OUTLOOK REPORT: DANISH R&D-INTENSIVE COMPANIES

AN UNDERSTANDING OF R&D ACTIVITIES IN CHINA

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Ministry of Higher Education and Science Denmark

MINISTRY OF FOREIGN AFFAIRS OF DENMARK

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FOREWORD

In the past three decades, China has experienced tremendous economic growth. Its average annual growth rate of approximately 7% has lifted millions of people out of poverty. Many Danish companies have been part of this economic transformation, especially through investments in Chinese production, distribution, and sales channels. Over the years, many companies have added R&D activities to their China activities. We know from the 'Survey of Danish Companies in China – Challenges and Opportunities'[1] that almost half of the Danish companies in China engage in R&D activities. In this report, we take a look at the most R&D-intensive Danish companies.

The report is prepared for Innovation Centre Denmark Shanghai, which was established in 2007 in a collaboration between the Danish Ministry of Higher Education and Science, and the Ministry of Foreign Affairs. Since then it has been bridging the Danish and Chinese ecosystem within higher education, science, and innovation. The centre has seen a remarkable development in Sino-Danish knowledge collaborations. In the period from 2010-2018, the number of joint academic publications with contributions from both Danish and Chinese authors increased by more than 400%. Denmark and China have a joint university centre, numerous exchange and research agreements, and a track record of joint bilateral funding calls for research and innovation activities.

With this report, the Innovation Centre Denmark Shanghai wants to facilitate a dialogue with Danish stakeholders by providing a first-hand perspective from one of the world's leading knowledge markets. The report provides insights into how the largest Danish companies conduct their R&D activities. Hopefully, this will provide inspiration for how the companies can utilise some of the existing networks and resources available for Sino-Danish knowledge collaborations.

Sincere thanks to our academic collaborators, Associate Professors Stine Haakonsson, Copenhagen Business School and Dmitrij Slepniov, Aalborg University and Programme Coordinator and Head of Educational Programme, respectively, at the Sino-Danish Centre for Education and Research. Also, the Danish Technological Institute and Jysk Analyse should be highlighted for their contributions to this report.

Finally, I would like to thank the interviewees and respondents to the survey. The answers come from the VP or director for R&D activities in China.

[1] https://kina.um.dk/en/the-trade-council/survey-of-danish-companies-in-china

INNOVATION
CENTRE
DENMARK

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EXECUTIVE SUMMARY

Over the past 20-25 years, several large Danish companies have added R&D activities to their engagement in China. This report provides insights into their activities and their experiences in China. The 30 most R&D-intensive companies in Denmark were invited to complete an online questionnaire; thirteen of those have R&D activities in China. Ten out of these 13 companies participated in a qualitative interview through their VP or director for R&D activities in China. The survey and interviews provide the data, which this report synthesises and presents.

The companies come from dvifferent industries; with about half from the pharmaceutical industry. They are very different in terms of size, ownership, and organisational structures. However, they all have their headquarters and the majority of R&D activities in Denmark. The Chinese R&D departments are typically governed under a global R&D strategy, with the R&D departments in China handling decisions in relation to client cooperation, research management, recruitment, competence development, and outreach to partners.

The output of the Chinese R&D efforts consists mainly of adjustments to products or the processes for existing products, or related to testing of products, materials, and processes in a Chinese environment. A few companies engage in research projects, which, in the longer run, become part of the global R&D pipeline. Thus, the mandate of the R&D departments is primarily to pave the way for the company in China through adaption of products to Chinese market, positioning the company, creating networks, and picking up on important technological and scientific trends that could go global in the near future. When research projects mature, the local mandate diminishes as HQ is getting more involved.

The approach to R&D in China varies between companies depending on their markets, regulation, experience, ambition, competences, and internal organisation. There are several reasons for companies to conduct R&D activities in China.

Market Access. China is a large and dynamic country with a population of 1.4 billion people. For pharmaceutical companies, a local R&D presence is necessary since they cannot launch new drugs without thorough testing (approval of the products) in the Chinese market. In this sense, the R&D department in China functions as a bridgehead to the Chinese market for Danish companies. In addition, the vast population in China means, for pharmaceutical companies, more patients and cases for clinical research. This can speed up testing and experiments for some drugs.

Market adaption and product development are two topics closely related to market access. The Chinese market is different from other markets on a variety of parameters, i.e., cost-base, regulation, culture, language, and standards. Adaption to the Chinese market through product

and process development is a big part of the R&D effort. Companies have their own testing facilities for quality assurance of both materials and products.

Sourcing knowledge, trends, and talent. In China, the technological development, academia, global companies, and therefore talent is highly concentrated around Beijing, Yangtze Delta, and Pearl River Delta. This is also where the R&D departments of the companies are located. Their physical presence and activities in these areas allow Danish companies to tap into the knowledge flow from universities, employees, partners, start-ups, and/or global leaders.

High-Tech status qualifies for tax deductions. According to the survey, tax deductions are not among the decisive reasons to locate in China, and government incentives are not a strong motivator for locating in China. However, it was mentioned in the case study that companies that receive a High-Tech status in China qualify for a significant tax refund per year. To obtain High-Tech status, companies are required to document significant R&D activity, primarily measured in Chinese patent registrations and a certain percentage of R&D spending compared to the revenue.

Crosscutting tendencies

Despite the differences between the companies and the variety of reasons for engaging in R&D activities, the report does identify a number of crosscutting tendencies. These tendencies point to issues that the companies generally consider either challenges or untapped potentials.

Recruitment of talent. The R&D departments are generally located in areas with high-performing innovation ecosystems and an inflow of talent from universities and other companies. However, the competition for the best available candidates is fierce, and the turnover is high while the R&D activities are growing. The companies need people with strong qualifications in their core competence fields.

Digitalization. Several companies stress that the digitalization trends in China are areas significantly more advanced than in other global markets and therefore could (for some, they already are) become a testing ground for advanced digital solutions in relation to optimisation of production processes, offering digital services to clients and, where relevant, to partners and consumers. Several companies express concern that they see rapid development within digitalization without having the means or capacity to take advantage of the insights.

Co-creation. The companies are looking to engage in co-creation processes with a broader range of Chinese partners. Currently, cooperation is primarily with business-partners (sub-delivers or customers), while cooperation with universities is still rare and interaction seems to be limited. Other co-creation partners can be start-ups or other large companies. The most

R&D intensive companies are already working with co-creation, utilising the open innovation concept as a pipeline for new products. For other companies, it remains the ambition to develop this form of relationship in the future.

Growth. In the years ahead, the R&D directors expect that the R&D activity in China will expand, including more collaborative R&D projects, more investments, more people, and an expansion of their network.

1. WHY THIS REPORT

A quick glance at one indicator of R&D activity, patents, clearly reveals the rapid evolution in Chinese activities. The activity can be gauged with a scan of the published patents[2] in global patent databases. The scan reveals more than 44,673 published patents (patent families) that each represent an innovation worthy of market protection. One in four patents is published by Novo Nordisk, followed by Novozymes, Danfoss, Lego, and Vestas Wind Systems. All of these have published more than 4,000 patents. In the 1,000 – 3,000 patent-range is FLS Schmidt, H. Lundbeck, Coloplast, and Rockwool.

Table 1 - Total published patents by Danish companies and affiliates in total and in China

Period	Total published	Published in China
1995-1999	3,523	0
2000-2004	3,568	19
2005-2009	4,638	125
2010-2014	7,391	259
2015-2019	10,112	384
2020*-	5,910	84

Source: DTI

Included companies and their affiliates in the search: Novo Nordisk, LEO Pharma, H Lundbeck, Danfoss, Novozymes, Ferring Pharmaceuticals, GN Store Nord (GN Hearing), Grundfos, Rockwool International, Haldor Topsøe, Hempel, ALK Abello, Danske Bank, Vestas Wind Systems, Demant, Coloplast, Ws Audiology,

[2] Figures are from DTI, tech mining global patent databases for this report. Internet, computer power, and digitalization of patents have opened a new analytical source of big data for monitoring indicators of global innovation and technological development. Since 2010 DTI has developed analytical approaches for tech mining in patent databases, partly in cooperation with the University of Georgia. Tech mining provide an overview for companies, analysts, or governments on trends, inventors, geographies, technological convergence, innovative clusters, measures of innovative strengths, national priorities, co-operating companies, industry leaders, and academic interests. It maps, measures, and compares competitors to companies, universities, regions, or countries.

Simcorp, Chr Hansen, Zealand, Pharma, Coop, NKT, TDC, Bavarian Nordic, Dako Denmark, Flsmidth, Orphazyme, Lego, Arla Foods, Sitecore Holding Ii, Nilfisk

Note: * Not all patents from 2020 are registered yet.

The number of Danish patents published in China has grown rapidly over the past 25 years, outpacing the overall growth in Danish patents. Between 1995-1999, Danish companies published a total of 3,523 patents, of which 0 were in China. In 2000-2004, those figures had grown to 3,568 with 19 in China. By 2015-2019, the numbers were 10,112 in total and 384 in China – more than 20 times as many patents in China as 15 years earlier. At this point, patents published in China were 3-4% of the total number of patents taken out by Danish companies. It is clear from the increase in patenting activities alone that Danish innovation in China deserves attention.

1.1. DATA AND METHODS FOR ANALYSIS

To get a deeper understanding of the practises, challenges, and results of the Danish R&D activities in China, an online questionnaire was mailed to the 30 most R&D-intensive companies in Denmark, as defined by the 2020 EU Industrial R&D Investment Scoreboard[3]. Of those 30, 10 semi-structured interviews were conducted with companies having R&D activity in China. The interviews were summarised in the form of case presentations (see Appendix A). All case material[1] presented in the Appendix has been approved by the companies before publishing. The analysis and reflections on data will primarily be based on those companies with R&D activity in China. You can find the entire online survey in Appendix B, and interview guide under Appendix C.

The questions formulated in both the online survey and the interview guide are based on perspectives in R&D internationalisation and global innovation. The academic literature on firms' internationalisation, and international business in general, has recently established that R&D is becoming part of the portfolio of international strategies implemented by multinational corporations. Firms are no longer doing all their innovation activities domestically or nearshore. Rather, to stay competitive, it is important to tap into different sources of knowledge and engage globally as innovation networks span geographically beyond their

[3] The 2020 EU Industrial R&D Investment Scoreboard | IRI (europa.eu)

home region, and beyond their value chain. Collaboration is therefore an integral part in R&D internationalisation efforts.

Data obtained for this report should reveal the depth and scope of R&D activities in China, with a specific focus on collaboration efforts within their innovation ecosystems. This report seeks to understand: (1) the background to R&D in China; (2) practises behind R&D; (3) an understanding of the output of R&D; and (4) relationship to the global R&D strategy. To understand this, several dimensions become relevant.

Construction of networks i.e., engagement with local and regional actors

The closer a network is to the existing value chain, the more likely the network is to generate incremental innovation, e.g., fine-tuning of products. Innovation networks spanning beyond the value chain, e.g., with universities, other value chains, science parks, or policy driven collaborations, are more likely to generate radical innovation - innovation new to market or industry. The network can span from a simple network merely consisting of sustaining a core network between HQ and the subsidiary, to co-creation in which the subsidiary has an established network of customers and partners with a joint value creation process.

Strategic motive

The strategic motive behind a firm's operations abroad can be determined by where, on the innovation value chain, the firm has its focus: a strong focus on *research* reveals that knowledge-seeking is the strategic focus area. *Development,* which is further downstream towards the market, indicates that market-seeking and product adaption is in focus.

Mandate and governance

Mandate here is understood as the licence to apply the subsidiary's distinctive capabilities to a specific market opportunity. The scope and scale of the R&D activities within an overseas R&D unit can therefore differ depending on its mandate from HQ. It can range from limited responsibility, acting as a supporting unit, to broad (and global) responsibility for new product introduction. Its mandate can further reveal its role in a global R&D strategy, as well as governance structures between HQ, its global R&D system, and the local R&D department.

Findings from the survey and semi-constructed interviews are presented in the following chapters: First, *Background to R&D in China* reveals the initial reason to establish a Chinese R&D unit(s). Second, *R&D Practises* disseminates how R&D is conducted in China. This includes an assessment of their internal and external networks, and how these are integrated into their existing business within research and development independently. Third, *Output of R&D* investigates the concrete outcomes from R&D units in China, in relation to the involved type

of R&D partner. This is subsequently assessed on results from research and development independently. Fourth, *Relation to Overall R&D Strategy* looks at the mandate and governance structure, and overall integration between HQ, global R&D, and locally. In the final two sections, we summarise findings of both *key challenges* and *future strategy* on R&D activities in China.

2. BACKGROUND TO R&D IN CHINA

China is not a novel location for most of the companies investigated. Companies have had R&D activities in China for an average of 12 years - spanning from R&D engagement since the 1990s to more recent establishments. Looking at *research* and *development* independently indicates no real differentiation; research activities have, on average, been going on for 12 years, while development for 13 years. This chapter is divided into two sections: (1) reasons behind locating R&D in China, and (2) reasons behind the geographic location(s).

2.1. WHY LOCATE R&D IN CHINA?

Danish companies take a range of factors into account when choosing whether to locate R&D activities in China (Table 2). Based on 10 respondents with R&D in China, the most important location factors are access to local know-how and talent, and access to market, followed by the need for product adaptation to the local market, and access to test and demonstration facilities. Although it can be a challenge to build up an R&D organisation or a sales organisation abroad, the companies surveyed do not see operational costs or investment costs as a priority in their location decision. Government incentives play only a minor role in the reported priorities.

Table 2 - Location of R&D activity in China – what is important?

	1. High priority	2.	3.	4. Low priority	Do not know
Low operational cost	10%	10%	30%	40%	10%
Low investment cost	10%	10%	20%	50%	10%
Access to local knowhow and/or talent	70%	20%	0%	0%	10%
Access to test and demonstration facilities	30%	30%	10%	0%	30%
Access to market	50%	50%	0%	0%	0%
Accessibility, especially access to an international airport	10%	40%	20%	30%	0%
Need for product adaptation to the local market	30%	40%	10%	20%	0%
Government incentives	0%	20%	50%	30%	0%

Note: Colouring of table is for easy navigation with red colouring for low figures and green for high figures.

Source: Survey

Interviews with drug companies, such as Lundbeck, LEO Pharma, and Novo Nordisk, highlighted the importance of locating R&D in China; they must conduct development

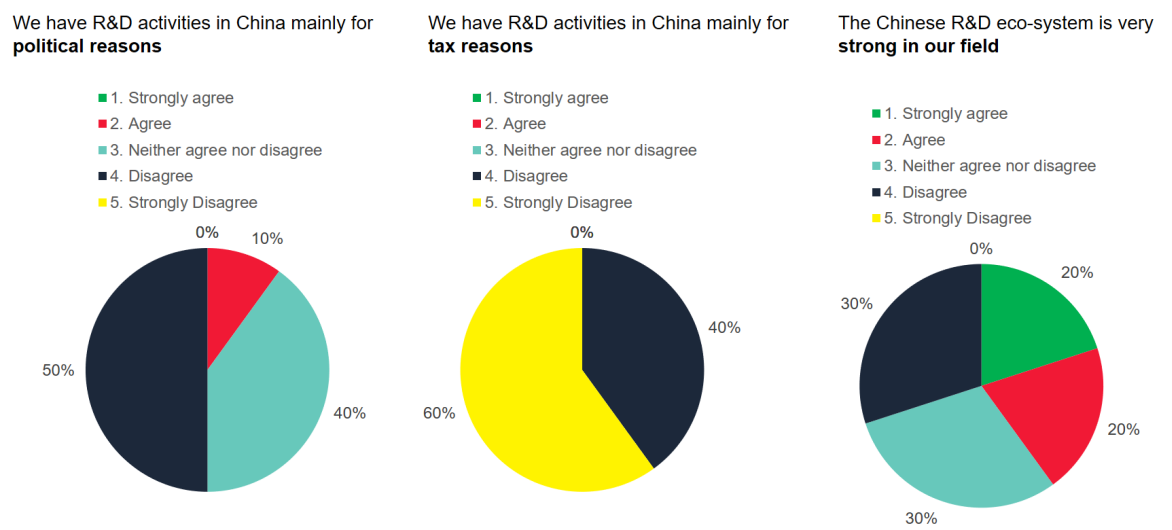
activities and clinical trials in China to sell their products on the Chinese market. ALK Abello stresses the importance of having a research lab in China for market access and competition reasons, in order to understand the distinctiveness of allergic constellations within the Chinese population. This knowledge allows for better design of allergy treatment in China, as well as for marketing. The biotech company Ferring points to several reasons for doing R&D in China: the market is highly attractive with much activity, venture capital, and a large population. Furthermore, the constellation of Ferring Institute of Reproductive Medicine (FIRM) in China allows it to connect with Chinese universities. Although this collaboration has not led to commercial products, Ferring does own commercialisation rights to research, which it funds through FIRM. The time to market from basic research can be from 10 to 15 years, so it is a long-time engagement. Ferring also mentions that China is interesting for testing since the size of the country and population means access to more patients and cases.

Danfoss Drives decided in 2005, alongside the establishment of a production facility, to start R&D activities in China for developing and producing frequency converters for simple applications. R&D facilities were established in Beijing, and the Chinese company Holip[4] was acquired to host production and R&D test activities, and is today an integrated part of Danfoss Drives.

