody>
</table>

### 2.2.1.2. Secondary Actors

The secondary actors in three stages of the generic value chain are defined in the table below:

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Secondary actors</strong></td>
<td>Affects the behavior of primary actors, for instance, either directly by setting example—setting goals and among others, competitive</td>
<td></td>
</tr>
</tbody>
</table>
Results by Furman, Porter and Stern (2002) suggest that public policy plays an important role in shaping a country’s national innovative capacity. *Beyond simply increasing the R&D resources available to the economy, other policy choices that shape human capital investments, innovation incentives, cluster circumstances, and the quality of linkages are also important.*

### 2.2.1.3. Institutions

Institutions are generally shaped by the nation’s history, culture, and governance systems. Institutional theory focuses on the “deeper and more resilient aspects of social structure” (Scott, 2004) and considers the processes that influence the primary and secondary actors’ behaviors. Institutions are the social structures with high degrees of resilience, schemes, rules, norms, and routines that have been established as authoritative guidelines for social behavior.

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutions</td>
<td>The sets of practices, rules, and other organizations that influence the actors’ behaviors.</td>
<td>The sets of practices, rules, and other organizations that influence the actors’ behaviors.</td>
</tr>
</tbody>
</table>

### 2.2.2. Quantitative factors

Overall throughout this report, quantitative factors include internationally comparable indexes and other indicators from reliable sources. The indicators are largely selected on their ability to indicate important innovation input, output, or knowledge transfer mechanisms, which are central to the creation, diffusion, and commercialization of new knowledge and innovation.
In general, how well a nation performs in terms of innovation depends in complex ways on the underlying research funding infrastructure, the quality of human resources, intensity of cooperation, interaction and integration among various stakeholders, creativity, and on the transfer of ideas and knowledge into social and economic practice (DASTI, 2014, p. 24-28). The following sub-chapters identify quantitative indicators for these factors related to innovation.

2.2.2.1. Innovation Input Factors
Generally, the preconditions that enable research success are training & education which requires sufficient core funding of universities. Researchers should be enabled to develop their skills freely and in the best learning environments, which can be achieved by offering long-term funding to pursue independent, creative, and unconventional projects. Further progress can be achieved by concentrating knowledge in clusters and centers, as this increases valuable cross-disciplinary and transcultural exchanges, interactions and collaborations, which spur new ideas and facilitate for knowledge transfers across the innovation chain (Ministry of Science, Innovation and Higher Education, 2014, pp. 12-15).

Basic research:
Generally, the level of academic proficiency is linked to strong underlying research funding infrastructures. DASTI (2014) indicates that funding to higher education and attracting funding internationally generally indicates successful research systems (Ibid., p. 27).

Freedom, autonomy, and accountability in research are also highly relevant (Ibid., p. 27). The highest degree of autonomy is advices for basic research. Transparent research funding and structures and processes that are independent from political influences are key to creating and maintaining successful research ecosystems (Ibid., p. 26).
The number of researchers per thousand people employed and the quality of such professionals who are engaged in the conception or creation of knowledge, processes, methods and systems are also relevant indicators.
Applied R&D:
Arguably, the most important input factors to applied R&D are access to talent and funding (DASTI 2014). Hence, the number of graduates in science and engineering indicates the influx of talent that will either educate the next generation of students or perform research and innovation themselves.

Gross expenditures on R&D financed are relevant yardsticks for applied R&D. Business R&D expenditures (per GDP) are frequently used to compare countries’ private sector efforts on innovation since industrial R&D is not only closely linked to the creation of new products from production techniques, but also mirrors market-oriented innovation efforts (OECD, 2014).

Commercialization:
Almost two-thirds of net new jobs are created by SMEs (EU, 2014). A nation will produce more entrepreneurs and SMEs to commercialize its innovations when it’s easy to start new businesses. This index's calculations are—among others—based on access to finance, available talent, competition, and cost of production, and on finding customers and regulatory factors, thus serving as a broad yardstick.

Outwards Foreign Direct Investments (FDI) involves the acquisition of knowledge, skills, and technologies, and these inputs may generate further R&D and commercial innovation output.

The share of companies conducting process innovation is also relevant, as process innovation may enhance long-term competitiveness.

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation input factors</td>
<td>• Funding to higher education</td>
<td>• FDI net outflows</td>
</tr>
<tr>
<td></td>
<td>• Research funding from</td>
<td>• Ease of starting a business</td>
</tr>
<tr>
<td></td>
<td>• Graduates in science and engineering</td>
<td>• Share of companies doing</td>
</tr>
<tr>
<td></td>
<td>• University-run science</td>
<td></td>
</tr>
</tbody>
</table>
2.2.2.2. Innovation Output Factors

Basic Research:

High numbers of citations are usually considered an important indicator for successful outputs in basic research (DASTI, 2014, p. 24). Note that this output indicator only serves as a basic yardstick, as it does not apply to all fields of research or faculties in a comparable manner.

Considering the output of human resources is also an important indicator, as graduates within science and engineering will either educate new generations of scientists and engineers or work directly on applied R&D.

University rankings are also a good yardstick for innovation output in basic research, as university rankings are based on a broad range of factors related to research quality and output, knowledge diffusion, international competitiveness, talent attraction, and more.

Applied Research and Development:

The most common measurement for measuring nation’s novel technology output is by measuring patents applications and granted patents. While this is a crude measurement in its own regard, we assess the IPR output’s quality by considering royalties and license fee receipts as an innovation output indicator for commercialization, which gives an indication of the quantity/quality relationship of the IPR output from a country.

---

1 Gross domestic expenditure on R&D (GERD)
Commercialization:
Commercialization of innovative new technology can be indicated by the high-tech output as a share of the economy and as a share of total exports. One drawback to this measurement, however, is that it fails to include commodity producers such as oil companies’ share of the exports, despite oil extraction technologies being highly technologically advanced.

Venture capital deals further indicate successful entrepreneurial activity in a nation.

Measuring productivity levels and growth is also a good indicator for how well process innovations have been implemented into the society, causing yet higher innovation output.

Firms use trademarks to launch new products on the market to signal novelty, promote their brand, and appropriate the benefits of their innovations (OECD, 2014, p. 464)

<table>
<thead>
<tr>
<th>Innovation output factors</th>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citations per publication</td>
<td>Patent stock</td>
<td>Royalties and license fee receipts (% of trade)</td>
<td></td>
</tr>
<tr>
<td>Graduates in science and engineering</td>
<td>Patent applications</td>
<td>FDI net inflows</td>
<td></td>
</tr>
<tr>
<td>University rankings</td>
<td>Utility model applications</td>
<td>High-tech and medium-high-tech output</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>High tech exports</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Venture capital deals</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Productivity growth</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trademark applications</td>
<td></td>
</tr>
</tbody>
</table>

2.2.2.3. Knowledge Transfers
Public research is the source of significant scientific and technological breakthroughs. To optimize the economic and social benefits from public research and the return on public R&D investments, effective linkages are needed between academia and industry. Knowledge flows between public research institutions and industry are channeled through spin-offs, joint research projects,
training, consultancy and contract work, the commercialization of research output, staff mobility between workplaces, and informal cooperation by researchers (OECD, 2014, p. 467).

It is generally found that interaction, cooperation, and partnerships nourish productive research environments by diffusing both codified and tacit knowledge, as well as receiving feedback with the need for new knowledge across the generic innovation value chain (DASTI, 2014, p. 27). It’s easiest to organize interactive learning and tacit knowledge transfers in settings where there are few language constraints and cultural constraints (Lundvall et al., 2002). Hence, a crucial part of these linkages tend to be organized on a national basis due to the impact of language, distance, and cultures in coordinating decisions and processes for knowledge transfers.