Table 3 shows answers to whether there have been political or tax reasons involved in locating R&D in China, as well as whether the R&D ecosystem is strong in their field. Almost none have political reasons nor tax incentives to locate R&D activities in China. However, four out of 10 companies agree that the Chinese R&D ecosystem is very strong in their field. This answer is in line with the high prioritisation of access to local knowhow and talent from Table 2. That is to say, China can be interesting for recruiting talent. For instance, Hempel has indicated that the pool of talent in the (bio)chemical field, important for the paint and coating industry, is vast in China both in terms of R&D talent as well as production talent. As such, Hempel is benefiting from having R&D as well as production facilities placed in China, and sees China as a significant element in its global aim of doubling the total Hempel revenues in five years from 2020. Grundfos had a somewhat similar reason to first locate in China in 2005/06, establishing a support function to recruit R&D employees, given challenges recruiting engineers in Denmark. With Grundfos, it is interesting to notice that the idea of establishing R&D in China did not originate from HQ in Denmark; rather, it was a local request to strengthen talent acquisition.

[4] http://www.jslingyue.com/en/about/about/index.html

Figure 1 - Reasons to have R&D activities in China



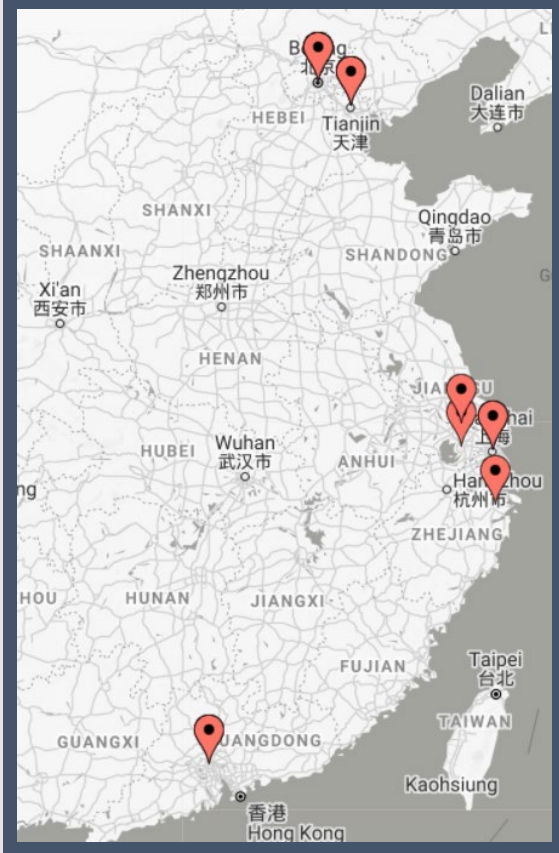
Source: Survey

2.2. DANISH COMPANIES LOCATE WHERE THE CHINESE ECOSYSTEM IS STRONGEST

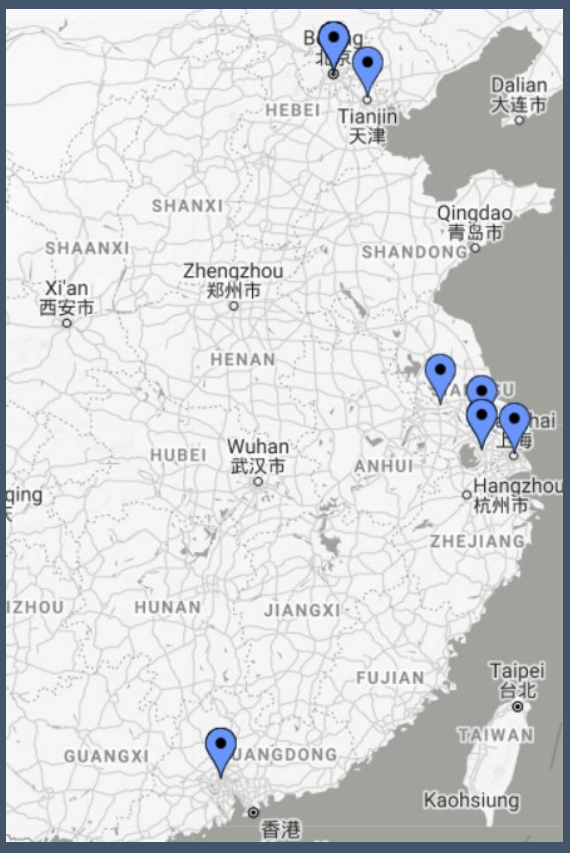
Danish R&D activities in China are based where the strongest innovation ecosystems are found. Survey answers indicate that R&D activities are concentrated in three areas: Beijing/Tianjin/Hebei, the Yangtze Delta region, and Pearl River Delta Metropolitan Region (Table 4). This does not come as a surprise as it is widely believed that these locations are the top tier locations in terms of innovation ecosystems. A map of locations for published patents by Danish companies (Table 5) reveals a similar picture, with a minor spread to other parts of China.

Figure 2 - Location of R&D activities in China

Location of research activities in China



Location of product and development activities in China



Source: Survey

Figure 3 - Geographical position of Danish companies holding patents in China

Note: Datamining, DTI. Data from global patent databases. Map is based on more than 1,300 patents published in China since the year 2000 by Danish companies. The current standard assignee address is used for the mapping and most patents have a Danish-based assignee. However, those patents that appear on the map have a Chinese address on the patent, from either the Danish company or an affiliate in China.

This distribution of Danish R&D activities is confirmed both in the case interviews and in the survey. The interviews brought us further insights into localisation decisions.

Lundbeck and LEO Pharma located their development departments, managing the clinical trials and product approvals near Beijing where the Chinese authorities are located. This provided the companies easier access to the authorities and management of the approval process. Furthermore, LEO Pharma also localised a R&D division in Shanghai because the region has a strong base of biotech companies and a vibrant biotech start-up ecosystem to tap into. ALK Abello's research facility is located in close proximity to other bio-based companies, which is deemed important to the research lab for networking and collaboration efforts through instrument-sharing platforms.

Hempel placed its R&D and production facilities right in the centre of a large chemical industrial area with good access to suppliers and partners. Hempel stressed the synergy effects of localising R&D and production at the same site, given that product development requires good access to materials and test facilities.

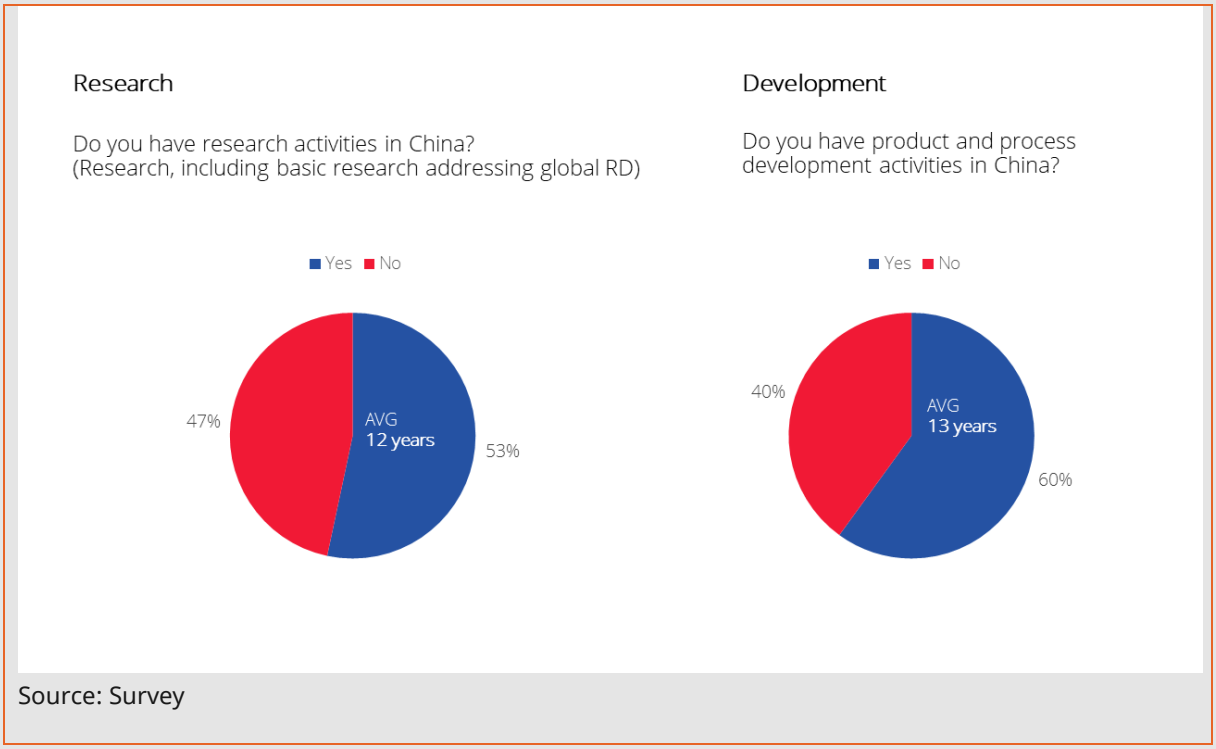
Rockwool has R&D activities in China mainly to be responsive to the local market, e.g., handling customer demand, calculating costs, adjusting recipes, and quality management, which includes testing of materials for production and final products. R&D towards new products is based with the HQ in Denmark.

3. R&D PRACTISES

The R&D process, as a rough generalisation, can be divided into two stages: (R) research activities, including basic and applied research, and (D) development. The development can adapt the products and services from a global company to a local market or it can be development of processes in production or sales.

In the survey, more than half of the companies answered that they have research activities in China, and slightly more indicated they have product and process development activities in China.

Figure 4 - Research and development in Danish companies in China



Source: Survey

Below, we explore the research and development practises by looking at which types of organisations the companies collaborate with. We do so in two steps: firstly, by looking at research activities and, secondly, at development activities.

3.1. COLLABORATION RELATED TO RESEARCH

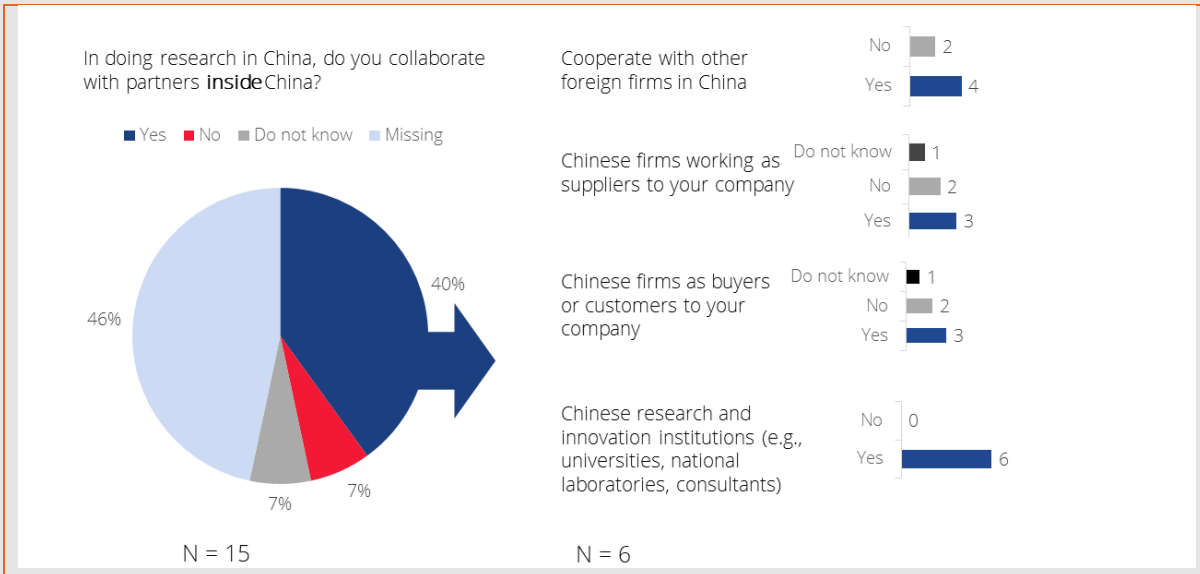
Six companies in the survey answered that they cooperate on research inside China. All of those engage in cooperation with Chinese research and innovation institutions, such as

Chinese hospitals or universities. Although Danfoss sees untapped potential in their collaborations with universities, there have been joint projects on access to computer power that allowed for advanced simulation. Meanwhile, Ferring currently has 44 academic research projects, in which Ferring is mainly financing the projects through the Chinese Academy of Science (CAS) in what is called the Ferring Institute of Reproductive Medicine (FIRM). Novo Nordisk is using the INNOVO© platform to attract research projects – often with hospitals, universities, biotech companies and consortia – that may later be part of the Novo Nordisk pipeline. Several companies do also cooperate within their value chain with Chinese suppliers or downstream with customers. Novozymes, for instance, assists its industrial partners in applied research in terms of bringing better value to its clients. Four out of six were also cooperating on research with other foreign firms in China.

The companies were also asked about research cooperation outside China. The answers indicate that research cooperation is coordinated with the Danish HQ and, in most cases, with company subsidiaries abroad. Lundbeck regularly makes use of external Chinese contract partners for specific research tasks. These research tasks are managed primarily by focusing on cost, quality, and flexibility, and coordinated closely with Lundbeck's primary research locations in Copenhagen, La Jolla, and Seattle.

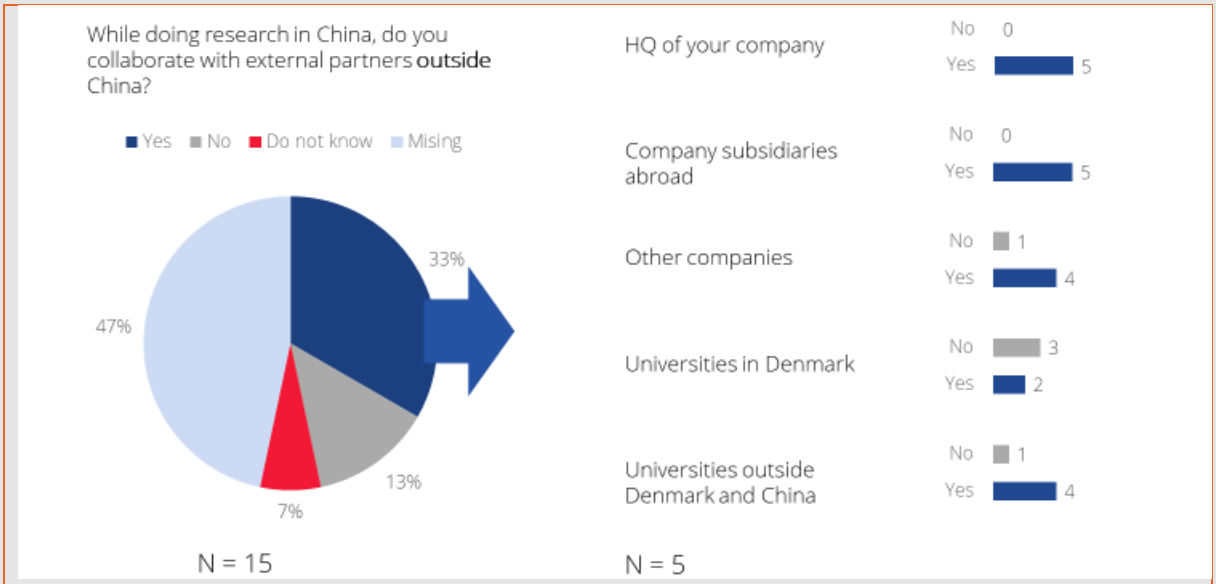
The survey answers also revealed that four of the five companies cooperate with universities in locations other than Denmark or China, and two out five cooperate with Danish universities. This may indicate a high degree of internationalisation or perhaps specialisation in the research with which companies seek knowledge on a global scale.

Figure 5 - Research cooperation inside China



Source: Survey

Figure 6 - Research cooperation outside China (from China)



Source: Survey

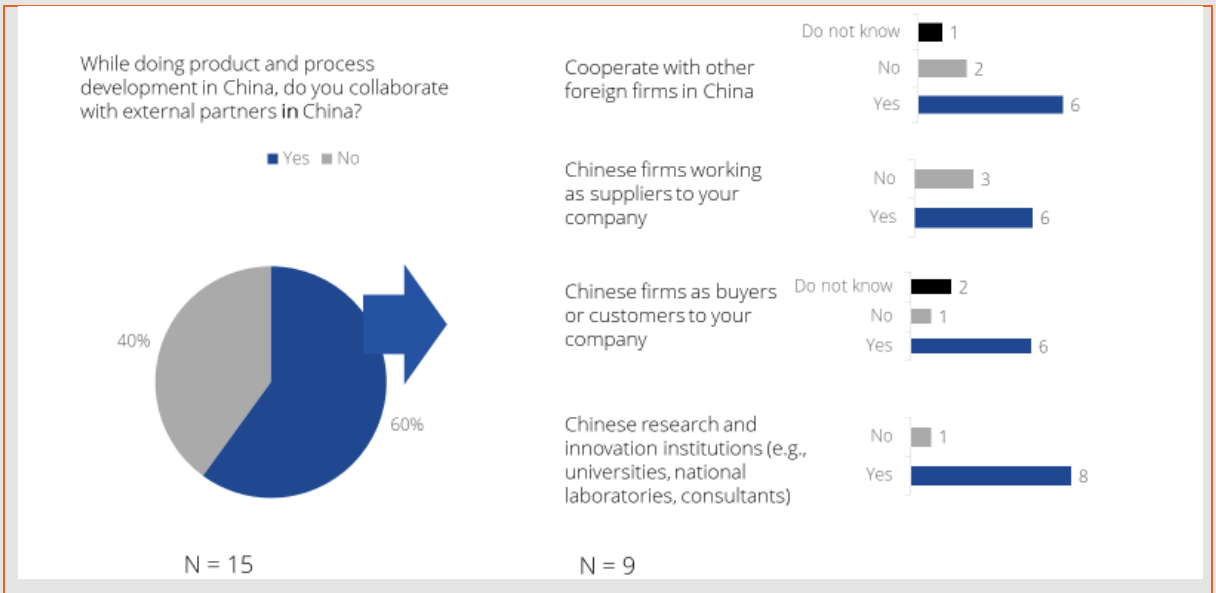
3.2. COLLABORATION RELATED TO PRODUCT AND PROCESS DEVELOPMENT

In relation to collaboration related to product and process development, almost everyone reported cooperation with Chinese institutions ranging from universities to consultants, and

two out of three cooperate both upstream with suppliers and downstream with companies. Two out of three cooperate with foreign firms in China.

From the interviews, the overall impression is that product and process development is the most important aspect for the R&D departments and that the focus is primarily adaptation to the Chinese markets to match demand, standards, and regulations. In the case of Rockwool, the R&D department set up production facilities and made arrangements with local suppliers, and test materials and products for their quality, durability, and strength. The Danish R&D department at HQ develops new Rockwool products. In concordance with Danish HQ, the department in China may modify the process or the recipes to better match Chinese conditions in the production or in the market. The Chinese R&D department cooperates with both suppliers and customers. Danfoss benefits from creating good working relationships with Chinese customers, seeking to understand the specific challenges and problems that the customers are facing to co-develop tailored solutions for these customers. Novozymes uses its university collaborations when research topics relate to ongoing technological development. Furthermore, Novozymes engages with universities for knowledge exchange and talent recruitment.

Figure 7 - Product and process development cooperation inside China



Source: Survey

4. CHINESE R&D OUTPUTS AND RESULTS

This chapter will look into outputs and results from R&D activity in China. The survey focused specifically on the relation between the type of partnership - both local (Chinese) and global - and different outputs in terms of partnership constellations. *Research* and *Development* is treated independently in this section.

4.1. RESULTS OF RESEARCH COLLABORATION

Table 11 shows the relationship between research output and type of local partnership. The most dominant partnerships are other foreign companies in China, and Chinese research and innovation institutions. The output from these two partnership types spawns research that is predominantly 'new to the world', which is research that can be applied within a range of industries. For Alk Abello, however, collaboration with universities, and technical consultants with clients, are set up to serve as a bridgehead to potential new solutions specifically in the Chinese market. An example is the Chinese house dust mite allergy market, which is the world's largest.

Glancing over research activities with partners outside of China (Table 12) we see an approximate 50/50 split in terms of whether research output is catered towards the Chinese market, or globally. These results indicate that some of the research is used specifically for products and processes in China, while there are some contributions from Danish R&D departments in China to a more global market.

The interviews revealed that the R&D responsibility for some departments extends beyond the Chinese borders. Ferring's main focus in China is to develop and commercialise products that may also be market-ready in Japan and elsewhere. The research requires clinical testing at both Phase 2 (testing therapeutic effects and safety of medicines) and Phase 3 (large confirmatory tests with thousands of patients; study of side effects). Novo Nordisk has a broad network of partners in China from universities to other biotech companies. Their Chinese open innovation platform (INNOVO©) contributes to Novo Nordisk's global R&D pipeline. Since the launch of INNOVO© in 2019, 70 projects in China have been reviewed, 23 projects have been granted access to the INNOVO© program, and two are now part of the global pipeline.

Table 3 - R&D Outcome of cooperation inside China

	Research new to industry	Research new to world	Don't know	Not relevant
Other foreign companies	2	4		9
Chinese firms as suppliers to our company	1	1	1	12
Chinese firms as buyers or customers to our company	2	1		12
Chinese research and innovation institutions, e.g., universities, national laboratories, consultants	2	4		9

Source: Survey. Numbers represent numbers of answers.

Table 4 - R&D Outcome of cooperation outside China

	Product/process new only to the Chinese market	Product/process new to the global market including to the Chinese market	No result	Do not know	Not relevant
HQ of your company	3	3			10
Company subsidiary abroad	2	2		1	10
Other companies	2	2		1	11
Universities in Denmark	1		1		13
Universities outside Denmark and China	2	1		1	11

Source: Survey. Numbers represent numbers of answers.

4.2. RESULTS OF DEVELOPMENT COLLABORATION

Turning the focus onto development in Table 13 reveals that when development activity is conducted in partnership with local suppliers and customers, that is cooperation within the value chain, focus is slightly skewed towards product adaptation to the Chinese market specifically. The interviews revealed several examples of these types of partnership. Danfoss Drive is a case in point. It has local test and development facilities where customers are invited to collectively test and specifically optimise products to customer needs. Focusing on development for the local market is naturally to gain a competitive advantage locally. Novozymes stresses the importance of both testing and validation of new products and technologies according to Chinese needs and local standards and requirements. Hempel is focusing on new developments, and has already gained a competitive advantage over competitors in many cases. However, it is not yet developing in China for its global demand. Grundfos also set up co-developing solutions with clients. The outcome of this type of cooperation is usually new to the client, but innovation output is rarely radical for the market in general.

Table 5 - R&D Outcome of development cooperation inside China

	New product/process only to the Chinese market	New product/process to the global market including to the Chinese market	Don't know	Not relevant
Chinese firms working as suppliers to our company	3	3		9
Chinese firms as buyers or customers to our company	4	2		9
Other foreign firms in China	1	5		9
Chinese research and innovation institutions, e.g., universities, national laboratories, consultants	2	4	2	7

Source: Survey. Numbers represent numbers of answers.

Table 6 - R&D Outcome of development cooperation outside China

	New product/process only to the Chinese market	New product/process to the global market including to the Chinese market	Do not know	Not relevant
HQ of your company	0	5		10
Company subsidiary abroad	0	4		11
Other companies	0	5		10
Universities in Denmark	0	1	1	13
Universities outside Denmark and China	0	2	1	12

Source: Survey. Numbers represent numbers of answers.

5. RELATION TO OVERALL R&D STRATEGY

R&D activities are organised differently in companies depending on products, company size, market demand, and strategic priorities. However, the vast majority of companies conduct their R&D activities in close coordination with the Danish HQ. In some affairs, or strictly local affairs, they act independently. This obviously plays out differently across the companies and, from our qualitative interviews, we can provide some sense of the differences.

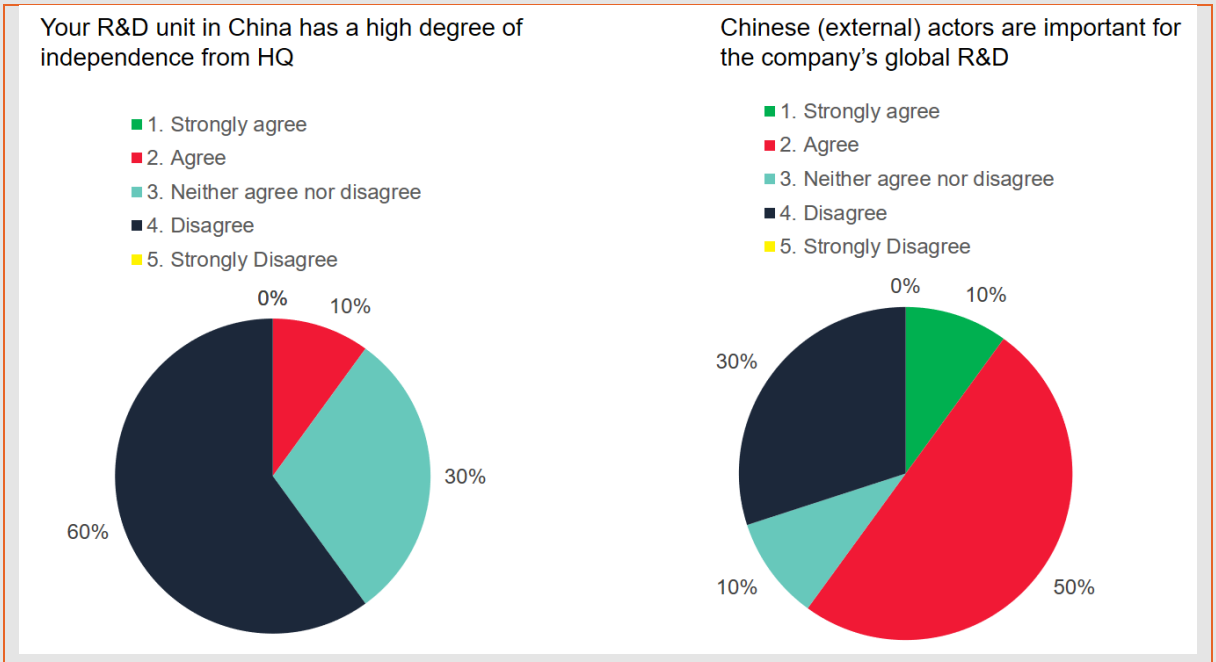
The Novo Nordisk Research Centre in China has high independence in establishing collaboration in early research phases with Chinese partners through the INNOVO© program based on open innovation. Whether research projects herein lead into the research pipeline is evaluated and decided in either China or Copenhagen. This is depending on resource need, data requirements, needs for competences, or technology. Much depends on the business prospects of the research. The Novo Nordisk Research Centre in China sees itself as part of a global organisation.

If Hempel China is to seek innovation through new types of raw materials, it requires a specific process, which is coordinated with HQ in Denmark to ensure mutual approach and quality. Approval further to initial tests is given at the head office in Denmark.

The Chinese R&D centre from Novozymes provides the global R&D strategy with (input) knowledge from the Chinese market. To strengthen a common R&D culture, Novozymes organises common global events with an opportunity for networking and sharing knowledge as well as through job mobility between the R&D centres.

The LEO Pharma R&D division in China is directly linked to the regional APAC R&D hub. Here, it emphasises not only the importance of local R&D, but also contributing to the global business development pipeline, in an effort to strengthen key areas of technological interest at LEO Pharma.

Figure 8 - Relation to global R&D in company



Source: Survey

6. CHALLENGES IN CONDUCTING R&D IN CHINA

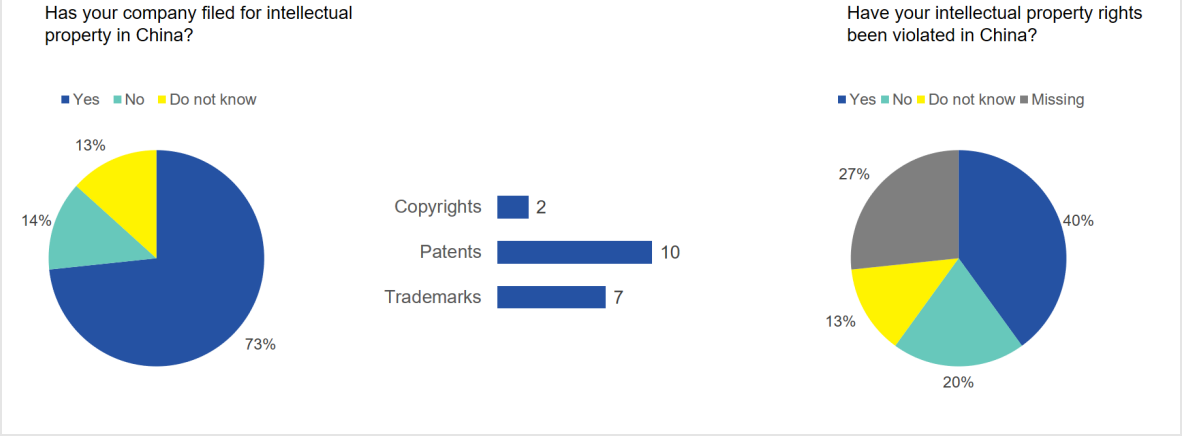
Some companies included in the survey do not have R&D activities. Findings suggest that certain frameworks, such as tax schemes, access to funding, NDA, and IPR are difficult to handle. One company specifically pointed to challenges with IP and language as main barriers to engage with R&D in China. Another statement highlights that current needs within R&D are met primarily in Denmark and elsewhere in Europe.

Companies established in China face several challenges carrying out R&D activity in China. The case interviews highlight a set of key challenges:

Intellectual property rights

Many of the Danish companies with R&D in China have filed for intellectual property rights (IPR) in China, as suggested by the patent activity from Chapter 1 and in Table 16. Further, Table 16 illustrates that 40% of respondents have experienced violation of IPR. This challenge has been mentioned frequently in the case interviews as well. Rockwool mentions IP protection and counterfeit products as a challenge, as well as the protection of know-how. It will increase its attention to both IP protection and fighting counterfeit products in the future. At Grundfos, IPR becomes very critical in co-developing solutions with clients. The issue of 'selling off their critical knowledge' is apparent; to overcome this, it has decided to use external legal advisors to overcome this challenge.

Figure 9 - Intellectual property rights in China



Source: Survey

Recruitment of talent

Several cases mention that the competition for talents is fierce. Companies are geographically located within innovation, the strongest innovation ecosystems in China. In such clusters, the demand is naturally high; they all need competent employees with know-how and experience. Talent retention is a general issue for several companies.

Data sharing

China has, in recent years, introduced a series of new data regulations. Data protection has further been intensified in China through its newly implemented data protection law. Ferring explains that it is a challenge to share data e.g., blood samples, within the company if the data is stored on servers outside China. Regulation is strict and always requires separate approval from the Chinese authorities. Novo Nordisk also mentions that in medical research it is difficult to work with data across borders because of human genetics-related data protection rules in both the EU and in China.

Universities not ready for commercial research

Danfoss has good connections with Chinese universities, but has had some difficulties in setting up projects with them. The younger researchers and PhD students generally work for the professors, and it is difficult to get them involved in Danfoss projects. Ferring similarly observes that researchers are less observant of the commercial value. Both Ferring and Novozymes acknowledge that part of their university-collaboration is also for university researchers to get a better understanding of research within business and hence understand the commercial value of research.

Chinese standards

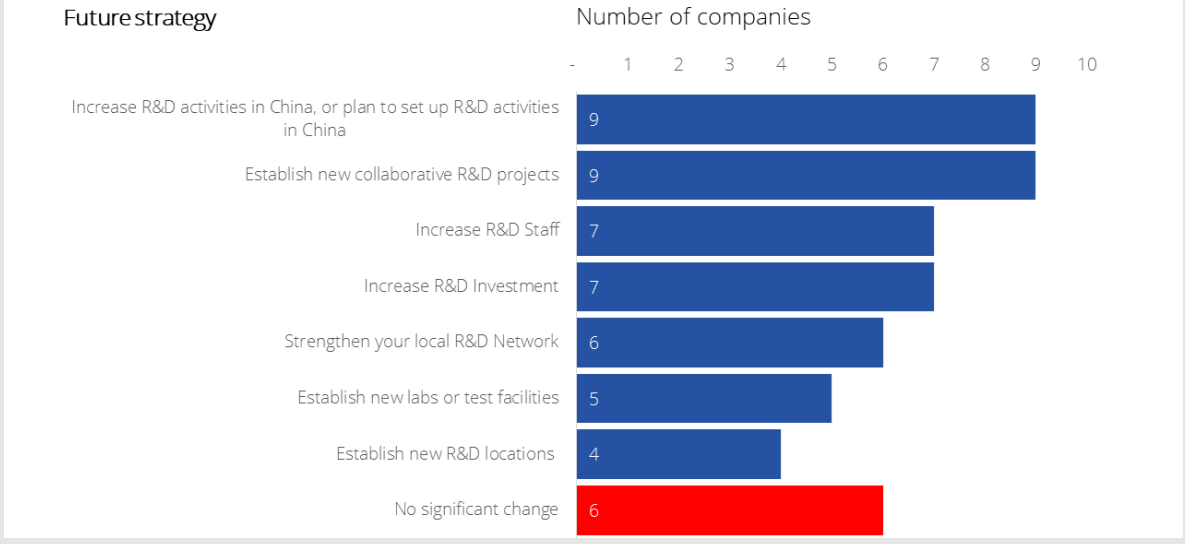
Living up to local standardisation requirements is a growing challenge. Grundfos has decided to recruit an expert who can handle issues related to standardisation and be a liaison officer to improve the collaboration with standardisation authorities. The role of the R&D department of Rockwool China is to ensure that its products are adjusted to local materials, including Chinese standards, or to meet local regulation before being introduced to the local market in China.

7. FUTURE STRATEGY FOR R&D ACTIVITIES

Two out of three of the companies expect to increase their R&D activities in the coming years, as indicated in Table 17. This can entail growth in their own capacity, such as more staff, more locations, more lab or test facilities, or investments. But a significant proportion of R&D increase also seems to be to expand their reach into the innovation ecosystem by establishing new collaborations on R&D projects or to strengthen the network. The case interviews provide some indications of the drivers behind such potential increases in the R&D activities.