**Basic Research:**
Scientific and technical publications are important for diffusing research knowledge to other parts of the world as well as to other parts of the generic innovation value chain.
International university and research collaboration is important for diffusing new knowledge internationally. International co-authorship in total scientific articles as a percentage of all publications is a direct measure of international collaboration in science (OECD, 2014, p. 468)

University funding by private companies generally indicates a trade-off, where the private company benefits from the research output. Hence, this indicates knowledge transfers throughout the value chain.

**Applied R&D:**
University-Industry collaboration is a relevant indicator for interaction, cooperation and partnerships in applied R&D (DASTI, 2014, p. 27; Meng, 2012).
The concentration of knowledge in clusters and networks indicate diffusion and sharing of knowledge as well.
International co-invention in PCT patent applications illustrates formal R&D co-operation and knowledge exchanges among inventors in different countries (OECD, 2014, p. 468)
Commercialization:
When companies pay for royalties and license fees, they are utilizing technologies and knowledge developed elsewhere in their own commercial efforts. This transfer of knowledge spans borders, and is a way to increase competitiveness quickly (albeit at a cost).

Furthermore, joint ventures and strategic alliances tend to involve knowledge transfers and exploring synergies. Hence, these types of deals may indicate relevant knowledge transfers.

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge transfer mechanisms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Scientific and technical publications</td>
<td>• Concentration of knowledge (clusters and networks)</td>
<td>• Royalties and license fee payments (% of trade)</td>
</tr>
<tr>
<td>• International research and university collaboration</td>
<td>• University/industry collaboration</td>
<td>• Joint venture/strategic alliance deals</td>
</tr>
<tr>
<td>• University funding by private enterprises</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.3 NATIONAL INNOVATION SYSTEM CLASSIFICATION MODEL

All the factors above are listed in the table below. It is a list of factors that is relevant to make a comparison of two nations’ innovation systems according to the theoretical discussion above.

Qualitative data regarding different innovation system actors are largely found in public reports and evaluations from The Danish Ministry for Higher Education and Science. Most of the quantitative data are gathered using databases from either OECD or the Global Innovation Index (GII) (or similar sources). Data from OECD is indexed so OECD average equals 100, and the GII index is indexed between 0-100 from worst to best performing among the sample countries.
### Definition

| Definition                                                                 | Basic research is the experimental or theoretical work with the primary objective to create new knowledge and understanding without any specific application in mind. | Applied R&D is systematic work with the primary objective to resolve specific problems for researchers, state, business, clients, and so on. Draws upon knowledge obtained through research or practical experience with the objective to develop new solutions such as products, processes, services, materials, or systems. | The commercial aspect of innovation refers to the national and international competitiveness of innovative solutions such as IPR, products and services, and application of innovative processes and systems to deliver those products and services. |

### Primary actors

<table>
<thead>
<tr>
<th>Primary actors</th>
<th>Undertake fundamental activities related to basic research, education, and research activities.</th>
<th>Undertake fundamental activities related to applied R&amp;D, and develop new technologies, products, services, processes, and systems.</th>
<th>Undertake fundamental activities related to commercialization of innovation, such as licensing of IPR, sales of innovative products and services, application of innovative processes, and systems in manufacturing, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Includes universities, research institutions, and, in some cases, private companies. Identify knowledge clusters, networks, science parks, and hotspots.</td>
<td>Includes R&amp;D departments, consultancies, research institutions, start-up companies. Identify clusters, networks, science parks, and hotspots.</td>
<td>Includes private companies, state-owned enterprises, hospitals, etc. Identify clusters, networks, science parks, and hotspots.</td>
</tr>
</tbody>
</table>

### Secondary actors

<table>
<thead>
<tr>
<th>Secondary actors</th>
<th>Affects the behavior of primary actors either directly by e.g. setting goals and objectives, or indirectly by e.g. responding to customer demands or market competition, national strategies.</th>
<th>Affects the behavior of primary actors either directly by e.g. setting goals and objectives, or indirectly by e.g. responding to customer demands or market competition, national strategies.</th>
<th>Affects the behavior of primary actors either directly by e.g. competitive strategy and KPI’s, or indirectly by responding to customer demands or market competition.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The sets of practices, rules, and other organizations that influence the actors’ behaviors.</td>
<td>The sets of practices, rules, and other organizations that influence the actors’ behaviors.</td>
<td>The sets of practices, rules, and other organizations that influence the actors’ behaviors.</td>
</tr>
</tbody>
</table>

### Institutions

<table>
<thead>
<tr>
<th>Institutions</th>
<th>The sets of practices, rules, and other organizations that influence the actors’ behaviors.</th>
<th>The sets of practices, rules, and other organizations that influence the actors’ behaviors.</th>
<th>The sets of practices, rules, and other organizations that influence the actors’ behaviors.</th>
</tr>
</thead>
</table>

### Innovation input factors

<table>
<thead>
<tr>
<th>Innovation input factors</th>
<th>Funding to higher education</th>
<th>Graduates in science and engineering</th>
<th>FDI net outflows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GERD funding from abroad</td>
<td>University-run science parks</td>
<td>Ease of starting a business</td>
</tr>
<tr>
<td></td>
<td>Research independence</td>
<td>GERD financed by business enterprises</td>
<td>Ease of entrepreneurship index</td>
</tr>
<tr>
<td></td>
<td>Researchers (per 1000)</td>
<td>Top 500 corporate R&amp;D investors</td>
<td>Share of companies doing process innov-</td>
</tr>
</tbody>
</table>
### Knowledge Transfer Mechanisms

- Scientific and technical publications
- International research and university collaboration
- Industry financed public R&D expenditure by private enterprises

### Innovation Output Factors

- Citations per publication
- Graduates in science and engineering
- University rankings
- Patent stock
- Patent applications > 3 offices
- Patent applications, national office
- Utility model applications
- Patenting firms younger than 5 years

### Definitions

**Basic Research**

- Fundamental experimental or theoretical work with the primary objective to create new knowledge and understanding without any specific application in mind.

**Applied Research and Development**

- Systematic work with the primary objective to resolve specific problems for researchers, state, business, clients, and so on. Draws upon knowledge obtained through research or practical experience with the objective to develop new solutions such as products, processes, services, materials, or systems.

**Commercialization**

- The commercial aspect of innovation refers to the national and international competitiveness of innovative solutions such as IPR, products and services, and application of innovative processes and systems to deliver those products and services.

### Primary Actors

**Basic Research**

- Undertake fundamental activities related to basic research, education, and research activities.

**Applied Research and Development**

- Undertake fundamental activities related to applied R&D, and develop new technologies, products, services, processes, and systems.

**Commercialization**

- Undertake fundamental activities related to commercialization of innovation, such as licensing of IPR, sales of innovative products and services, application of innovative processes, and systems in manufacturing, etc.

Includes universities, research institutions, and, in some cases, private companies. Identify knowledge clusters, networks, science parks, and hotspots.
### Secondary actors
Affects the behavior of primary actors either directly by e.g. setting goals and objectives, or indirectly by e.g. responding to customer demands or market competition, national strategies.

- The sets of practices, rules, and other organizations that influence the actors’ behaviors.

### Institutions
The sets of practices, rules, and other organizations that influence the actors’ behaviors.

### Innovation input factors
- Funding to higher education
- Research funding from abroad
- Transparency of funding mechanisms
- Research independence
- Researchers (per 1000 employed)
- Quality of researchers
- University-run science parks
- GERD financed by business enterprises
- Top 500 corporate R&D investors
- GERD financed by the public
- FDI net outflows
- Ease of starting a business
- Share of companies doing process innovation

### Knowledge transfer mechanisms
- Scientific and technical publications
- International research and university collaboration
- Industry financed public R&D expenditure by private enterprises
- State of cluster development
- University/industry collaboration
- GERD performed by business enterprises
- Royalties and license fee payments (% of trade)
- Joint venture/strategic alliance deals

### Innovation output factors
- Graduates in science and engineering
- University ranking
- Assessment in reading, mathematics and science
- Patents filed by universities and public labs
- Patent stock
- Patent applications
- Utility model applications
- Royalties and license fee receipts (% of trade)
- FDI net outflows
- High-tech and medium-high-tech output
- High tech exports
- Venture capital deals
3. DANISH AND CHINESE INNOVATION SYSTEM

Innovation is the translation of ideas and knowledge into products and processes with societal and commercial value. This requires interaction and transfer of knowledge throughout the generic value chain—from basic research to commercialization.

Relevant data from Denmark and China will be presented below, and used as input for further analysis and discussion in chapter 4. First, the innovation system actors are presented for Denmark, China in chapters 3.1 and 3.2, and collectively in 3.3. Second, quantitative innovation input-, knowledge transfer- and output factors are presented for Denmark and China in chapters 3.4, 3.5, and 3.6.

3.1 3.1. DENMARK’S INNOVATION SYSTEM

Denmark’s innovation system performs well internationally, according to the Global Innovation Index. The index lists Denmark at 8th place in 2014, up from 9th in 2013 (GII 2014). The following chapters outline some of the central Danish innovation actors and innovation system elements.

3.1.1. Denmark’s Primary Actors

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Actors</strong></td>
<td>Eight universities, three among top-200 on Times Higher Education ranking and two universities among top-100 on Academic Ranking of World Universities.</td>
<td>Private enterprises employ 63% of R&amp;D staff while the remaining 37% are employed in public institutions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17% of all companies conduct own R&amp;D</td>
</tr>
</tbody>
</table>
Denmark’s main primary basic research actors are its universities: e.g. Aarhus University, Copenhagen University and Technical University of Denmark. Although Denmark only has eight universities, at least three of the universities are internationally renowned, particularly within natural sciences, environment and ecology, and in social sciences. Danish research performs well in international comparisons. Danish researchers rank third in terms of numbers of publications per capita, and also ranks third in number of citations per publication.

Applied R&D is mainly conducted by large, private enterprises. The private sector employs 63 percent of those working with R&D (Danmarks Statistik, 2014). 17 percent of all Danish companies conduct R&D activities, and 15.5 percent of Danish SMEs have external innovation collaborations. The industrial sectors account for more than half of all R&D expenditures, followed by professional services and ICT sectors at 13 percent each (Danmarks Statistik, 2014). Medical and disease research accounts for the largest share of public R&D spending and also a solid share of private R&D funding. The large enterprises are also mainly involved with commercializing R&D achievements in terms of IPR: only 3 percent of Danish companies are engaged with IPR activities, yet they account for 46 percent of revenues.
The Danish public sector is also an important primary actor within applied R&D as the public sector employs about 37 percent of those engaged in R&D. Technical University of Denmark was Denmark’s fourth largest patent applicant in 2013 (Appendix 4).

Denmark has nine GTS institutes, which aim at creating more innovative and competitive Danish companies by making science and knowledge available for a broad range of Danish companies (law nr. 419 of June 6 2002). The GTS institutes provide services that are consistent with both primary and secondary actors.

Denmark has several industrial clusters and innovation networks, many of which are triple helixes (Danish Ministry of Science and Technology, 2014). Overall, they are organized in one of two ways: either as large partnerships or as focused projects. Large partnerships promote coordination, distribute knowledge, and undertake explorative activities, while focused projects are required for product development (DEA and DI, 2014, p. 38). Denmark’s Mechatronics Cluster and Pervasive Computing Clusters are amongst the top cluster performers in Temouri’s 2012 ranking. Other prominent clusters include Medicon Valley, the life sciences cluster centered in Copenhagen.

3.1.2. Denmark’s Secondary Actors

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Secondary actors</strong></td>
<td><strong>Basic Research</strong></td>
<td><strong>Applied Research and Development</strong></td>
</tr>
<tr>
<td></td>
<td>• Danish governmental policies</td>
<td>• Danish governmental policies</td>
</tr>
<tr>
<td></td>
<td>• Finance law appropriations</td>
<td>• Innovation Fund Denmark</td>
</tr>
<tr>
<td></td>
<td>• Communal and regional funding</td>
<td>• Development and Demonstration Programmes</td>
</tr>
<tr>
<td></td>
<td>• International funding</td>
<td>• Danish Innovation Foundation</td>
</tr>
<tr>
<td></td>
<td>• Danish National Research Foundation</td>
<td>• Danish Council for Strategic Research</td>
</tr>
<tr>
<td></td>
<td>• The Danish Council for Independent Research</td>
<td>• INNO+</td>
</tr>
<tr>
<td></td>
<td>• Danish Council for</td>
<td>• EU’s research program</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Danish government is aware that Denmark is a knowledge-based society and that innovation is, and will be, a key driver for growth, job creation, and competitiveness (Nielsen, 2014). Innovation is central in the Danish government’s agenda, which has resulted in several primary, secondary, and institutional initiatives to support innovation at all stages of the generic value chain. As a secondary actor, the Danish government has affected the primary actors by e.g. allocating more funds to R&D and education, establishing private-public partnerships and affecting framework conditions for enterprises. 40 percent of public funds are allocated on a competitive basis and 60 percent as basis allocations to e.g. higher education (Danish Ministry of Higher Education and Science, 2014).

In the Danish public sector, 42 percent of R&D spending goes to basic research, 45 percent to applied research, and 14 percent to development. For the private sector, only seven percent of R&D spending goes to basic research, 14 percent to applied research and 79 percent to development (Statistics Denmark, 2014). Evidently, the public sector focus more on basic and applied research, while the private sector focuses on developing concrete products and services for commercial purposes.

There are many available funding mechanisms for researchers and companies in Denmark. Both public and private funds are available for all stages of the

<table>
<thead>
<tr>
<th>Strategic Research</th>
<th>Strategic Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private funds, e.g. Lundbeck Fonden, Oticon Fonden.</td>
<td>Private funds, e.g. Lundbeck Fonden, Oticon Fonden.</td>
</tr>
<tr>
<td>Triple helix clusters and innovation networks</td>
<td>Triple helix clusters and innovation networks</td>
</tr>
<tr>
<td>Pilot partnerships with relevant actors in areas with strong commercial and scientific positions.</td>
<td>Nine GTS institutes</td>
</tr>
<tr>
<td>Aim: solve concrete societal challenges related to e.g. food, water, climate and smart energy.</td>
<td>Pilot partnerships</td>
</tr>
</tbody>
</table>


value chain, ranging from research funds to commercially oriented business angels, venture capital and private equity funds. Hence, the Danish research, development and innovation funding mechanisms ensures research and development within prioritized areas, as well as ensuring good framework conditions for basic research.

Evaluations about the Danish innovation system concludes that while Denmark has strong basic research capabilities, Denmark has unrealized potential in commercializing their R&D efforts (Ministry of Higher Education and Science, 2014). Hence, the government has created initiatives such as public-private and triple helix partnerships to facilitate for knowledge transfers and R&D commercialization.

Triple helix clusters and innovation networks organize knowledge institutions, companies and public actors within areas such as energy, environment, food, ICT, production, materials and design, life sciences, and transportation (Danish Ministry of Higher Education and Science, 2014). Their objectives are to strengthen public-private collaboration and knowledge transfers on research and innovation.