Lundbeck highlights the opportunities in the digital field, and the expectation that it could benefit from examining this field in more depth to understand the digital opportunities concerning online access to medication for patients, use of digital biomarkers, and digital data sharing between stakeholders. The Chinese digital trends could, in many ways, be an indicator of what is going to happen globally. Similarly, Grundfos expects digitalization to continue to be a driver for its R&D-activities in China with Suzhou becoming the global R&D HQ for digitalization. Besides digitalization, Danfoss expects cost to continue as an important driver of future R&D activities. European Danfoss departments need to move in the direction of China by focusing on costs, whereas China will have to move in the direction of adding more features while sustaining the cost focus. Finally, several companies highlight the potential of working with various forms of co-creation or open innovation partnerships, whereby the companies find ways of engaging with Chinese knowledge partners, whether they are start-ups, academic institutions, customers or other companies.

Figure 10 – Future strategy



Source: Survey

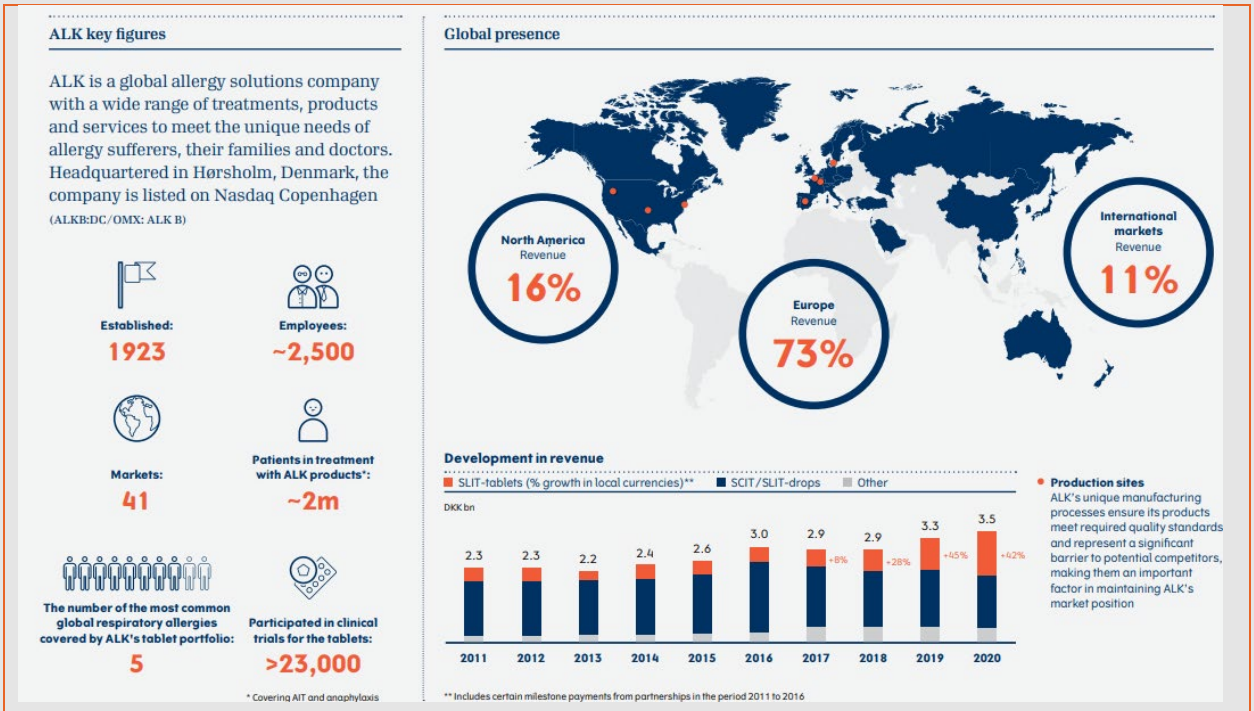
APPENDIX A: DANISH COMPANY CASES – R&D IN CHINA

ALK-ABELLÓ

ALK is a global specialty pharmaceutical company focused on allergy and allergic asthma. It markets allergy immunotherapy treatments and other products and services for people with allergies, and to allergy doctors. Headquartered in Hørsholm, Denmark, ALK employs around 2,500 people worldwide and is listed on Nasdaq Copenhagen. H. Lundbeck A/S, the Foundation, is the largest and controlling shareholder of ALK, owning 67% of the votes (40% of the capital).

ALK's existing business in China is centred around its subcutaneous treatment for house dust mite (HDM) allergy, Alutard® HDM, as well as Soluprick SQ® skin prick diagnostic tests. China is already one of the world's largest markets for HDM allergy immunotherapy treatments but has the potential to become significantly larger, and ALK is working towards a market introduction of its HDM tablet, ACARIZAX®[5].

Figure 11 - ALK at a Glance



Source: ALK Annual Report, 2020

[5] https://ir.alk.net/news-releases/news-release-details/alk-and-grandpharma-team-market-first-adrenaline-autoinjector

ALK spent almost EUR 70 million on research and development in 2020, the majority of this in support of clinical development for the SLIT-tablet portfolio.

ALK China has offices[6] in Beijing, Shanghai, Guangzhou, and Hong Kong. Since 2005 ALK has a research lab in China in Guangzhou.

The ALK research facility in China has a staff of one senior scientist (now senior manager), two biochemistry associates, and one technician. In 2005, the ALK-China research collaboration unit was established, and three researchers were transferred from Denmark to China to work in the lab temporarily. In 2006. Dr. Lai Xuxin started to work for ALK, where there are now six employees, with one working half-time; in total 5.5 full-time employees consisting of one director, 0.5 manager, two scientists, and two technicians.

The R&D is located in Guangzhou International Biological Island[7], houses a number of bio-based industries, and has its own research facility. Most of ALK Abello's research is based in the HQ in Hørsholm, Denmark, along with research in Spain where ALK Abello has a production facility.

Guangzhou International Bio Island

Alk Abello R&D is located as part of Guangzhou International Bio Island Co., Ltd (referred to as "Bio Island Company"). It was founded in September 2010 by the Administrative Committee of Guangzhou Development District with a registered capital of RMB 700 million; at present, it has introduced more than 80 biotechnology enterprises. The Bio Island Company has been providing an all-round 'one-stop' and 'nanny style' service system for enterprises in the park, which cover diversified services such as discussion of project, review and approval of site selection, industrial and commercial registration, property management, consultation on policies, conferences and meetings, and supporting services such as catering. Recently, establishment of a public platform of international standard for pilot plant test and launching fundraising for bio-industries are planned so as to create a sound bio-industrial system[8].

Guangzhou is a part of the Pearl River Delta Metropolitan Region that encompasses Hong Kong, Shenzhen, and Macau. The Metropolitan region is almost the size of

[6] Contact us | ALK

[7] GIBI--Biotech Island Introduction-Guangzhou International Bio Island Co., Ltd (bio-island.com)

[8] GIBI--Biotech Island Introduction-Guangzhou International Bio Island Co., Ltd (bio-island.com)

Denmark and has 78 million inhabitants, making it a megacity and one of the most densely populated cities in the world; it's also known as the 'Factory of the World'.

The leader of scientific affairs at the research centre in Guangzhou is Dr. Lai Xuxin[9]. Dr. Lai Xuxin went to Denmark in 2001 as a trainee in the global research department in ALK HQ for six months. The DTU supervisor acquired the Industrial PhD funding for Lai Xuxin, and she began her PhD studies in Denmark in 2002, concluding the PhD degree in Sep 2006. Since 2006, Dr. Lai Xuxin has been employed by ALK in China where she started to work in Guangzhou at the research lab. The research centre is all financed from the HQ in Denmark.

The ALK research facility has research projects with universities in Guangzhou as well as with a biotech company. The proximity to other bio-medical companies at Bio Island is important to the research lab for networking and collaboration. Bio Island also offers networking services and an instrument sharing platform. The research at ALK in China is from basic research to experimentation[10].

The research facility has several functions, from research in collaboration with universities to technical consultations with clients, and for ALK Abello it has the important function of a bridgehead into the Chinese market. China has the potential to become the world's largest house dust mite allergy market, with more than 75 million HDM allergic people against a backdrop of 300,000 who currently receive AIT treatment[11]. The research lab has been instrumental in branding ALK Abello in China as a company of the highest standards and strong scientific foundation.

The ALK research facility has quarterly meetings with the HQ in Denmark on priorities in projects including review of science's impact, and HQ may also provide scientific support for projects. The ALK research facility is not strategically involved in business or research decisions in ALK Abello. Dr. Lai Xuxin notes that digitalization and data-driven innovation are moving fast in China and, in general, Denmark could learn from Chinese experience.

The ALK research facility is not much into digitalization, and limitations set by data protection regulation on patient information in China also limit the opportunity to do data-based research

[9] Dr. Lai Xuxin was interviewed 23-11-2021

[10] At the TRL-scale Dr. Lai Xuxin places the research at level 1-3+4.

[11] https://www.thepharmaletter.com/article/allergy-specialist-speeds-up-china-program-for-slit-tablets

across borders. The commercial department in ALK Abello in China looks to improve the use of digitalization.

Another important function of the research lab is to better understand the allergies in the Chinese population that are different from allergies within the European population. This knowledge helps both research in Denmark to design the portfolio for treatment of allergy in China and for marketing in China.

Finally, the ALK research facility provides clinical advisory to marketing, supports HQ on regulatory affairs, and is part of collaboration with partner companies in development of new products.

It is a requirement to be registered as a legal entity in Bio Island, so this is in the near future for the ALK research centre. The requirement is also a part of environmental regulation in China and an expression of a vision of growth. In the future, on a 10-year horizon, Dr. Lai Xuxin expects that the activities in the research lab will expand from basic research to include development and deployment of a new product if a new diagnostic product is successful.

DANFOSS

Danfoss has 11 factories in China out of a total of 71 globally[12]. All three business divisions – Climate Control, Drives, and Power Solutions – are represented in China. Power Solutions recently acquired Eaton with a total of 11,000 employees globally, making the merged hydraulics company one of the biggest in the world. This report, however, focuses on the Drives division.

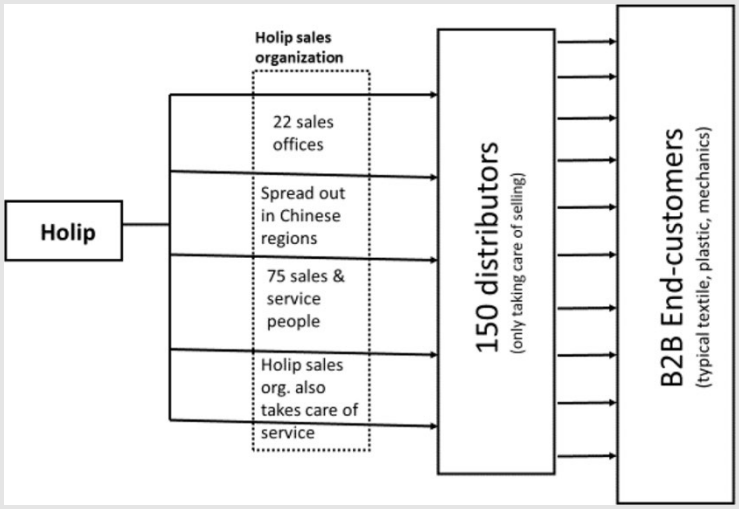
Around 45% of the energy in the world is used for turning a motor, so there is a huge potential for improved energy efficiency. Since 1969, Danfoss has been producing inverters for motors for saving energy in applications like building automation, heating and ventilation systems, and for various industrial applications in which goods have to be processed, sorted, or transported. The key selling points are quality, cost, and performance in relation to the ability to make applications involving a motor more energy efficient.

Danfoss decided in 2005, alongside the establishment of a production facility, to start R&D activities in China for making frequency converters for simple applications. R&D facilities were established in Beijing and the Chinese company, Holip, was acquired to host production and R&D test activities and is today an integrated part of Danfoss Drives (Figure 1 – acquired capability).

The Holip acquisition allowed Danfoss to introduce a second-tier brand of inverter products to supplement the more advanced inverter products in the portfolio. The production facilities are today producing products for Danfoss aimed at a global market. Locating production in China was to improve the production cost structure and to be able to compete in the Chinese low-end mid-tier market.

[12] Danfoss Annual report 2020

Figure 12 - Holip at a glance



Source: Danfoss in China: How Family-Owned Danfoss Turned China Into Their Second 'Home-Market'. Authors: Svend Hollensen, Britta Boyd & Toshio Goto; SAGE Publications: SAGE Business Cases Originals.

In China, the mid-tier market represents 70-80% of the market, whereas in Europe it only represents 40%. Innovation also matters in China, but the key factor is cost and hence innovation is also about getting the cost down.

Danfoss R&D set-up in China

Danfoss today employs 5,500 people in China. When Danfoss Drives started in 2005, there were 45-50 expats across all Danfoss divisions. Today, only a few expats are left; the rest is Chinese staff employed in the company. The business environment in China is moving more and more towards the Chinese language after 15-20 years of being influenced by English. The change towards local culture and local language towards the customers is today a pre-requisite to be successful in China.

With the Eaton acquisition, Danfoss Power Solution also added 30-40 R&D staff in China. Compressors in Climate Control has 150 R&D staff employed, which represents full R&D activity of the division in China. Danfoss Drives also has 150 employees in R&D. For the Drives division, there are also smaller R&D sites in Italy and Germany and big sites in Denmark, Finland, and in the US.

IP strategy in China

At the beginning, Danfoss decided that for IP reasons it would keep the sensitive part of the software development in Denmark and just develop the non-critical software part and the

physical products in China. After a while, Danfoss realised that cost optimization was limited by software and hardware development being physically developed on different sites. Consequently, the critical software development was moved to China to have all competences at one location for new product development.

Danfoss prioritised from early on to officially apply for High-Tech status in China. To obtain this status, companies are required to document significant R&D activity primarily measured in Chinese Patent registrations and a certain percentage of R&D spending compared to the revenue. This High-Tech status qualifies Danfoss for a significant tax refund per year. The High-Tech status for companies is, however, a moving target and the conditions are changing regularly based on where the government wants to have technology focus. Therefore, Danfoss needs to continuously adapt its R&D activities to fit the requirements. Nevertheless, High-Tech status requires substantial IP development every year to be maintained. In Europe, the patent strategy is focusing on patents on a higher technical level and has less focus on patents with lower-level inventions, as in China.

Local competitors for Danfoss in the Drives segment operate even deeper in the IP applications than Danfoss does. Even with the slightest sign of newness, the companies will file a patent application. Danfoss seeks a more varied approach to staying competitive. For instance, Danfoss has found that it benefits from creating good working relationships with customers by seeking to understand the specific challenges and problems that customers experience and adapting products to meet these requirements.

Attracting skilled staff

Danfoss has managed the IPR issues by introducing employment contracts that restrain employees who would leave Danfoss from working with a competitor for a year. Fortunately, for Danfoss, this contract clause has never been used. At the beginning, many of the newly-hired Chinese engineers was located in Denmark for training in products, processes, and tools. The training time the China engineers spent in Denmark helped in changing the Danish colleagues' perspective from 'Danfoss will move all activities to China now' into 'now we have good colleagues in China working on expanding the scope of what we can do.' After two years, a large number of the expatriates stationed for establishing the R&D facility China was relocated back to the headquarter according to plan, but it was needed and decided that they continue to work for the China organisation but in Denmark, as a bridge between the China/Danish organisation, understanding and translating both working cultures. Looking at

staff in peripheral roles, Danfoss has experienced staff leaving for pay rises of 20-30% elsewhere, but due to good working conditions and a better work-life balance, most of the key people have stayed on, and some of the staff that left then later returned. Nevertheless, attracting new staff, especially the requisition of talent with engineering competencies, requests higher attention in order to be successful going forward.

For instance, it is difficult to get blue collar workers in today's China. Young people (even master's graduates) would much rather do a job delivering packages than working in a factory assembling products. For Danfoss, therefore, attracting people is not only a cost-issue but also an image issue. Salaries in China are increasing at a higher rate than in Europe. Furthermore, local considerations, like bonuses, incentives etc. are expected.

Danfoss attracts new staff by offering clear project opportunities with full competence coverage in China. There are examples of other global companies in which people were hired in China expecting interesting R&D work but, after the training period, the expected R&D projects never came from global headquarters. For Danfoss, R&D projects were present from day one, and it was therefore easier to hold on to staff by engaging them directly in great R&D projects.

Danfoss uses external partners for 15% of the testing based on the external partners' test facilities. Mechanical design was outsourced in the beginning but had significant challenges. Danfoss Drives found quality issues with the hardware developed externally and the level of reuse of the external developed parts was limited.

Sustainable development goals

Sustainable development is the main driver for Danfoss. Everything the company does is linked to energy efficiency. Danfoss China uses Denmark and Danish cities as benchmarks to convince Chinese customers to invest in improved energy efficiency, but at the same time, there is pressure from the central government of Chinese city administrations to improve energy efficiency. This is where Danfoss steps in and offers significant savings on their power and water utility infrastructures.

In terms of business clients, the focus on sustainable development is becoming increasingly important. However, this focus is likely to grow faster in the future as pressure from government mounts. Many OEM customers of Danfoss are also establishing themselves in China as large proportions of their markets have moved to China (50-70%).