The Danish Ministry of Business and Growth has assigned growth teams within specific areas to research and monitor the factor conditions for their area, and then to make concrete recommendations to Danish ministries on how to improve factor conditions for innovation and growth in the following areas:

- The Blue Denmark
- Water, Bio, and Environmental solutions
- Energy and climate
- Tourism and experience economy
- Creative businesses and design
- Health- and welfare solutions
- Food
- ICT and digital growth
All in all, Denmark’s strong focus on innovation as a key national strategy has resulted in several secondary actor initiatives aimed at helping primary actors driving the Danish economy forward.

### 3.1.3. Denmark’s Institutions

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Institutions</strong></td>
<td>• Culture: creativity, diversity, education, freedom, transparency, high trust</td>
<td>• Culture: creativity, diversity, education, freedom, flat hierarchies, transparency, high trust</td>
</tr>
<tr>
<td></td>
<td>• Social welfare and security</td>
<td>• Culture: creativity, diversity, education, freedom, flat hierarchies, transparency, high trust, low corruption, Law of Jante</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Social welfare and security</td>
</tr>
</tbody>
</table>

The Danish culture is one that values creativity, education, diversity, freedom of speech, transparency, high levels of trust, and flat hierarchies—factors that enable the formation and expression of ideas. However, one might argue the case that the Law of Jante stands strong in Denmark, which is an inhibiting factor for pursuing entrepreneurial ventures.

At the societal level, Denmark provides its citizens with free education, unemployment benefits, healthcare benefits, pension systems, and more. However, the benefits package comes at the price of high income taxes.

The Danish culture and social safety net enables Danes to pursue individual careers with little risk. Hence, these institutions are likely a strong contributing factor to Denmark’s good score on OECD’s “ease of entrepreneurship index”, though it could be argued that with a social welfare system as fallback option entrepreneurs have less incentive to go that extra last mile.
3.2 CHINA’S INNOVATION SYSTEM

China’s GDP growth rates are declining, and the 7.3 percent growth in 2014 is the lowest rate since 1993. A general trend is that China is transitioning from being driven by production and infrastructure investments towards being driven by consumption and innovation. China’s rank in the Global Innovation Index is 29th in 2014, up from 35th in 2013 (GII 2014).

3.2.1. China’s Primary Actors

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary actors</td>
<td>• 1.3 million researchers (2011)</td>
<td>• 74% of R&amp;D expenses are privately funded</td>
</tr>
<tr>
<td></td>
<td>• 25 million students enrolled in higher education (2011)</td>
<td>• High-tech industrial zones and clusters</td>
</tr>
<tr>
<td></td>
<td>• 41% of and 17% of of PhD-students enrolled in engineering and natural sciences, respectively.</td>
<td>• Universities and Science parks (triple helix)</td>
</tr>
<tr>
<td></td>
<td>• Chinese high-tech companies</td>
<td>• Chinese high-tech companies</td>
</tr>
<tr>
<td></td>
<td>• Three largest patent applicants: ZTE, Tencent, Shenzhen China Star</td>
<td>• Three largest patent applicants: ZTE, Tencent, Shenzhen China Star</td>
</tr>
</tbody>
</table>

Historically, China’s primary R&D actors have focused on incremental process- and product innovations. While this is still largely the case, there are observable trends are towards more fundamental innovations and R&D achievements increasingly reach international markets.

China has an impressive number of researchers and highly educated workforce within engineering and natural sciences. China ranks third amongst countries with the most citations from scientists, and Chinese researchers produced about 14 percent of scientific papers in 2011, up from only two percent a decade earlier. However, the number of citations per scientific publication remains relatively low. And the concentration of talent engineering and natural sciences may hamper interdisciplinary discoveries. Furthermore, many top universities are commercially oriented due to national strategies and science park objectives. Hence, basic research output remains low.
Universities often play a pivotal role to industries particularly in triple-helix high-tech industrial zones. Special university science parks are key to bringing talent and opportunity together, resulting in university-industry collaborations, university spin-offs, and strong focus on applied R&D.

R&D investments in China have surged over the past decade, and are now accounting for about two percent of GDP. This has resulted in significantly increased R&D output in recent years, and China is now the country that applies for most patents domestically and second in international patent applications (WIPO, 2014). The areas with most patent applications are digital communication, computer technology, pharmaceuticals, and production-related technologies such as electrical machinery, measurement tools, and materials sciences (Appendix 4).

As for commercialization, we find that the largest Chinese companies within digital communication and computer technology file the most patents. These giants—including ZTE, Huawei, and Tencent—are among the global leaders in terms of IPR output. While domestic patent applications are driven largely by the government’s incentive plans, these companies are increasingly achieving commercial success outside of China’s border as well. Xiaomi also makes for an interesting case study: the four-year-old startup has already sold 61 million smart phones, and is now the world’s third-largest smartphone maker (TechCrunch, 2014).

Besides large, R&D-driven companies, Chinese entrepreneurs are often small in size, agile, and resilient. Startups “try and fail quick”, and are often in hypercompetitive environments with small margins.

An important factor across the generic innovation value chain is the returning overseas Chinese. More than 760,000 students and researchers who have studied abroad had returned to China by 2011. Half the staff in some Chinese elite universities now has overseas experience, and many returnees have started new businesses where they import new technology from e.g. USA.
A final important note is that managerial skills are critical for conducting and commercializing innovation activities. Managerial skills are hard to measure using quantitative indicators. Nevertheless, innovative MNC’s in China are often cited stating that access to managerial talent is among their top challenges. That being said, innovation is more likely to be near or at the top of top management priorities in Chinese companies than their MNC peers (Strategy&, 2012, 2013 & 2014).

3.2.2. China’s Secondary Actors

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary actors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Five Year Plans</td>
<td>Five Year Plans</td>
<td>High-Tech Industrial Zones</td>
</tr>
<tr>
<td>National Plan for Building Indigenous Innovation</td>
<td>Industry Technology Innovation Alliances</td>
<td>Industry Technology Innovation Alliances</td>
</tr>
<tr>
<td>Capabilities (2011-2015)</td>
<td>National Technology Transmission Centres</td>
<td>The Development Plan of National Strategic Emerging</td>
</tr>
<tr>
<td>(2010-2020)</td>
<td>National Medium and Long-Term Plan for Building Key S&amp;T</td>
<td></td>
</tr>
<tr>
<td>12th FYP for National High-Tech Parks</td>
<td>Infrastructure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12th FYP for National High-Tech Parks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12th FYP for National High-Tech Incubators</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sparse early-stage investments</td>
<td>Sparse early-stage investments</td>
</tr>
<tr>
<td></td>
<td>Special Funds for Subsidizing Foreign Patent</td>
<td>State Intellectual Property Office</td>
</tr>
<tr>
<td></td>
<td>Applications</td>
<td></td>
</tr>
<tr>
<td></td>
<td>InnoFund</td>
<td>InnoFund</td>
</tr>
</tbody>
</table>

China’s secondary actors are greatly influenced and often directly shaped by the Communist Party and the government. The recent Five Year Plans outline
strategies to build indigenous innovation strategies, as well as to build competencies, in seven emerging growth industries: biotechnology, new energy, high-end equipment manufacturing, energy conversation and environmental protection, clean-energy vehicles, new materials, and new-generation IT (Danish Embassy, 2014).

The central government outlines e.g. innovation strategies and objectives in five-year plans, which are being implemented by the regional and local governments by providing policy tools such as e.g. infrastructure, funding, tax incentives, procurement policies, and more, to guide the primary actors’ behaviors. A selection of relevant policies has been included in the table above, and Appendix 3 provides an overview of the most central policies listed above.

*Some of the main issues that are being addressed by the science, technology and innovation policy in China include enforcement of IPR laws, weak research-industry linkages, insufficient evaluation of government R&D expenditures at certain levels, progress in expanding basic research, and improving coordination of government agencies that are responsible for STI.*

China’s IPR protection has seen progress in recent years. The international community recognizes the governmental efforts brought about in the third revision of patent law that came into force in 2011. Foreign companies still face challenges—particularly to access information—but generally, the situation is perceived to be improving and the foreign companies are also developing strategies for dealing with the situation.