Innovation practices

Danfoss has good connections to Chinese universities, but when attempting projects with the universities, it becomes difficult e.g., to get PhDs to work on Danfoss projects. In Denmark, the Industrial PhD is a good tool, but this does not exist in China. The cost of what the universities would charge for supporting Danfoss R&D activities was quite high. Consequently, R&D collaboration with universities has not been used much by Danfoss. There have, however, been collaborations with universities to access computer power that would allow for advanced simulations.

Danfoss conducts R&D and innovation through both local developments as well as with Danfoss R&D sites elsewhere in the world. For one innovation project, it used the online tool Miro to support innovation processes across four different sites globally online. It worked well and has been repeated on other projects. Nevertheless, Danfoss does not believe in one solution for all. Most of developments in China are 80% based on adaption to local needs. Danfoss operates an Application Development Centre which offers a kind of R&D directly with the customer. At this centre, Danfoss tests and optimises products together with its customers.

The Chinese market is cost sensitive with multiple global and local players. Key to being successful is to be very accurate in selecting features, stretching technology, and being flexible without adding cost. In other words, R&D in China has a different focus because it is operating in a different market. Nevertheless, R&D in China is adding extra features to its mid-tier units so that it can defend the applications and the market for high-tier segments. Consequently, different market segments are merging, which also means better integration between R&D units globally. Danfoss simply must continue improving its collaboration across units to adapt to these market conditions by offering both the best cost options, as well as the best features for client needs.

The current trade war between the US and China also affects this corporate collaboration. In China, the realisation is that electronic components more and more need to be provided by local suppliers. Chinese customers are also influenced to purchase local supply when possible and, in certain situations, Danfoss is cut off because Chinese customers are prioritised over Danish businesses. Due to the scarcity and cost, Danfoss is seeing more Chinese suppliers emerging, e.g., for semiconductors.

Future R&D developments

Looking ahead, Danfoss expects the cost-driver to play a major part in future R&D activities. The products sold in China and in Europe will become more and more similar based on factors like usability and low cost will be implemented into the same solution. The global R&D setup and diverse focus within Danfoss is an important factor to achieve this in the most optimal way.

Currently, Chinese competitors are growing at a rate of 40-60% while Danfoss is growing at 25-30% per annum. China could be moving ahead of Europe in certain areas like robotics and digitalization. The Internet of Things is another focus area in China, becoming increasingly important and not to be underestimated.

Certain sectors in China are concentrated in certain geographical locations. For instance, there is a 'Crane city' in China where all the crane companies are located. It is important to evaluate this when placing a business and starting up in China, especially in relation to customers and suppliers

Going forward, the present local competitors in China are focused on fulfilling the global standards, through their own development or acquisitions, to be able to compete in the global marked, i.e., the work already done in Danfoss China will reused globally going forward.

FERRING

Ferring is a research-driven, specialty biopharmaceutical group, a leader in reproductive medicine and maternal health, and with specialty areas within gastroenterology and urology. Ferring was founded in the 1950s in Denmark by Frederik and Eva Paulsen and has since developed into a global company headquartered in St-Prex, Switzerland. Privately-owned, Ferring now employs around 6,000 people worldwide[13]. The products are distributed in more than 110 countries around the world. In-house production is carried out in Argentina, China, the Czech Republic, Denmark, Germany, India, Israel, Mexico, Switzerland, the UK, and the US. In China, Ferring has manufacturing facilities at the National Health Technology Park in Zhongshan City in Guangdong Province.

Figure 13 – Ferring R&D Locations

Source: Global Locator – R&D – Ferring Global

Ferring has R&D centres in Brazil, China, Denmark, India, Israel, Japan, Russia, Switzerland, the UK, and two in the US. The largest product development centre is in Copenhagen, Denmark while the main research hub of the network is the Ferring Research Institute in San Diego, USA. The Copenhagen and New Jersey sites drive and execute product innovation and development of new molecular entities as well as further development of existing in-line products.

Ferring Pharmaceuticals (Asia) Co. Ltd. is based in Shanghai. Ferring in China employees about 400 people and has a turnover of EUR 100 million. The HQ and R&D is in Shanghai with 60-70 employees, and production is in Zhongshan[14], with the most employees in regulatory affairs is

[13] Ferring Annual Report, 2020: Ferring-2020-Annual-Report-2020_Final_Digital_Spreads.pdf

[14] Manufacturing in Zhongshan City since 2005: Grand Opening of Ferring Pharmaceuticals (China) Co Ltd - Zhongshan Manufacturing Site - Ferring Global

based in Beijing. Ferring has been based in China for almost 10 years but was also active in China before. The R&D operations in China and Japan are headed by the chief scientific officer, Henk Jan Out[15], who has been with Ferring in China for two years; he has a long track-record in the Netherlands pharmaceutical industry and academia.

Development. The main purpose of R&D in China is development to commercialise products in China. That requires clinical testing at both Phase 2 (testing therapeutic effects and safety of medicines) and Phase 3 (large confirmatory tests with thousands of patients; study of side effects). The process from research to final, marketed product may last 10-15 years, if successful. Drugs approved in the EU or the USA need a similar testing process in China and Japan before approval.

Research at the corporate level is mainly done in Copenhagen and San Diego, and when research projects are started in China, they are usually initiated by the overall management in Denmark and Switzerland. The local decision power is practical to implement and oversee that the R&D processes are running; it maintains connections to the Chinese market, Chinese authorities, and Chinese development centres and universities.

Recruiting talent. One major challenge for Ferring is recruiting the right talent. The competition for talent in biomedicine is strong since many major global players are based in Shanghai. They all need competent employees that have know-how in their field and the experience to work in a global organisation. Language is a major barrier to hiring non-Chinese employees. The turn-over of employees is fast, and despite talent-retention programs, employees rarely stay at the same company for more than 2-2½ years. Employees are shopping new employers to increase salary or to get more prestigious positions. Chief scientific officer, Henk Jan Out, often experiences that applicants change their minds in the mid-hiring process and start with another company.

To overcome the recruitment problem, Ferring also has local partners in China to help with trials in the development of new products. How much to outsource is a balance and depends on the pipeline, explains Henk Jan Out. Much of the outsourcing regards monitoring clinical trials including documentation, verification, and lab-activities locally at hospitals, while in-house tasks are primarily project management. Henk Jan Out estimates that the distribution of work between in-house and outsourcing is about 50/50.

Testing in China is attractive since the size of the country means access to more patients. For example, in IVF centres, an area in which Ferring is very active, large centres in Denmark may have 1,000 IVF cycles per year, whereas there are hospitals in China with more than 40,000

[15] Interviewed 29-11-2021

cycles. The development process is challenged by bureaucracy, and it is a slow process in China where the procedures are not necessarily standardised. The Chinese authorities are working on a system to be more efficient and are mimicking the US system for approval of drugs.

Ferring has no direct R&D cooperation with competitors in the market since it is complicated with legal agreements for commercialisation. Ferring is a member of the R&D-based pharmaceutical association committee (RDPAC) that is organising and voicing common interest issues.

In the same way that Ferring is looking for ways to market its drugs in the Chinese market, there are already Chinese companies seeking cooperation with Ferring to find a way to move Chinese drugs into the EU and US markets.

Research. The research in which Ferring gets involved in China is very basic and Ferring currently has 44 academic research projects, mainly financing the projects through the Chinese Academy of Science (CAS) in what is called the Ferring Institute of Reproductive Medicine (FIRM). Studies primarily focus on infertility, obstetrics, and reproductive disorders[16]. [See also Ferring Institute of Reproductive Medicine advances research - Chinadaily.com.cn, and INSTITUTE OF ZOOLOGY, CHINESE ACADEMY OF SCIENCES (ioz.ac.cn)] FIRM was jointly founded by the State Key Laboratory of Stem Cell and Reproductive Biology (SRLab), the Institute for Stem Cell and Regeneration (ISCR[17]), the Chinese Academy of Sciences (CAS[18]) and Ferring Pharmaceuticals, based on a long-term strategic collaboration agreement to work closely together on both basic research and translational R&D. The mission of FIRM is to promote the clinical translation of cutting-edge biomedical research and provide solutions for the prevention, diagnosis, and treatment of reproductive diseases. FIRM is committed to improving scientific research through the discovery of novel therapeutic mechanisms and strategies for unmet needs in reproductive medicine and maternal health[19]. The collaboration network of FIRM extends all over China[20].

The reason for the engagement in research in China is both to liaise with universities and to further the leadership of Ferring in China. Henk Jan Out explains that academia in China is doing research at a high level and is very efficient at reporting in high-level publications – but less observant of the commercial value. So far there have been no direct commercial results since it is early research in a public-private partnership, and basic research of the market might

[16] https://watchthis.chinadaily.com.cn/content/WS60ec3035a310e0cf100f0783.html

[17] http://iscr.ac.cn/en/science/collaboration/firm

[18] https://english.cas.cn/

[19] Quoted from FIRM website: http://firm.ioz.ac.cn/

[20] http://firm.ioz.ac.cn/home/fg/?Network

take 10-15 years. In the agreement with universities, IPR from basic research belongs to the universities, but Ferring has a first right to exploit the results commercially. The research projects are overseen by a scientific committee with three representatives from the CAS and three from Ferring. There are quarterly meetings and yearly reviews to evaluate the innovative potential of the research. If there is a specific potential for innovation, the global R&D organisation of Ferring will be further involved. Commercialisation is not immediately in the mindset of the Chinese research organisation.

An important challenge for research is the sharing of data, even if it is data placed on servers outside China, or blood samples across borders. Regulation is strict and always requires separate approval from Chinese authorities. This is slowing the process.

The attractiveness of research in China is the speed and scientific options with large organisations, large availability of patients, and high-level expertise.

The future. Henk Jan Out observes that biotech is a very active market in China with much activity, much venture capital, and a market of 1.4 billion people. In the future, Henk Jan Out expects more globally- coordinated launches of new drugs if Phase 3 development can be done more effectively in China. But Phase 3 developments will also always be necessary in China since the Asian population deviates ethnically from the US or the EU populations and may therefore metabolise medicines differently.

GRUNDFOS

Grundfos is a Danish-owned, globally-operating company working with the manufacture and sale of pumps and pump solutions. In total, the Grundfos Group has approx. 20,000 employees.

Grundfos is in the process of transforming the company from being a supplier of pumps to a supplier of water systems targeting different market segments:

> In 2020 we announced a complete re-organisation of our Grundfos business. The new organisational structure serves two primary purposes: strengthening our ability to bring innovation to market; and serving our customers even better through customising customer journeys and experiences targeting specific applications and sales channels. For many years the Grundfos customer-facing organisation has been organised primarily along a geographical dimension. Going forward, we have chosen to organise our Grundfos business in four global customer segments covering Domestic Building Services, Commercial Building Services, Industry and Water Utility. The customer segments will be supported by our Global Service business. We have established cross-functional customer segment leadership teams that will drive end-to-end thinking to the benefit of our customers. [21]

In China, Grundfos has established seven subsidiary companies[22] focusing on manufacturing and/or sales, as well as with R&D activities in Suzhou. Briefly, the R&D activities have evolved over the last 15 years as follows:

2005/06	Due to challenges for recruiting engineers in Denmark, a support function was established in China, and the first R&D employees were recruited; however, the R&D strategy for China was not very clear.
2008/09	R&D became more focused on product development at a request from the Chinese sales company to have the opportunities to do local or their own R&D projects in China.
Up until 2012	The R&D expanded, and the number of R&D employees increased to 80 Chinese employees in addition to five to six Danish engineers stationed in

[21] Grundfos-Annual_report_2020.pdf, p. 4

[22] Companies in China: DAB Pumps (Qingdao) Co. Ltd. Grundfos (China) Holding Co. Ltd., Grundfos Pumps (Chongqing) Co. Ltd., Grundfos Pumps (Hong Kong) Ltd., Grundfos Pumps (Shanghai) Co. Ltd., Grundfos Pumps (Suzhou) Ltd., and Grundfos Pumps (Wuxi) Ltd. Grundfos-Annual_report_2020.pdf

China. However, the R&D effort did not have much impact on the Chinese market position for Grundfos. Instead of shutting down the R&D activities, the R&D activities became fully integrated in the global R&D set-up.

2013 – The R&D in China has carried out a mix of local and global projects and become the most global-oriented R&D unit in the Group.

The next step will be to implement the four global customer segments (performance goal, see above), of which one will be situated in China. Further, the Chinese R&D unit will have to establish closer partnerships with Chinese as well as global actors.

R&D and innovation in China

In general, Grundfos considers R&D as a critical business activity. 'Our R&D functions are globally organised with most activities placed at company headquarters in Bjerringbro, Denmark and with significant R&D teams in selected key markets such as China and India. R&D covers a wide range of activities such as research into materials, product development, production technologies and methodologies etc. We partner with universities, and public and private partners, supporting research activities and applying technology in practice.' [23]

Today, Grundfos has 140 employees in China working with R&D.

The aim of doing R&D and innovation in China

Grundfos is applying *a global R&D strategy for the entire group* but specialised within the four global customer segments (see above). However, it is challenging to establish a *common global R&D culture* as Grundfos has several physically-separated R&D units around the world. Grundfos has recently employed 40 researchers in China and one main challenge is to integrate them socially and culturally into the Grundfos organisation. Basically, the organisational set-up is the same in the entire organisation, but Grundfos has experienced different approaches to management. All in all, the Chinese R&D unit in Grundfos is very independent. To integrate it in the global R&D culture, Grundfos is organising common events for all R&D units. Due to the COVID-19 pandemic, it has organised common teams-sessions with professional content as well as elements to encourage teambuilding (socialising the global R&D team). However, it missed the opportunity to organise physical meetings as a stronger instrument to establish a common culture and trust among all R&D employees.

Partnership with external business or R&D partners is a part of the Grundfos business model. External partners are associated to Grundfos in areas of business in which Grundfos does not

[23] Grundfos-Annual_report_2020.pdf, p. 5

have the competences to do it alone, and/or if the cost and time to establish these competences are too prohibitive. Typically, Grundfos is partnering with other companies on an equal basis, expecting that the partner can fill a specific position in Grundfos, e.g., being a global supplier of control board/touch board or software solutions (digitalization), and thereby be a partner for the global business development and not limited only to supporting Grundfos in a local market.

Grundfos also has relations with universities, including two universities in China (hydraulic and software). Universities will typically be invited to take part in projects carried out at Grundfos, among others companies, to share knowledge; however, Grundfos is not directly involved in R&D projects at the universities or in other ways engaged in activities at the universities.

Conducting applied approach – benefits and challenges

When doing R&D in China, some challenges (barriers) are related to:

- *Recruiting:* In general terms, the needed competences/knowledge are present and the pool of experts, e.g., engineers, is sufficient in China (critical mass present on the labour market). However, Grundfos is challenged with regard to recruiting the top-qualified experts as Grundfos is not considered to be among the most attractive companies to work for in regard to salary (and the salaries are increasing), prestige, etc.[24] By the applied strategy of focusing on four global customer segments, Grundfos aims at changing its narrative from being a pump manufacturer to being a supplier of water systems and being a company based on a Nordic working culture with a good work-life balance. Hereby, Grundfos aims for a position as an attractive company in the Chinese labour market. Alternatively, Grundfos might recruit from India or the Philippines.
- *IPR:* As Grundfos is expanding the number of partnerships and collaborative relations, IPR becomes critical. Grundfos fears that it will be 'selling off its critical knowledge'. IPR or other kinds of agreements will be the tools used to manage these partnerships. It will apply different approaches to have these competences onboard, e.g., using a legal adviser (private or public services) or by recruiting legal experts.

In China, Grundfos is meeting other challenges such as:

- *Local standards* might be difficult for foreign companies to manage and therefore have an appreciable negative impact on business. Grundfos aims to recruit an expert who can handle issues related to standardisation and be a liaison officer to improve the collaboration with standardisation authorities.
- *Access to data* on the entire water supply system is critical for optimising the system. However, water supply is considered as critical infrastructure; consequently, access is limited to date. As operational reliability is the main competitive resource, and not the price, access to data is a critical parameter for Grundfos to demonstrate operational reliability.

Local authorities have been offering Grundfos (tax) *incentives* or other benefits. Grundfos has declined such offers as it fears that they might be a threat to keeping knowledge or IPR exclusively for itself.

Results and outcomes of R&D in China – relation to the overall R&D and innovation strategy

[24] If 10 stands for top-qualified experts, Grundfos is only able to recruit from layer 5 or at lower level.

Grundfos operated with two main types of R&D projects. First, global R&D projects with a duration of 24-36 months, and secondly, minor local-oriented R&D projects. The outcome of both types of projects are results that are new for the clients.

Grundfos China has excellence within digital solutions. However, new digital or cloud solutions often require training of the clients. Further, it is often difficult to transfer such technological solutions between different markets without doing some adaptation. Introduction of digital solutions will often be a long-lasting process.

In the years to come, R&D in the Chinese R&D unit will be even more dominated by Chinese R&D experts and managers being responsible for the development of new technical solutions. However, R&D will still be a common business area for the entire group influenced by the strategy and needs related to the specific area of business. Within the specific area of business, the ability to innovate together with the clients will become an even more critical competitive parameter as well as being able to deliver total systems for water supply and management (high-end products or solutions). At the same time, manufacturing of more simple or standard pumps might be outsourced. The R&D units must be able to position themselves in this global innovative landscape of Grundfos.

HEMPEL

Hempel A/S is a global supplier of coatings and services. Hempel finds its market in the protective, decorative, marine, container, industrial, and yacht segments. The company was founded in Copenhagen, Denmark in 1915 and today is owned by the Hempel Foundation. It is headquartered in Kongens Lyngby, near Copenhagen, Denmark. Globally, Hempel has 6000+ employees, 28 factories, and 15 R&D centres. In China, it has between 900-1000 employees with 40 employed in R&D.

Hempel has Chinese headquarters in Shanghai and operates factories at three sites in China: Yantai, Guangzhou, and Zhangjiagang (new building operational in 2022). In addition, it also has offices in Shenzhen, Hong Kong, Beijing, Dalian, and Qingdao in the Shandong province.

Hempel opened its first factory in Yantai in 1992 and has since become an established part of the local chemical coating industrial park and the local community at large. The buildings total 18,000 m2 and the size of the land is 52,000 m2. Production capacity is estimated at 102,000 tons/year covering the following coating types: waterborne, solvent-based, and powder.

Hempel has established a new factory in Yantai in order to sharpen its focus on delivering innovative and more sustainable coating solutions to customers in China. The Chinese market represents a significant share of the global Hempel business and, with this ongoing investment, Hempel seeks to demonstrate its confidence in the region.

The Yantai facility represents better production facilities to deliver on Hempel's goal of doubling revenue in the next five years to EUR 3 billion.

Figure 14 - Hempel new factory in Zhangjiagang, China being inaugurated in 2022.

Source: Hempel, official website, 2021

Hempel will open another new factory in the Yangtze International Chemical Industrial Park in Zhangjiagang, which will be the company's largest production site in the region with an annual production capacity of 200,000 tons.

Hempel has already opened a temporary R&D facility in Zhangjiagang and will move to the new facility at the new factory site in 2022, bringing Hempel's R&D network to a total of 15 R&D centres across the globe. The new facility will be a hub for the development of sustainable coating solutions aimed at customers in China.

Originally, Hempel R&D in China had five or six organisational layers. It was simply too many to operate efficiently. Today, Hempel has reduced the organisational complexity to three layers which support better communication and information flow. Communication between the R&D teams across the global regions is also actively encouraged and supported.

The Chinese R&D department conducts most activities internally, including internal testing. Contracting out is used for tasks for which Hempel R&D in China requires test equipment that it does not possess at its own labs.

Independent certification of equipment, production facilities, or products is sourced externally. Hempel China has recently required certification of two new factories. For one of these factories, Hempel was able to use a certification of one of the older factories, but for the second one it had to acquire a new certification. For all these certifications, ISO 9001 is the basic requirement.

The main competitors of Hempel are all non-Chinese global companies and, like Hempel, also located in China. There are local Chinese companies operating in this market, but they are still quite small and primarily serve the smaller projects, e.g., paint for bridges, etc. It does happen occasionally that Hempel loses to Chinese companies in China and typically on smaller projects. Somehow these Chinese companies navigate the certification process faster than Hempel and other foreign companies, giving them a clear advantage.

The Hempel code of conduct is extremely important, and it conducts regular training in its code.

Staff management in China

The R&D department in China invests in developing its staff to ensure internal succession planning. The main goal is that new managers are promoted up through the ranks. Offering advancement to management level drives engagement and motivation among staff. The opportunity to manage interesting R&D projects is a real attraction to employees. Employees

also become important promoters of their own workplace. Hempel staff identify and attract new colleagues via their own networks. Additionally, Hempel can attract new candidates in chemistry directly from universities. As such, Hempel is an attractive workplace for new talents.

It is vital to Hempel that all employees globally adhere to Hempel's 'Hempel at Heart' values: Connecting to customers, constantly challenging, inspiring confidence, and socially committed.

New lab

R&D in China is currently working on new developments which it hopes will soon deliver a competitive edge in China. Hempel is already leading in certain areas, but in China it is not developing yet for global demand.

The location for the latest chemical factory was chosen because it was right in the centre of a chemical industrial zone. Hempel has established R&D together with the production plant because Hempel's R&D also needs access to good raw materials' storage. Hempel always requires fresh materials, and it conducts testing in combination with the production systems. In addition, having R&D close to the production plant allows Hempel to invite clients who come visiting to view the R&D department and new products under development.

Hempel China wants to use the local science infrastructure more, but it has not been able to take advantage of this yet. It would like to offer internships for students in the future. Hempel's R&D director has been invited to do a presentation at one of the important universities of Shanghai and has agreed.

Hempel R&D in China maintains close relations to marketing and sales departments. As such, R&D is at the heart of the company. Sales and marketing require product certifications to enable trading. If Hempel China is to seek innovation through new types of raw materials, it requires alignment and approval from Denmark. Positive conclusions from initial tests of new materials will help in the process.

LEO PHARMA

LEO Pharma is founded and headquartered in Denmark, currently employing 6,000 professionals in 60 countries. LEO Pharma supplies treatments to people with medical needs in more than 130 countries around the world. LEO Pharma has the ambition to positively impact the lives of 125 million people by 2025. Around 960 scientists and specialists work within R&D in LEO Pharma.[25]

LEO Pharma has an ambitious 2030 strategy, positioning itself as a market leader and for long-term growth driven by innovation[26]. LEO Pharma seeks to accelerate its R&D efforts and rapidly diversify its portfolio of innovative medicines to cover a range of dermatological indications including rare diseases. LEO Pharma's R&D organisation is concentrated at the HQ in Ballerup, Denmark. LEO Pharma's product development is entirely based on insight-driven innovation[27].

The license agreements are important for LEO Pharma in adding to its pipeline and product portfolio and extending its international reach with new deals achieved.

LEO Pharma collaborates with academia, biotech companies, and pharma companies. It is interested in global and regional partnerships at all development stages, from early discovery to marketed products, covering the following[28]:

- Academia: PhDs, post-doctorates, and scientists on the verge of ground-breaking drug discovery.
- Biotech: Its agile and capable R&D organisation is ready to advance assets towards commercial success.
- Pharma: Collaborating on pharmaceutical assets or delivery technologies.

[25] https://www.leo-pharma.com/
[26] https://www.leo-pharma.com/media-center/news/leo-pharma-unveils-ambitious-2030-strategy-positioning-itself-for-long-term-growth
[27] https://www.leo-pharma.com/our-science/our-innovation-ecosystem
[28] https://www.leo-pharma.com/partnership

Figure 15 – Alliance Wheel LEO Pharma

Source: LEO Pharma, official website, 2021

Business in China

In China, net sales 2020 decreased by DKK 73 million compared to 2019, due very much because of the COVID-19 restrictions. Nevertheless, the pandemic has led to new ways of interacting with customers in China, with the online channel growing by 77% and accounting for 21% of sales, thereby offsetting some of the decline seen in the hospital channel[29].

LEO Pharma Group invests heavily in R&D and 21% of its total turnover was allocated to research and development of new innovative solutions in 2020[30].

As a concrete example of LEO Pharma activities in China, LEO Pharma has licensed global rights from two Asian biotech companies: Taipei-based Oneness Biotech and its parent company Microbio Shanghai.

LEO Pharma R&D in China

LEO Pharma commenced its R&D activities in China 13 years ago. This happened when LEO Pharma established a strategic company in China (December 2008)[31]. At that time, the key focus was on development and clinical trials with Chinese patients as a requirement for foreign medical companies for drug registration. R&D started in China as a requirement to be able to trade in China. Today, LEO Pharma is putting more resources into R&D in an effort to

[29] LEO Pharma Annual Report 2020
[30] LEO Pharma Annual report 2020
[31] https://www.fiercebiotech.com/biotech/leo-pharma-establishes-strategic-company-china

strengthen itself within focus areas and be a market leader. It has divisions in both Beijing and Shanghai.

The R&D department in Beijing primarily functions within regulatory affairs and clinical trials for new drug development and registration. Traditionally, all registrations need to be submitted on paper to authorities. Hence, it is placed in Beijing close to the regulatory authorities.

In Shanghai, it is focusing on supporting the global business development to feed the company's pipeline. It does this by screening the market for opportunities. It is seeking early opportunities in discovery and research, especially in key areas to further strengthen its market position; for instance, in small molecular research. In the big picture of LEO Pharma R&D, the Shanghai unit is small, and is seen as part of the R&D APAC hub. The APAC hub takes care of local interests, but also of widening the scope by having a global mind-set to facilitate the global LEO Pharma objectives and organisation.

Shanghai is an ideal place for scouting cutting-edge technologies, given the infrastructure of biotech start-up in the city. Shanghai is open and more international than other regions. The business environment in Shanghai is also one of the best in China, e.g., the government in Shanghai is very proactive in providing services to companies. Data showed a high patent activity in the life science area. At the same time, the biotech region was growing its share of biotech activity in China. Furthermore, other large biotech and pharmaceutical companies were also locating in the region.

LEO Pharma in Shanghai strives to build networks and ecosystems by running events and taking part in relevant conferences, this in an effort to promote LEO Pharma as a focused and innovative company that offers attractive cooperation opportunities.

LEO Pharma may also be interested in working with well-established companies. Here, it is looking at opportunities for licensing-in or licensing out. When working with early start-up projects, it is initiating a short one- to two-year initial collaboration in order to pilot-test the technology. After pilot studies, an evaluation will decide whether to continue collaboration.

Intellectual property rights

In Shanghai LEO has not encountered serious intellectual property rights (IPR) issues. HQ, local legal departments, and alliance managers will always be involved to identify related risks. Normally, if in-depth discussion is needed with a certain company, a non-disclosure agreement will be signed before any disclosure of confidential information.

Barriers

LEO Pharma is not that well known amongst start-ups and research institutions in China as compared to other big multinational companies. New and smaller biotech companies might not be aware of the opportunities within dermatology, and therefore raising awareness about the potential is important. It is doing this by spreading a unique message: 'Collaboration with LEO Pharma will be an important steppingstone for start-ups to enter the market for dermatology and treatment of skin diseases.'

Future

China is becoming more and more important to LEO Pharma – especially for development and clinical trials – to stay on the growth track. There is great potential to grow in the Chinese market and several opportunities lie ahead, and it is ramping up its ambitions in China, specifically by focusing on core areas within the LEO Pharma business while looking for more advanced technologies.

Academic collaboration presents great future opportunities. LEO is already utilizing the global dermatological community, for instance in Japan, and would like to push for more interaction with Chinese universities as well. LEO Pharma stresses that Denmark has very strong researchers in dermatology, who serve as a great opportunity for cross-border academic collaboration.

LUNDBECK

Lundbeck has both HQ and production facilities in Denmark, as well as production in the USA, France, and Italy. In addition, it has research centres in both Denmark and the USA. It has been present in China since the late 1990s and China has since become Lundbeck's second-largest market. The current R&D presence and activities in China are managed and conducted by +30 full-time staff who focus on development activities, whereas the research activities in China are conducted by external collaboration partners.

Figure 16 – Lundbeck at a glance

Source: Lundbeck, official website, 2021

Lundbeck in numbers

1915 – Founded in 1915 by Hans Lundbeck in Copenhagen.
5,600 – Approximately 5,300 employees worldwide.
70% – Largest shareholder is the Lundbeck Foundation owning approximately 70%.
100 – Products are registered in more than 100 countries globally.
70 – Lundbeck has been building its neuroscience expertise for over 70 years.
50 million – The portfolio of products reaches more than 50 million people yearly.

Lundbeck R&D in numbers

700 Global employees in R&D, of which the majority is in Denmark.
Two to three are employed in development departments.
One to three are employed in research departments.

Collaboration in China

Lundbeck has tried to establish new relationships with several leading academic institutions but found it too time-consuming and challenging to get valuable cooperation properly established. Working with primarily three contract research partners allows Lundbeck the flexibility to choose the research partner with the competences that fits the specific research task to be delivered. Lundbeck submits the research specification while the partners deliver the chemical compounds asked for and use their own equipment and staff. These research projects are managed primarily by focusing on cost, quality, and flexibility. Chinese research activities are then coordinated closely with Lundbeck's primary research locations in Copenhagen, La Jolla, and Seattle.

Emerging trends, the government, and competition

New trends are important for Lundbeck and right now there are new trends emerging in the Chinese pharmaceutical markets. The digital interfaces for patients to medical services is developing faster than in most other Lundbeck markets. Lundbeck's observations suggest that Chinese patients have better access to such services than their Western counterparts.

As a patient in China today, you may interact digitally with the healthcare system. Patients consult their doctors digitally, get their medicine prescription digitally, and receive their medicine from a digital pharmacy. Digitalization is a reality in China, and it might just be a question as to when we will see similar trends in Europe and the US.

Furthermore, in clinical trials and other medical processes, the Chinese sector is advancing in the use of digital biomarkers and digital data sharing between hospitals and general practitioners. The provision of digital data to patients is also progressing fast in China although, like Europe, there are significant GDPR requirements under way in China.

Overall, the Chinese government is making healthcare more widely accessible through digital means, and is increasing the focus and support for Chinese-developed and manufactured innovative medicines. These developments will accelerate the importance of the Chinese pharmaceutical sector from a global perspective.

The Chinese government is implementing new policies to address access to care and primary medicine in rural areas, and at the same time access to innovation and the treatment of rare diseases. There is a lot of changing policy to expand the availability of medicine across the country in general. All this is contributing to an expanding market for Lundbeck and other pharmaceutical companies.

However, the competition from innovative Chinese companies within Lundbeck's area of business is also emerging fast. Local companies are developing new and innovative products, and are beginning to pay attention to global markets through partnerships with pharmaceutical companies in specific target markets.

R&D & Innovation practices

In the area of development, Lundbeck has experienced an increase in quality, largely based on increased demands from the Chinese authorities and ongoing inspections of clinical trial processes and documentation. Among other things, this has also resulted in hospitals wanting to examine clinical trial data in-depth before these data are released. China has joined the ICH-collaboration, which adds additional quality assurances to processes and results. The staff operating on behalf of Lundbeck's global clinical trial partners have also improved in terms of skills and quality assurance as the documentation demands on Chinese hospitals have been increasing.

Current R&D & Innovation activities

Lundbeck is currently conducting three clinical studies for which they are collaborating with hospitals through their development partners who facilitate the process. Each clinical trial may be conducted at up to 30 hospitals.

Barriers within R&D & Innovation

Lundbeck has experienced some barriers in conducting research and development in China. From the Chinese government, there is an interest (and concrete regulation) to secure that the Chinese research and development partners, whether private companies or hospitals, must retain a share of the resulting innovation in some sort of IPR sharing model. Lundbeck further states that negotiations of site agreements in clinical trials can be a challenge.

Coping with the barriers

Lundbeck actively engages in a network with other global pharmaceutical companies active in China, to share experiences and learn how others have dealt with problems arising. To succeed

in the Chinese pharmaceutical R&D market, Lundbeck must act proactively and continuously seek contractual compromises.

In terms of development partners, Lundbeck is satisfied with the quality of the clinical trial results achieved. Development partners will submit clinical trial results ranging from 20 patients in an early phase to 1000 patients in a Phase 4 clinical trial. Lundbeck typically examines global development partners ahead of selecting partners for bids to understand their clinical trial experiences in the brain disease areas where Lundbeck operates.

Lundbeck's R&D Strategy

Following a restructuring of the R&D strategy in 2020, more than 20% of Lundbeck's revenue is now reinvested into global R&D activities. The Lundbeck business is very connected around the world, from basic research all the way through supply chain, commercialisation, and social media. Despite trade wars and regulatory barriers, it seems impossible to stop the trend toward a global community; there is too much to be gained from sharing information and sharing capabilities.

Despite this global collaborative approach of Lundbeck and many other global pharmaceutical companies, they find it extremely difficult to transfer clinical study data out of China to other research centres within Lundbeck for further analysis. Results of blood tests, for example, are particularly difficult to get out of China. The approval process to transfer clinical trial data out of China is generally challenging. Chinese authorities view data established in their country as the property of China and therefore aim to secure a share of the IP (if any) generated from the data.

Future Lundbeck R&D strategy in China

There are opportunities for Lundbeck in the digital field, and Lundbeck could benefit from examining this field in more depth to understand the digital opportunities moving forward. The Chinese digital trends could, in many ways, be an indicator of what is going to happen globally. More generally, China is a special market to operate in, but Lundbeck will continue its clinical development to maintain market access

Companies from the USA and the UK can exploit the access to well-educated resident Chinese in their countries; these residents speak both English and Chinese and thus can play a role in helping the companies develop their R&D and business activities in China. Danish companies do not have the same access to Chinese talents in Denmark with dual knowledge of Western

and Chinese cultural and language skills and are therefore dependent on building up the company culture while gradually growing the business in China.

Legislation and rules in both the R&D and the pharmaceutical sector are constantly changing, and this requires continuous ongoing adaption of the Lundbeck priorities globally as well as in China.

NOVO NORDISK

Novo Nordisk has a global research organisation with 12 R&D centres around the world[32] and more than 40,000 employees. Novo Nordisk was the first global pharmaceutical company to establish a research facility in China in 1997 with R&D collaborations in China beginning in 1994.