The Five Year Plan outlines intentions to strengthen international cooperation and internationalization of Chinese research. Focus shifts away from traditional exchange of personnel towards more international joint research partnerships with joint laboratories, research centers, innovation parks, and technology transfer centers (Danish Embassy, 2014).

China has pursued cluster and specialization strategies since the establishment of the first Special Economic Zone in 1980. Today, there are more than
one hundred Industrial High Tech Development Zones. Focus areas in the high-tech zones include (ICDK, 2012, p. 12):

- electronics and information technology;
- bioengineering and new medicine technologies;
- new materials and application technology;
- advanced manufacturing technology;
- aerospace technology;
- marine engineering;
- nuclear application technology;
- modern agricultural technology; and
- other new technology in the transformation of traditional industries.

Science parks are integrated into the High Tech Zones and provide favorable policies, such as subsidies or funding, to support e.g. startups or R&D organizations. National University Science Parks are located in proximity to universities with strong research capabilities and aim to provide support and services for scientific and technological achievements, high-tech business incubation, and innovation and entrepreneurship training (ICDK, 2012, p. 13).

Industry Technology Innovation Alliances are co-operations between enterprises, universities, and research institutions that aim to promote innovation abilities in certain industries. This is achieved by joining innovation efforts and complementary competencies from all the involved parties, such as efficient allocation of resources, sharing of IPR, implementing technology transfers, and accelerating commercialization of scientific achievements (ICDK, 2012, p. 13).

National Technology Transmission Centres are service organizations that facilitate knowledge flow and technology transfers by providing brokerage, technology integration and management, investment, and financial services (ICDK, 2012, p. 14).

The Ministry of Finance (2012) have issued special funds for subsidizing foreign patent applications that provides financial assistance for Chinese who file patents applications abroad.
While the government has begun to see venture capital as essential to encouraging indigenous innovation, there is still a lack of capital and early-stage support to entrepreneurs. Angel investments are growing but still scarce in China. This is set to improve as Chinese companies such as Alibaba get large windfalls from e.g. IPOs or M&A’s, yet these success stories are still wide and afar. However, the Innovation Fund for Small Technology-Based Firms—InnoFund—and the availability of tax and other incentives in science parks are important to highlight.

China established specialized talent programs as a part of the 12th five year plan, that involves several ministries, and aims at providing training and developing “innovation champions”. This indicates that the government also sees human resources and talent development as a key to China’s development. See also Appendix 2 for elaboration on “Medium and Long-Term Talent Development Plan” and other related policies.

To summarize, China is rapidly improving framework conditions, ranging from cluster development, triple helix cooperation and knowledge transfers, human resources development, tax and funding incentives, and more. It will be interesting to see how quickly these investments will pay off in terms of high quality output.

3.2.3. China’s Institutions

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied Research and Development</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutions</td>
<td>Confucius</td>
<td>Incremental process and product changes</td>
</tr>
<tr>
<td></td>
<td>Pragmatism</td>
<td>Top-down</td>
</tr>
<tr>
<td></td>
<td>Top-down</td>
<td>Environmental challenges</td>
</tr>
<tr>
<td></td>
<td>Environmental challenges</td>
<td>Public health</td>
</tr>
<tr>
<td></td>
<td>Public health</td>
<td>Social welfare and security</td>
</tr>
<tr>
<td></td>
<td>Social welfare and security</td>
<td>Ageing population</td>
</tr>
<tr>
<td></td>
<td>Ageing population</td>
<td>Economic growth and transition</td>
</tr>
<tr>
<td></td>
<td>Economic growth and transition</td>
<td>“Try and fail quick”-mentality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pragmatism</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Top-down</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental challenges</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Public health</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Social welfare and security</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ageing population</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Economic growth and transition</td>
</tr>
</tbody>
</table>
China’s institutions, culture, and governance are dominated by some central elements: a large population, perpetual, rapid transformations, and large-scale societal challenges. An implication is that the governance systems are hierarchical and top-driven and designed for pragmatism. The pragmatism affects how research and innovation is conducted. Researchers are more focused on solving practical problems rather than on conducting long-term basic research.

The Chinese culture values conformity, authority, and hierarchies, and its education system values memorization over critical skills, ultimately inhibiting creativity. There are also low levels of trust and widespread corruption in the society (albeit improving due to the ongoing efforts to stop corruption).

In China individual impulsive mobility is lower than in Denmark. There are limitations ranging from which schools individuals may attend, where to live/ when to move, and regulations on e.g. how many children to have, use of car, and www restrictions. The social benefits package in China is not as advanced as in Denmark. While there are regional differences, one can’t generally count on sufficient unemployment benefits, and healthcare benefits, public pension, and other benefits are relatively low. This must believe to affect individual priorities.

China’s family planning is relevant for the discussion on innovation in terms of entrepreneurship and choice of career. When children grow up without siblings and with parents and grandparents who are expected to live longer, and who may not receive pension in old age, these children are expected to provide for their elders in adulthood. Hence, parents and grandparents groom their children
to pursue careers with good earning potential and minimal risk. Many therefore pursue academic degrees within engineering and natural sciences, as it is perceived to give good career opportunities. This is a partial explanation for why China has so many students enrolled in these branches.

While the Chinese educational culture is not much fostering critical thinking nor abstraction, it has a strong appetite and demand for such abilities to create solutions to the large challenges it is meeting on e.g. health and pollution. Further, China’s social structures pushes people to maximize their earning potential, yet often within relative ‘safe’ boundaries. China’s economic transformation and societal challenges (and opportunities) push innovation supply and demand, but as of yet more for finding practical solutions than development breakthrough scientific accomplishments or inspire to risky start-up careers.

### 3.3 3.3. SINO-DANISH INNOVATION SYSTEM

The following is a brief account of the Sino-Danish innovation system: the primary actors, secondary actors and institutions that China and Denmark have in common.

#### 3.3.1. Sino-Danish Primary Actors

All the Danish universities have relations to Chinese universities, including strategic partnerships and alliances as well as specific collaborations between institutions and researchers.

Danish and Chinese scholars co-author papers within life sciences and physical sciences, at 45 and 29 percent, respectively. There were 864 papers with Danish and Chinese authors in 2013. Typically, Danish scholars from Copenhagen University, Aarhus University and Technical University of Denmark collaborates with Chinese scholars from Chinese Academy of Sciences, as well as
the leading universities such as Tsinghua, Peking and Zhejiang University (Danish Embassy, 2014). Private enterprises also contribute in this area.

ICDK Shanghai has hosted Top Talent Denmark since 2012, the largest platform for promoting Danish education and career opportunities. In 2012, there were 716 Chinese full-degree students and 390 exchange students in Denmark. Denmark had 381 exchange students and only six full-degree students in China the same year. Yet, these numbers will increase as the joint university collaboration with Sino-Danish Centre for Education and Research between the Danish universities and Chinese Academy of Sciences provides seven master programmes within natural sciences and social sciences. This will allow better access to elite Chinese students and researchers to Danish universities, research institutes and companies.

Many of the largest and most innovative Danish companies have a strong presence in China, and increasingly also within R&D. While there is generally stronger focus on development, there are prominent examples of Danish enterprises conducting research in China, as well.

3.3.2. Sino-Danish Secondary Actors

Many secondary actors have close collaborations with China. For example, the Danish Council for Independent Research provides support to a Danish-Chinese genome-mapping consortium. The Danish National Research Foundation and the National Science Foundation of China collaborates on the establishment of joint basic research centers, and have established ten centers established since 2005 within cancer research, ICT, sustainable energy and nanotechnology).