The research centre is in Zhongguancun Life Science Park in Beijing where it takes up six floors. The research centre in China plays a key role in the discovery of novel drug candidates. From the onset ,research was mostly in centred on industrial enzymes and healthcare but it has since expanded to pharmaceuticals.

The organisation in Beijing is divided between Research that employs a staff of 140 people and Development with a staff of 250 people. 40% of the research staff is from overseas. The Research centre focuses on research while the Development department is more oriented towards clinical trials, and regulatory and medical affairs. Dr. Han Dan[33] is responsible for research at the research centre in Zhongguancun.

Figure 17 – Novo Nordisk, 12 R&D Centres

Source: Novo Nordisk, official website, 2021

In China, Novo Nordisk R&D Centre is part of Novo Nordisk's global R&D system.

[32] Research & technology centres (novonordisk.com)

[33] Dr. Han Dan was interviewed 22.11.2021

The centre focuses on early drug target discovery and verification, to candidate drug molecular screening and optimization, and preclinical pharmacological testing and evaluation[34]. The R&D centre participates in many of the company's new drug research projects in the fields of diabetes, obesity, and other metabolic-related chronic diseases, e.g., non-alcoholic steatohepatitis, atherosclerosis, chronic kidney disease, etc.

For drug discovery, the centre has the technical capabilities ranging from early target discovery to pre-clinical research, and it has advanced research facilities, including world-class animal facilities that meet European standards.

Novo Nordisk China R&D Centre taps into the ecology and talent advantages brought by China's rapid development of biomedical technology and through extensive cooperation with biotech companies, universities, scientific research institutes, and hospitals.

The research centre in Beijing launched an open innovation platform, INNOVO®[35], in China in 2019, to increase partnership with local academic institutions and small biotech companies. The aim is to work closely with local innovation forces to strengthen and be part of an ecosystem of open pharmaceutical innovation cooperation that can contribute to Novo Nordisk's global R&D pipeline.

Novo's other research centres around the world work with open innovation strategies, but only in China has this been formalised with the INNOVO® programme. For the research centre in Beijing, the benefit of the program is the focus and the structure it gives to open innovation.

The open innovation platform contributes to Novo Nordisk's global R&D pipeline. So far, 70 projects have been reviewed, 23 projects have been started, and two are now part of the global pipeline.

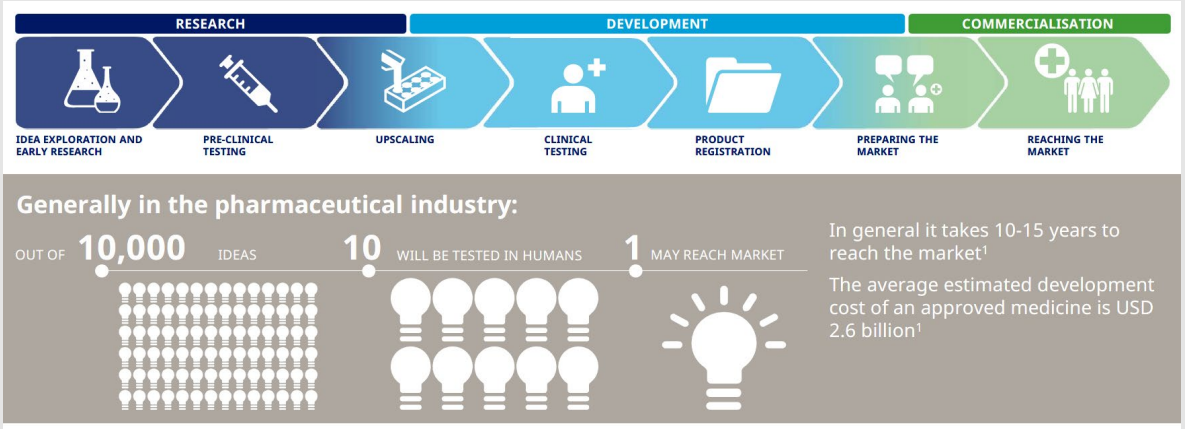
The partners come from universities, biotech companies, hospitals, scientific research institutions, and alliances, and the research covers multiple fields, including diabetes, obesity, cardiovascular disease, non-alcoholic steatohepatitis, artificial intelligence-assisted new drug development, and technology exploration.

New projects and collaborations under the open innovation start through personal networks, conversations, presentations at conferences, and researchers from the community reaching out.

[34] https://www-novonordisk-com-cn

[35] https://www-novonordisk-com-cn

Figure 18 – Overview of R&D process in the pharma industry



Source: Novo Nordisk presentation material

For Novo Nordisk, it is important to be part of the Chinese scientific society and to have INNOVO© as a mechanism to bring in all kinds of relevant innovations. The evaluation of research to proceed into a more formal research pipeline is a systematic decision, and the decision may lie in China at the research centre or at the HQ in Denmark, depending on resource needs, data needs, need for competences, or technology. Much depends on the business opportunities in a project.

The research centre sees itself as part of a global Novo research organisation, but it is clearly a challenge to be locally engaged and to maintain relations around the globe. Digitalization may be part of the solution and, at global scale, Novo works with digital communication both internally and externally.

Dr. Dan Han points to the specific challenge for collaboration on research involving human genetics- related data that is necessary in pharmaceutical research, but working with data across borders is difficult and heavily regulated by European GDPR regulation and new equivalent regulations in China. The process for approval of exchange and use of data may take up to two years or more.

NOVOZYMES

Novozymes A/S is a global biotechnology company focused on research, development, and production of industrial enzymes, microorganisms, and biopharmaceutical ingredients. Originally, Novozymes was established as an integrated part of what was Novo Nordisk in the 1940s. As a spinoff in 2000, Novozymes was founded as a dependent company and has since expanded globally (Textbox 1).

Figure 19 – Major events from 2000 to the present

2006: Acquisition of Australian biopharma company GroPep and UK-based biotech company Delta. This marks the start of the biopharma business.

2007: Novozymes acquires Philom Bios of Canada, a first step in producing biological products for the agricultural market.

2008: Inauguration of the world's largest enzyme fermentation facility in China, primarily with focus on products for the bioethanol industry.

2010: Acquisition of Brazilian bioagricultural company Turfal.

2011: Acquisition of EMD/Merck Crop BioScience. Inauguration of new hyaluronic acid plant in China.

2012: Inauguration of enzymes (for biofuels) plant in Blair, Nebraska.

2013: The world's first commercial-scale cellulosic ethanol plant opens in Crescentino, Italy using Novozymes' enzymes. In a transformational alliance, Novozymes and Monsanto come together to create The BioAg Alliance to develop and bring more sustainable bioagricultural solutions to farmers.

2014: The BioAg Alliance becomes fully operational, conducting more than 170,000 field trials in the U.S.

Source: Our heritage (novozymes.com)

Worldwide, Novozymes is represented by 47 companies in total of which 12 companies are performing R&D. Seven of the R&D performing companies also have business activities within production and sales & marketing while five have R&D together with sales and marketing (Textbox 2).

Table 7 – Companies in the Novozymes' group performing R&D

Company	Country	Production	Sales & marketing	R&D
Novozymes A/S	Denmark	x	x	x
Novozymes BioAg S.A.	Argentina	x	x	x
Novozymes Latin America Ltda	Brazil	x	x	x
Novozymes BioAg Limited	Canada	x	x	x
Novozymes (China) Investment Co. Ltd.	**China**		x	x
Novozymes Berlin GmbH	Germany		x	x
Novozymes UK Ltd.	UK		x	x
Novozymes Biologicals, Inc.	USA	x	x	x
Novozymes North America, Inc.	USA	x	x	x
Novozymes South Asia Pvt. Ltd.	India	x	x	x
PrecisionBiotics Ltd.	Ireland		x	x
Novozymes Japan Ltd.	Japan		x	x

Source: The Novozymes report 2020: PDF The--Novozymes--Report--2020.pdf

In China, Novozymes is present with four companies of which one is performing R&D together with sales and marketing (facilities in Beijing), while three companies have activities within production and sales and marketing (located in Tianjin, Shenyang, and Suzhou)[36].

R&D and innovation in China

'Novozymes was Denmark's most active European patent applicant at the EPO in 2018. In total, Novozymes filed 192 new applications, also making it number three in the EPO's overall company ranking in the field of biotechnology. … Novozymes markets more than 700 products, and one in five of the 6,500 employees work in research and development. 13% of

[36] See annual report 2002 and https://www.novozymes.com/en/about-us/management-ownership/subsidiaries

its total revenue is reinvested into research each year, and innovation typically expands the number of products by a double digit every year'.[37]

In China, 130 employees are working in research and development.

The aim of doing R&D and innovation in China

The R&D activities in China are a part of Novozymes' global R&D strategy formulated by the headquarters, indicating the focus of the technological development and the R&D to be carried out. The R&D centre in China supports this strategy by contributing to technology and product development both for the global market and China's regional growth. The R&D centre in China also has a role to stay connected with the science and technology ecosystem in China, which might bring additional innovation strengths to Novozymes.

Organisationally, the R&D activities are embedded in:

- Basic research R&D that leverages technology platforms focusing on basic scientific investigation that can support new product development.
- Applied research R&D, as several other R&D centres around the world, to develop the application in different market or industrial sectors, e.g., in China food sector, energy, and other sectors. The applied research R&D is working closely together with the commercial teams to adapt the technology to different needs in the market.
- In all, the R&D centre is not doing front-edge research but is focusing on product development and localization of solutions.
- To the Chinese market and hereby supporting marketing division.

Conducting applied approach – benefits and challenges

The R&D centre has a collaborative relation to:

- Chinese universities where the research topics are related to the technology or the ongoing technological development in Novozymes. The collaboration with the universities is also a platform for the exchange of knowledge and for recruiting new talent, e.g., through scholarships.
- Industrial partners (clients) in China where the aim is to assist the industrial partner to develop technical solutions or to do applied research/innovation of high value for the clients.

[37] https://www.novozymes.com/en/news/news-archive/2019/03/novozymes-named-most-innovative-company-in-denmark-by-european-patents-office

Globally, R&D activities in Novozymes are organised in the same way, though the performance differs. In China, the overall assessment is that R&D is carried out at a higher speed, and the involvement of the universities contributes thereto as the universities are also learning from business in terms of being dedicated and providing quicker scientific results.

Over time, the R&D centre has established a wider range of contact with the research environment and with the industry, having an interface with several sectors, established companies but also start-ups. In this sense, they have become more professional but also more open to the exchange of knowledge without sharing business secrets. Even though it is essential for the client to learn from Novozymes, knowledge sharing goes both ways. Today, the R&D centre has become more integrated in the ongoing business.

Doing R&D-based business in China includes facing barriers, but barriers might also be transformed into new opportunities. Import regulations might be a challenge, as a registration of food product /technology can take two years or even longer. It is also a matter of trust, and R&D carried out in China will contribute to building trust, especially through collaboration as well as important co-creation activities. Increased political focus, e.g., on green technologies and digitalization, might have a booming impact on research and thereby on introducing new technologies as well as on R&D collaboration.

Results and outcomes of R&D in China - relation to the overall R&D and innovation strategy

The Chinese R&D centre is contributing to the technology development and new solution development. The more direct contribution to the Novozymes' business is to adapt products/technical solutions to the Chinese conditions/needs. The established relationships to Chinese universities and the industry are important elements for success. The main outcomes or benefit of having R&D in China is that the R&D activities provide an access to:

- Test and validate new products and technologies according to Chinese needs and to local standards/requirements.
- The market insight and key regional industry players.

Among other advantages, the cost might be lower and, presumably, R&D can be done much faster. In the Novozymes group, the aim is that R&D is organisationally and culturally integrated. As such, the Chinese R&D centre (and other R&D centres) will provide the global R&D strategy with (input) knowledge from the Chinese market, e.g., specific technological needs or challenges. To strengthen a common R&D culture, Novozymes organises common global events with an opportunity for networking and sharing knowledge as well as through job mobility between the R&D centres.

ROCKWOOL

Rockwool Group is a global leader in thermal insulation, providing products and solutions to building structures. The products help secure fire safety and reduce the energy consumption of buildings, coupled with sound absorption, noise reduction, and indoor comfort. Rockwool has more than 11,000 employees in 39 countries, and 47 stone wool factories worldwide.[38]

Figure 20 – Rockwool global presence

Source: Yearly report 2020, Rockwool

Rockwool has more than 20 years of exploration and operation in China with two factories and about 400 employees in China. Rockwool has made an investment of 488 million RMB to build a high-quality fireproof and thermal insulation stone wool manufacturing plant in Guangfo (Fogang) Industrial Park, Guangqing Special Economic Cooperation Zone, Guangdong.[39]

Rockwool China has, at present, an annual stone wool production capacity of 140,000 tons in Guangzhou, Fogang and Yangzhou, and subsidiaries located in Beijing, Guangzhou, Hong Kong, Taiwan, the Philippines, and other major cities at present.

[38] 中国册子-英文-V4-小文件-20200224 (rockwool.com)

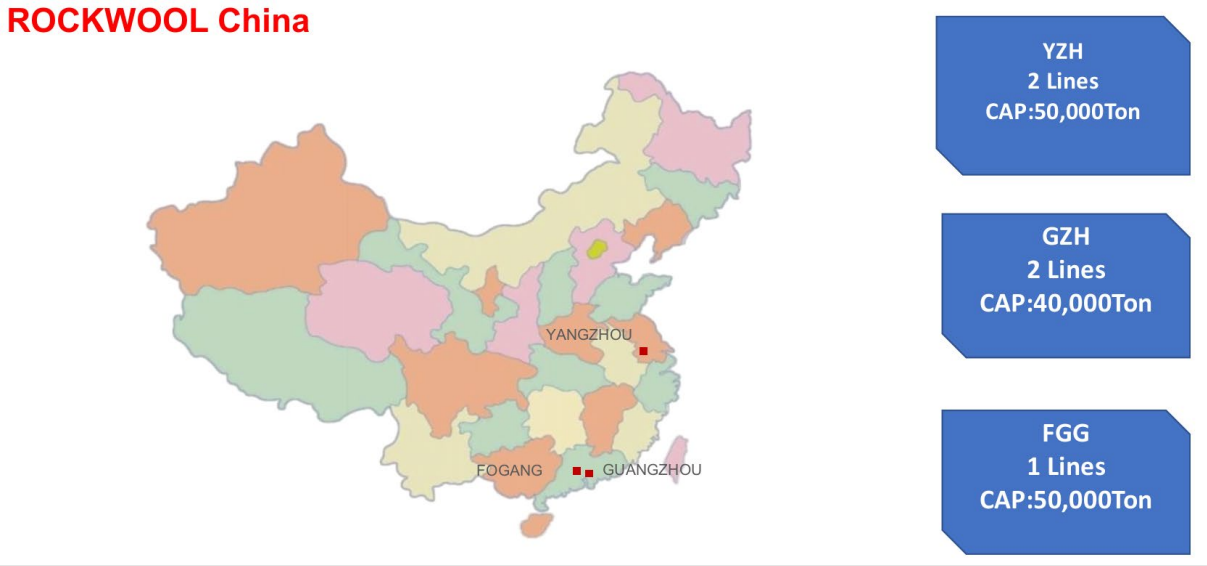
[39] ROCKWOOL Qingyuan Factory

Operations Director for Rockwool China, Gordon Jiang[40], explains that the products produced in China are building insulation (exterior wall insulation, roof insulation, and other), passive fire protection, and products for industrial applications. The raw materials for stone wool are stones such as basalt or dolomite that are melted at temperatures exceeding 1,450 degrees Celsius in a cupula furnace then spun, cured, cut, and packed into products.

In China, the Rockwool R&D department has existed since 2015. The department employs five people: one manager, two process engineers, and two project managers. The R&D department reports to the operations director and the operations director reports further to HQ in Hedehusene. Much is controlled from the HQ, such as QA and R&D sending both materials and products as well as new recipes to HQ for approval.

The R&D department is occupied mainly in development by introducing new products from Rockwool. The department locates and sources raw materials and equipment, and engages in continuous projects to improve efficiency and quality of the production. Products are developed by the R&D department in Hedehusene. The role of the R&D department of Rockwool China is to secure its products being adjusted to local materials and Chinese standards and meeting local regulations before being introduced to the local market in China.

Figure 21 – Rockwool China



Source: Rockwool presentation

The R&D department in China has its own laboratory facilities. The laboratories are used for testing products and materials or adjusting recipes for the production and so forth. The

[40] Interview with Operations Director for Rockwool China, Gordon Jiang, 01 December 2021

laboratory equipment can measure, e.g., compressive strength, tensile strength, shear strength, water repellence or absorbance, thermal conductivity, chemical composition, or density, among others factors. Gordon Jiang estimates that 70% of the lab-testing needs are met in-house. The rest is external testing, such as fire testing, requiring a large setup.

Rockwool has R&D capacity in China to implement the strategy of Rockwool. It is necessary for Rockwool to also have the technical and development capacity in China to follow the R&D procedure from the HQ, handle recipes for the production, source and test material input for production, test equipment, and oversee installation of technology; in the production, the R&D department is also responsible for running tests and pilots. Finally, the R&D department can be part of the product promotion.

The main reason for Rockwool to have R&D Capacity in China is the need to be responsive to the Chinese market. Being responsive to the local market means, for instance, that the R&D department can handle customer demand on, e.g., calculations on cost and quality performance of insulation, provide information about fire resistance, strength, and aging of products, lengthy life span, environmental impact, and energy consumption.