The Danish Council for Strategic Research the Council for Science and Research collaborated with the Chinese Ministry of Science and Technology on providing financial support for sustainable energy research projects. About 74 million DKK was appropriated to 14 projects in the period 2009-2013 (Danish Embassy, 2014).
Denmark and China are on good political terms, and have signed Memorandum of Understanding in several relevant areas after China’s state visit to Denmark in 2012 and Denmark’s state visit to China in 2014, including (Danish Ministry of Foreign Affairs, 2014):

- Education and research
- Biotechnology and biomedicine (TCM), agricultural and food technology
- Clean and renewable energy, particularly wind power, bio energy power and fuel cells
- Green maritime technologies
- Nanoscience and technology
- Elderly care
- Health and TCM application
- Milk technology
- Trade and investment

Furthermore, there are joint funding programs between Denmark and China:

- The Chinese Ministry of Science and Technology (MOST) and Danish Research Council for Strategic Research within sustainable and renewable energy
- MOST and Danish Energy Agency within wind energy and smart grid
- National Natural Science Foundation in China and the Danish National Research Foundation within cancer research, nanotechnology, renewable energy, and ICT.

### 3.3.3. Sino-Danish Innovation Institutions

Considering the so-called CAGE distance framework, there are few institutional commonalities between Denmark and China. These are challenges that can be worked around with experience, good leadership and management.

### 3.4 INNOVATION INPUT FACTORS

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied R&amp;D</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DK</td>
<td>CN</td>
</tr>
<tr>
<td>Funding to higher education</td>
<td>65.2</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Comparing Danish and Chinese Basic Research innovation input factors, we find that Denmark has comparably more researchers per capita than China does. Basic research expenditures make up 0.54% of Denmark’s GDP, which is six times higher than the share of GDP in China. Hence, Denmark has both more researchers and invests more into basic research.

Considering the innovation input factors related to applied research and development, we find that Danish GERD is higher than Chinese overall, but not remarkable by international comparisons (Global Innovation Index 2014). In fact, there is an inverse relationship between how much R&D is being funded and how much is being performed by private enterprises in Denmark and China: Danish private enterprises finance comparably less and performs comparably more R&D than their Chinese counterparts.

Considering innovation input factors for commercialization, we find that Denmark scores high on the ease of starting a business index at 92.3, with China also performing reasonably well on this index at 67.4. While Denmark and China performs almost identical in terms of outwards foreign direct investments as a share of GDP, this activity is slightly less than average in international comparisons.

### 3.5 KNOWLEDGE TRANSFERS
Considering knowledge transfer indicators relating to basic research, we find that Denmark is a world leader in producing scientific and technical publications, whereas China ranks fairly low. Note, however, that these are indexed numbers and that China’s publications far outnumber Danish publications in absolute numbers. Denmark also ranks well above the OECD average in international co-authorship of academic papers, whereas China significantly underperforms on this indicator.

Interestingly, the industry-financed public R&D expenditures by private enterprises in China exceed the OECD average at 118.9 while Denmark only scores 62.7.

For applied R&D, we can see that Denmark and China have slightly above-average developed clusters and university/industry collaborations. Danish business enterprises perform more R&D than do Chinese enterprises.

In terms of commercialization, we see that royalties and license fee payments account for a larger share of Danish trade than Chinese, yet both countries remain quite low in this area at 35.8 and 26.3, respectively. Denmark also conducts comparably more joint venture deals and strategic alliance deals, yet both countries remain quite low also on this measure at 34.4 and 9.0, respectively.
3.6 INNOVATION OUTPUT FACTORS

<table>
<thead>
<tr>
<th>Basic Research</th>
<th>Applied R&amp;D</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DK</td>
<td>CN</td>
</tr>
<tr>
<td>Graduates in science and engineering</td>
<td>34.6</td>
<td>N/A</td>
</tr>
<tr>
<td>University rankings</td>
<td>70.9</td>
<td>76.8</td>
</tr>
<tr>
<td>Assessment in reading, mathematics and science</td>
<td>64.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Patents filed by universities and public labs (per GDP) (OECD avg=100)</td>
<td>127.9</td>
<td>22.3</td>
</tr>
<tr>
<td>Publications in top-quartile journals (per GDP) (OECD avg=100)</td>
<td>172.7</td>
<td>22.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: Global Innovation Index 2014; OECD 2014; WIPO 2014

Danish and Chinese top universities rank evenly and reasonably high at 70.9 and 76.8, respectively. However, some interesting numbers follow. China ranks first in assessment in reading, mathematics, and science. Yet, further investigations show that only data for Shanghai is included and, therefore, are results unclear at the general level. Some interesting basic research output is also found: Denmark performs much better than China on both the number of patents filed by universities and public laboratories and on the number of publications in top-quartile journals.
Some interesting observations also follow for applied R&D. While China does not perform well on the number of patents filed in more than three patent offices, China does rank first in patent applications and utility model applications at national offices. This indicates that China applied for many patents domestically and few internationally. China had more than one million active patents in 2013 and Denmark only had 50,277, hence China has 20 times more patents than Denmark does (WIPO, 2014). However, when calculating per capita, Denmark has 12 times more active patents than China does.

Commercialization innovation output is perhaps the most interesting category to consider. Here, the sum of the inputs and knowledge transfers across the generic value chain are displayed. We find large similarities and dissimilarities here. The numbers for FDI net outflows and high- and medium-high tech outputs are almost identical for Denmark and China. However, Denmark performs better on royalties and license fee receipts and venture capital deals, and China performs better on trademark applications and high-tech exports.

Finally, worth mentioning is that GDP per capita in Denmark is US $59,832 growing at around 0.8 % and US $6,807 growing at 7.3 % in China.

3.7 SUMMARY

<table>
<thead>
<tr>
<th>Primary actors</th>
<th>Basic research</th>
<th>Applied R&amp;D</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+ Denmark (overall, esp. social sciences)</td>
<td>+ China (ICT)</td>
<td>+ China</td>
</tr>
<tr>
<td></td>
<td>+ China (natural and technical sciences)</td>
<td>+ Denmark (life sciences, energy and environment)</td>
<td></td>
</tr>
<tr>
<td>Secondary actors</td>
<td>+ Denmark</td>
<td>+ China</td>
<td>+ China</td>
</tr>
<tr>
<td>Institutions</td>
<td>+ Denmark</td>
<td>+ Denmark</td>
<td>+ Denmark</td>
</tr>
<tr>
<td>Input factors</td>
<td>+ Denmark</td>
<td>+ Denmark</td>
<td>+ Denmark</td>
</tr>
<tr>
<td>Knowledge transfers</td>
<td>+ Denmark</td>
<td>+ Both</td>
<td>+ Denmark (yet low)</td>
</tr>
<tr>
<td>Output factors</td>
<td>+ Denmark: research</td>
<td>+ Denmark (quality)</td>
<td>+ China: exports</td>
</tr>
<tr>
<td></td>
<td>+ China: graduates</td>
<td>+ China (quantity)</td>
<td>+ Otherwise mixed</td>
</tr>
</tbody>
</table>

Finally, worth mentioning is that GDP per capita in Denmark is US $59,832 growing at around 0.8 % and US $6,807 growing at 7.3 % in China.
At the very general level, we find that Denmark is stronger than China in basic research, with more mixed results in applied R&D and commercialization.

Both countries have strong innovation focuses, and have a presence of strong primary and secondary actors within selected industries across the value chain. Denmark’s institutions are evaluated to enable innovation more than China’s institutions do—something China compensates for with strong secondary institutions. Denmark is also evaluated to have better innovation input factors across the value chain after accounting for population and GDP size.

Both countries have potential to improve their knowledge transfers. For example, Denmark’s scientific paper output is a very good indicator of explicit knowledge transfers from universities, yet tacit knowledge transfers appear less prominent. Both countries underperform by international standards in knowledge transfers in the commercialization step.

In terms of output factors, Denmark’s basic research output is great and also produces low-volume, high-quality applied R&D output. China, on the other hand, is better at producing outputs such as many graduates within science and technology and a large number of national patent applications and high-tech exports.

4. DISCUSSION AND CONCLUSION

Denmark is a small country with a developed and advanced economy. Denmark punches above its weight within basic research. And while its applied R&D and commercialization achievements are good, there is potential for improvement. Denmark’s growth remains low after the financial crisis, with only 0.8 percent growth in 2014. New growth can be sought either via product or process innovations or via new market growth outside of Denmark.

China, by contrast, is a developing economy and the world’s most populous country with a population 240 times larger than Denmark’s. China is already a
significant global player within research, development, and innovation, largely driven by investments and political objectives. When compared with Denmark and OECD countries, China’s innovation output still lags behind other nations when GDP and per capita is accounted for. It will take more time before investments in quantity innovation input is matched by quality innovation output.

Existing innovation cooperation between Denmark and China largely reflect mutual strongholds as well as Chinese demand for solutions within e.g. sustainable energy, water and environmental protection, welfare- and social policies, design, leadership and food safety. There is Sino-Danish collaboration within the all three steps of the innovation value chain.

The purpose of this paper is not to conclude with what we already know Denmark and China can cooperate together on in terms of innovation, but rather to raise new questions and opportunities that Denmark and China can explore together. Based on data in the previous chapter, some reflections and questions are discussed in the following.

4.1 QUESTIONS AND OPPORTUNITIES

As China becomes a more direct competitor and competent partner to Denmark: how can Denmark boost its meager 0.8 % GDP growth by utilizing China’s transitioning economy?

The following table contains a brainstorming on this question – only with the objective to inspire conversation about potential areas for cooperation and growth; also among institutions in Denmark and China.

<table>
<thead>
<tr>
<th>Primary actors</th>
<th>Basic research</th>
<th>Applied R&amp;D</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Why do Danish researchers produce higher quality basic research than Chinese researchers</td>
<td>Why do young Danish SMEs patent so much? What can China learn from this?</td>
<td>Should Danish venture capital consider China for early stage investments?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Why are the</td>
<td>Should Danish</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Secondary actors</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Address co-funding mechanisms in MoUs</td>
<td>• Could Denmark benefit from providing incentives to patenting SMEs?</td>
</tr>
<tr>
<td>• Consider factor conditions and physical infrastructure for industry and academic cooperation</td>
<td>• Consider factor conditions and physical infrastructure for industry and academic cooperation</td>
</tr>
<tr>
<td></td>
<td>• Address IPR concerns and business factor conditions for Danish companies in China and vice versa</td>
</tr>
<tr>
<td></td>
<td>• Does &quot;sister cluster&quot; (equivalent of sister cities) programmes make any sense?</td>
</tr>
</tbody>
</table>

### Why do Danish papers get published in top-quartile publications?
- Identify need for reciprocal knowledge
- Map competencies and competence gaps to aid partner searches and joint opportunities

### What are the factor conditions to conduct bilateral basic research cooperation?
- Identify need for reciprocal knowledge
- Map competencies and competence gaps to aid partner searches and joint opportunities

### Identify need for reciprocal knowledge
- Map competing and competence gaps to aid partner searches and joint opportunities

### Map market entry barriers for Danish research-driven companies
- Identify need for reciprocal knowledge
- Is shanzhai product innovation something Denmark should learn more about?
- Map competencies and competence gaps to aid partner searches and joint opportunities

### Map market entry barriers for innovative companies in Denmark and China
- Address IPR concerns and business factor conditions for Danish companies in China and vice versa
- Does "sister cluster" (equivalent of sister cities) programmes make any sense?

### Could Denmark benefit from providing incentives to patenting SMEs?
- Consider factor conditions and physical infrastructure for industry and academic cooperation
- Address IPR concerns and business factor conditions for Danish companies in China and vice versa
- Does "sister cluster" (equivalent of sister cities) programmes make any sense?

### Consider factor conditions and physical infrastructure for industry and academic cooperation
- Address IPR concerns and business factors conditions for Danish companies in China and vice versa
- Does "sister cluster" (equivalent of sister cities) programmes make any sense?
<table>
<thead>
<tr>
<th>Input factors</th>
<th>Knowledge transfers</th>
<th>Output factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• How can Denmark benefit from China’s massive talent pool?</td>
<td>• Learn about science park set-ups and evaluate fit for Denmark</td>
<td>• Danish universities and public labs file more patents than the OECD average—</td>
</tr>
<tr>
<td>• How can Denmark get better at mathematics, science and reading?</td>
<td>• Identify best practices for joint research programmes and centres</td>
<td>• Which factor conditions allow many young Danish firms and few Chinese firms to</td>
</tr>
<tr>
<td>• How can Denmark benefit or utilize China’s massive talent pool?</td>
<td>• Consider factor conditions and physical infrastructure for industry and academic cooperation</td>
<td>• As China becomes a more direct competitor and competent partner to Denmark: how can</td>
</tr>
<tr>
<td>• Impact study of public R&amp;D spending in Denmark: consider fit for China.</td>
<td>• Identify best practices for joint research programmes and centres</td>
<td></td>
</tr>
<tr>
<td>• How can Denmark benefit or utilize China’s massive talent pool?</td>
<td>• Actively scout IPR holders and match potential licensing partners?</td>
<td></td>
</tr>
<tr>
<td>• Is there something for Denmark to learn from Chinese best practice entrepreneurial hotspots, like Zhongguancun?</td>
<td>• Joint-venture set-up: is there an optimal setup?</td>
<td></td>
</tr>
<tr>
<td>• Do Denmark and China have similar or different feedback mechanisms with knowledge gaps from commercialization to basic research and applied R&amp;D? Can something be learned here?</td>
<td>• Do Denmark and China have similar or different feedback mechanisms with knowledge gaps from commercialization to basic research and applied R&amp;D? Can something be learned here?</td>
<td></td>
</tr>
<tr>
<td>what can Chinese universities and public labs learn from this?</td>
<td>file patents?</td>
<td>Denmark boost its meager 0.8 % GDP growth by utilizing China’s transitioning economy?</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>---------------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>• How does Denmark achieve high research output per GDP, and what can China learn from this?</td>
<td>• China files record numbers of utility models and patents domestically: are these potential input factors for Danish companies to improve and take internationally?</td>
<td></td>
</tr>
</tbody>
</table>

### 4.2 CONCLUSION

There is much that Denmark and China can offer each other; synergies are likely to be found when focusing on cooperation and opportunities that mean exchange of knowledge (also about systems and policies, best practices etc.) and identification of growth areas. Strengthening institutions and framework conditions are more important for China and Denmark’s long-term development than developing or selling the next new, cool technology to each other, however, to ensure a more short term operational improvement some issues seem more apparent to start working on immediately; commercialization of Danish R&D in China, and knowledge transfer of ‘sitting’ patents could be good places to start.
5. LIST OF REFERENCES

- Danish Embassy in Beijing (2014): Confidential


• Global Innovation Index:


• Ministry for Science, Technology and Development (2002) *Danish law nr. 419 of June 6 2002 about technology and innovation*.


• Veldhoen, S., Mansson, A., Peng, B., Yip, G., and Han, J. (2014) *China Innovation Survey—China’s innovation is going global*.


5.1 Appendix 2: Distribution of Danish and Chinese University Students

Kinesiske og danske studerende fordelt på uddannelsesretning

- Humaniora
- Samfundsvideneskab
- Naturvidenskab
- Sundhed
- Pædagogik
- Forsvar
- Jordbrug
- Administration
- Teknisk
## 5.2 APPENDIX 3: KEY CHINESE POLICIES RELATED TO S&T&I

<table>
<thead>
<tr>
<th>Policy</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Medium and Long Term S&amp;T Development Plan (2006-2020)</strong></td>
<td>The main guiding policy for STI is the Medium and Long Term S&amp;T Development Plan (2006-2020) whose goals are further detailed in five year plans (FYP), such as the current 12th FYP for Science and Technology Development. These policies show an increasing focus on STI as a means to address societal challenges as well as focus on building up indigenous innovation by improving university-industry links, attracting overseas talent, enhancing intellectual property rights protection, and strengthening international cooperation.</td>
</tr>
<tr>
<td><strong>The Development Plan of National Strategic Emerging Industries (2011-2015)</strong></td>
<td>Industrial policy documents supporting STI include the Development Plan of National Strategic Emerging Industries (2011-2015), which aims to foster knowledge intensive industries such as ICT and biotechnology and five year plans for specific industrial sectors such as those for environmental protection, waste recycling technology, solar power development or for the bio-industries.</td>
</tr>
<tr>
<td><strong>National Plan for Building Indigenous Innovation Capabilities (2011-2015)</strong></td>
<td>There is also a National Plan for Building Indigenous Innovation Capabilities (2011-2015), which contains a number of measures to reduce China’s dependence on foreign technology, aiming at promoting Chinese-owned technology and IP. This has been viewed by foreign firms as a means to limit their business opportunities in China’s economy.</td>
</tr>
<tr>
<td><strong>Medium and Long-Term Talent Development Plan (2010-2020)</strong></td>
<td>These are human resources policies supporting STI. Both policies aim to encourage greater innovation and entrepreneurship whether among students or by attracting overseas talent. Educational reforms include promoting more intense cooperation between companies and the vocational education sector, and measures to address skills shortages in certain areas.</td>
</tr>
<tr>
<td>National Medium and Long-Term Plan for Building Key S&amp;T Infrastructure (2012-2030)</td>
<td>Policies to improve research and technology infrastructure. New major infrastructures are planned in seven strategic areas: energy, life science, earth system and environment, materials, particle physics and nuclear physics, space and astronomy, and engineering technology, which will be open to outsiders.</td>
</tr>
<tr>
<td>12th FYP for National High-Tech Parks</td>
<td>China has also planned to accelerate the development of high-tech parks, clusters, and incubators increasing their innovation support capacity and prioritising strategic emerging industries as well as the service sector. Recently, the western part of China has also become a popular place for SME clusters, with the government highlighting development in the region.</td>
</tr>
<tr>
<td>12th FYP for National High-Tech Incubators</td>
<td></td>
</tr>
</tbody>
</table>
5.3 APPENDIX 4: SELECTED PATENT DATA FOR DENMARK AND CHINA

Sources:

Danish Patent Applications by Top Fields of Technology (1999 - 2013)

<table>
<thead>
<tr>
<th>Field of Technology</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmaceuticals</td>
<td>11.58</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>9.95</td>
</tr>
<tr>
<td>Medical technology</td>
<td>8.25</td>
</tr>
<tr>
<td>Organic fine chemistry</td>
<td>6.66</td>
</tr>
<tr>
<td>Engines, pumps, turbines</td>
<td>5.22</td>
</tr>
<tr>
<td>Food chemistry</td>
<td>4.81</td>
</tr>
<tr>
<td>Civil engineering</td>
<td>4.47</td>
</tr>
<tr>
<td>Other special machines</td>
<td>3.71</td>
</tr>
<tr>
<td>Electrical machinery, apparatus, energy</td>
<td>3.49</td>
</tr>
<tr>
<td>Audio-visual technology</td>
<td>3.44</td>
</tr>
<tr>
<td>Others</td>
<td>38.42</td>
</tr>
</tbody>
</table>

Source: WIPO statistics database; last updated: 12/2014

<table>
<thead>
<tr>
<th>Applicant</th>
<th>Publication</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>VESTAS WIND SYSTEMS A/S</td>
<td>107</td>
<td>198</td>
</tr>
<tr>
<td>NOVOZYMES A/S</td>
<td>84</td>
<td>259</td>
</tr>
<tr>
<td>NOVO NORDISK A/S</td>
<td>63</td>
<td>336</td>
</tr>
<tr>
<td>DANMARKS TEKNISKE UNIVERSITET</td>
<td>48</td>
<td>443</td>
</tr>
<tr>
<td>COLOPLAST A/S</td>
<td>37</td>
<td>558</td>
</tr>
<tr>
<td>WELLTEC A/S</td>
<td>35</td>
<td>583</td>
</tr>
<tr>
<td>GRUNDFOS HOLDING A/S</td>
<td>28</td>
<td>731</td>
</tr>
<tr>
<td>HALDOR TOPSOE A/S</td>
<td>28</td>
<td>731</td>
</tr>
<tr>
<td>DUPONT NUTRITION BIOSCIENCES APS</td>
<td>27</td>
<td>764</td>
</tr>
<tr>
<td>F.L. SMIDTH A/S</td>
<td>26</td>
<td>798</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field of Technology</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital communication</td>
<td>8.72</td>
</tr>
<tr>
<td>Computer technology</td>
<td>6.75</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>6.29</td>
</tr>
<tr>
<td>Electrical machinery, apparatus, energy</td>
<td>6.16</td>
</tr>
<tr>
<td>Measurement</td>
<td>5.62</td>
</tr>
<tr>
<td>Materials, metallurgy</td>
<td>4.46</td>
</tr>
<tr>
<td>Basic materials chemistry</td>
<td>3.86</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>3.68</td>
</tr>
<tr>
<td>Civil engineering</td>
<td>3.44</td>
</tr>
<tr>
<td>Food chemistry</td>
<td>3.30</td>
</tr>
<tr>
<td>Others</td>
<td>47.72</td>
</tr>
</tbody>
</table>

![Pie Chart: Chinese Patent Applications by Top Fields of Technology (1999-2013)](chart.png)

*Source: WIPO statistics database, last updated 12/2014*
<table>
<thead>
<tr>
<th>Applicant</th>
<th>Publication</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZTE CORPORATION</td>
<td>2,309</td>
<td>2</td>
</tr>
<tr>
<td>HUAWEI TECHNOLOGIES CO., LTD.</td>
<td>2,110</td>
<td>3</td>
</tr>
<tr>
<td>SHENZHEN CHINA STAR OPTOELECTRONICS TECHNOLOGY CO., LTD</td>
<td>916</td>
<td>17</td>
</tr>
<tr>
<td>TENCENT TECHNOLOGY (SHENZHEN) COMPANY LIMITED</td>
<td>359</td>
<td>53</td>
</tr>
<tr>
<td>BOE TECHNOLOGY GROUP CO., LTD.</td>
<td>353</td>
<td>54</td>
</tr>
<tr>
<td>ZOOMLION HEAVY INDUSTRY SCIENCE AND TECHNOLOGY CO., LTD</td>
<td>284</td>
<td>74</td>
</tr>
<tr>
<td>HUAWEI DEVICE CO., LTD.</td>
<td>276</td>
<td>76</td>
</tr>
<tr>
<td>CHINA ACADEMY OF TELECOMMUNICATIONS TECHNOLOGY</td>
<td>227</td>
<td>92</td>
</tr>
<tr>
<td>INSTITUTE OF MICROELECTRONICS OF CHINESE ACADEMY OF SCIENCES</td>
<td>139</td>
<td>140</td>
</tr>
<tr>
<td>SHENZHEN BYD AUTO R &amp; D COMPANY LIMITED</td>
<td>130</td>
<td>150</td>
</tr>
</tbody>
</table>