The R&D department can better handle customer feedback and complaints. Further, the R&D department helps answer technical demands of a new bidding project, or monitor and provide feedback on threats from competitors.

Finally, responsiveness to the local market for Rockwool R&D entails working with local partners and suppliers of material and technology related to the production. The main partners are therefore suppliers of binders and additives used in production as well as of equipment or production line suppliers.

The R&D department has been involved in the development process to produce low-formaldehyde products that are safe and comfortable, and to develop dual density stone wool slabs to be both energy saving and cost-effective. The R&D department has also been involved in creating super fire-resistant and super aging-resistant products.

The R&D strategy in China is following the group strategy of creating products that are green and energy saving, low on emissions and water use, while safe and comfortable to use.

The R&D department in China can supplement R&D activities elsewhere within Rockwool by troubleshooting and proposing improvements, but the activities mainly concentrate on the local market. The activities in R&D China are moving towards product innovation, with a focus on cost-effectiveness, quality performance, and new products.

The main challenge to Rockwool in China is the competition. There are other producers of stone wool insulation in China and, while variable product cost in production is close to that of local competitors, the selling price of Rockwool products is still 40% higher. Rockwool succeeds in this because it is a premium product and cost-effective in the long run. But competition is

fierce, and competitors have developed quickly in the past 10 years while improving on their quality.

Gordon Jiang also points to IP protection and counterfeit products as a challenge as well as the protection of know-how. There will be more attention to both IP protection and fighting counterfeit products in the future.

Recruitment for R&D at Rockwool in China is a challenge since there is no one with specialised knowledge on stone wool production; new talent needs internal training. It is a threat when employees move on to competitors so, to protect Rockwool, the R&D department works with NDAs with employees.

While the Rockwool China R&D department is involved in both development and innovation, Gordon Jiang also expects that the R&D department will work more closely with industries, especially the chemical industries, in the future, as well as conducting more research with universities and institutes, but this will require more resources. A very relevant area for further research in China is fire resistance. So far, the R&D department has not yet been involved in more basic research and it has not taken out patents, but Gordon Jiang sees that as an option for the future

APPENDIX B: ONLINE SURVEY

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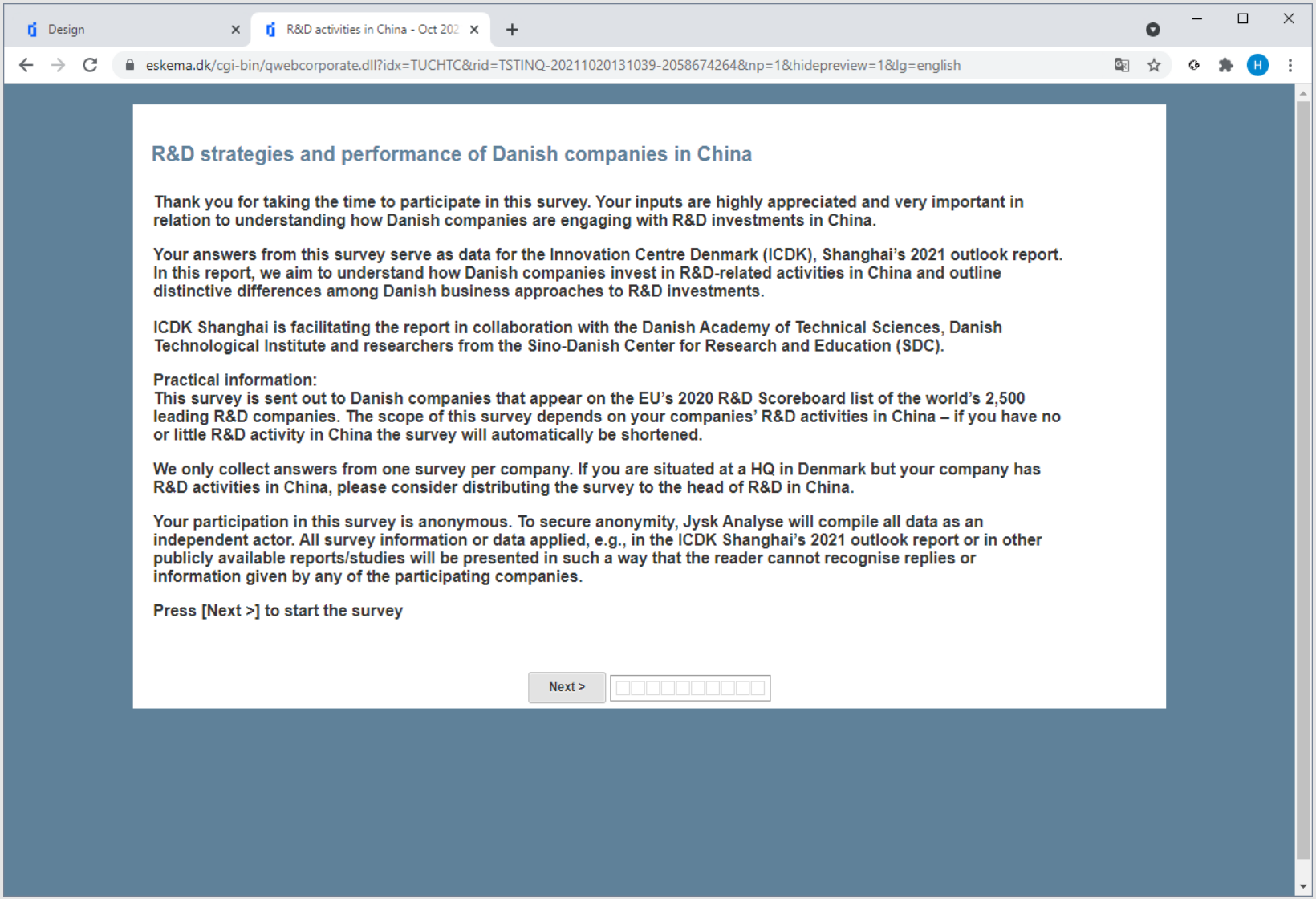

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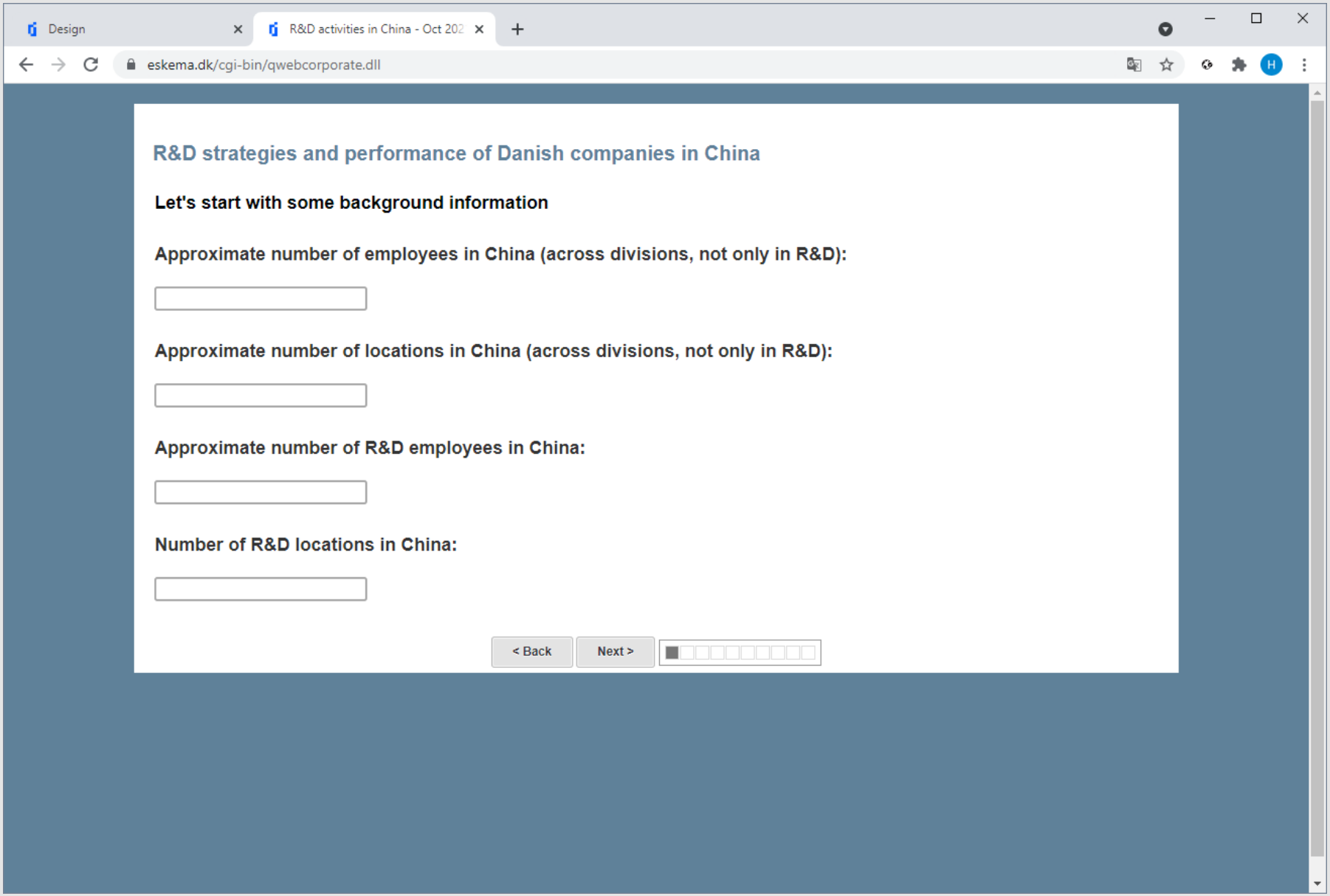

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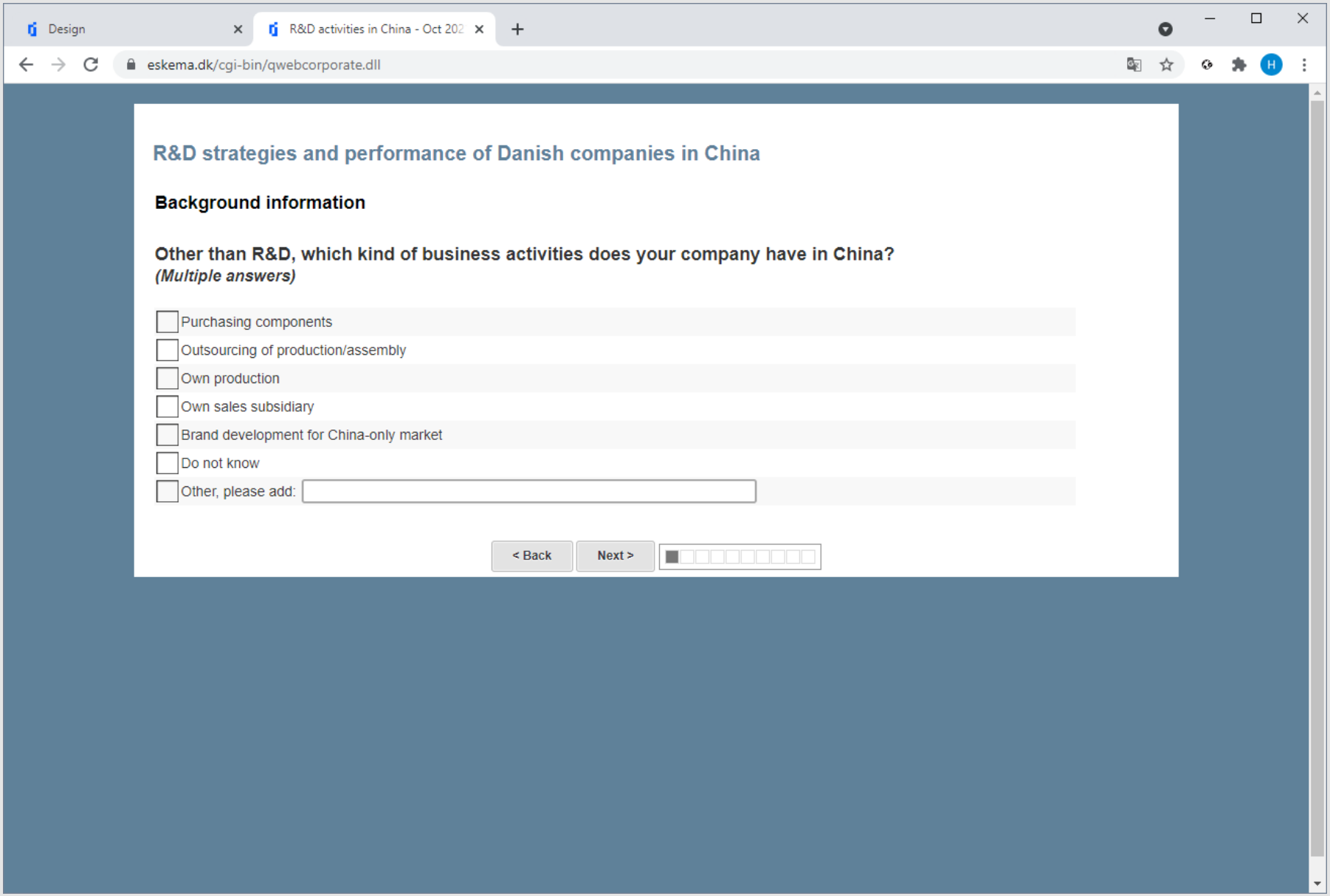

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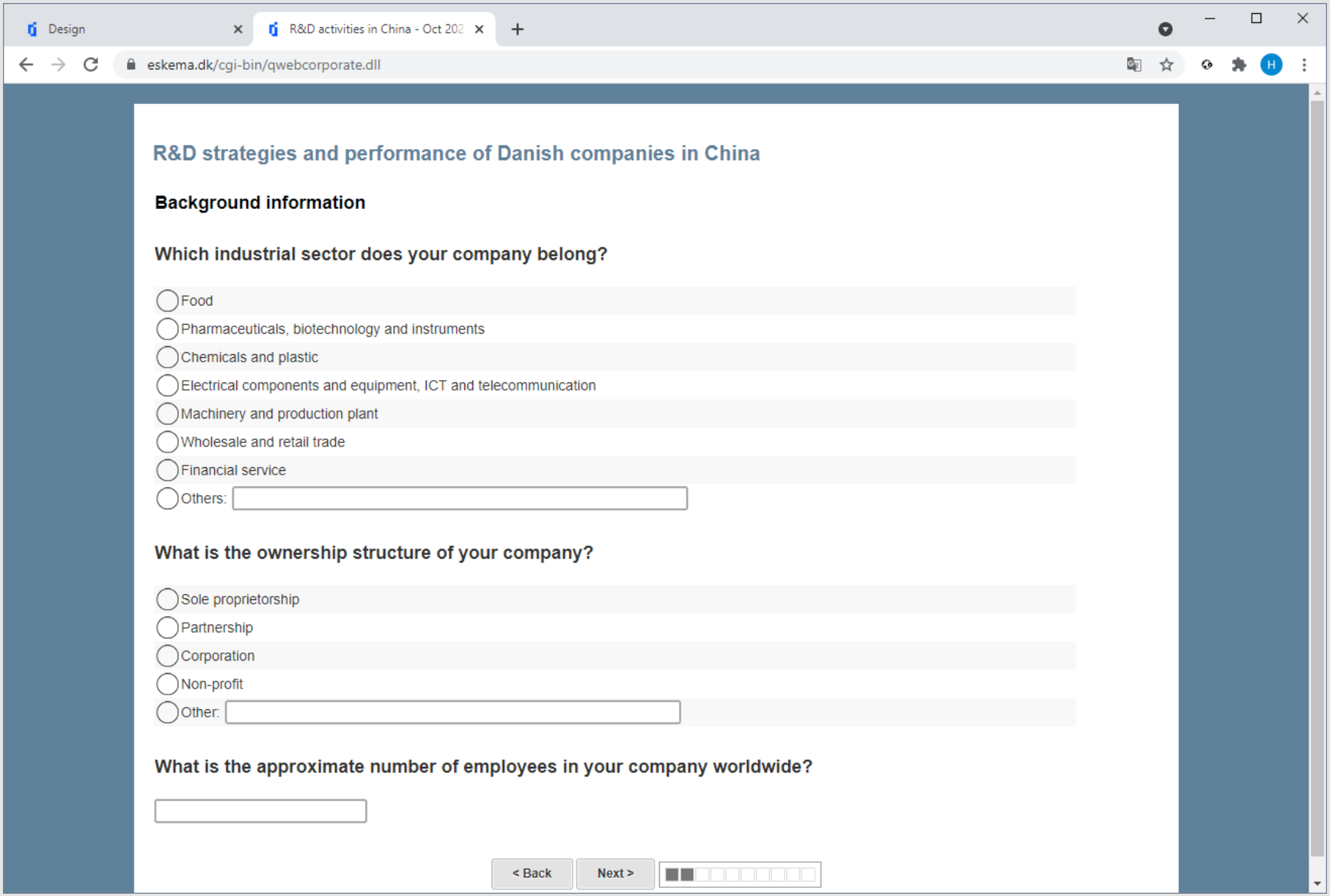

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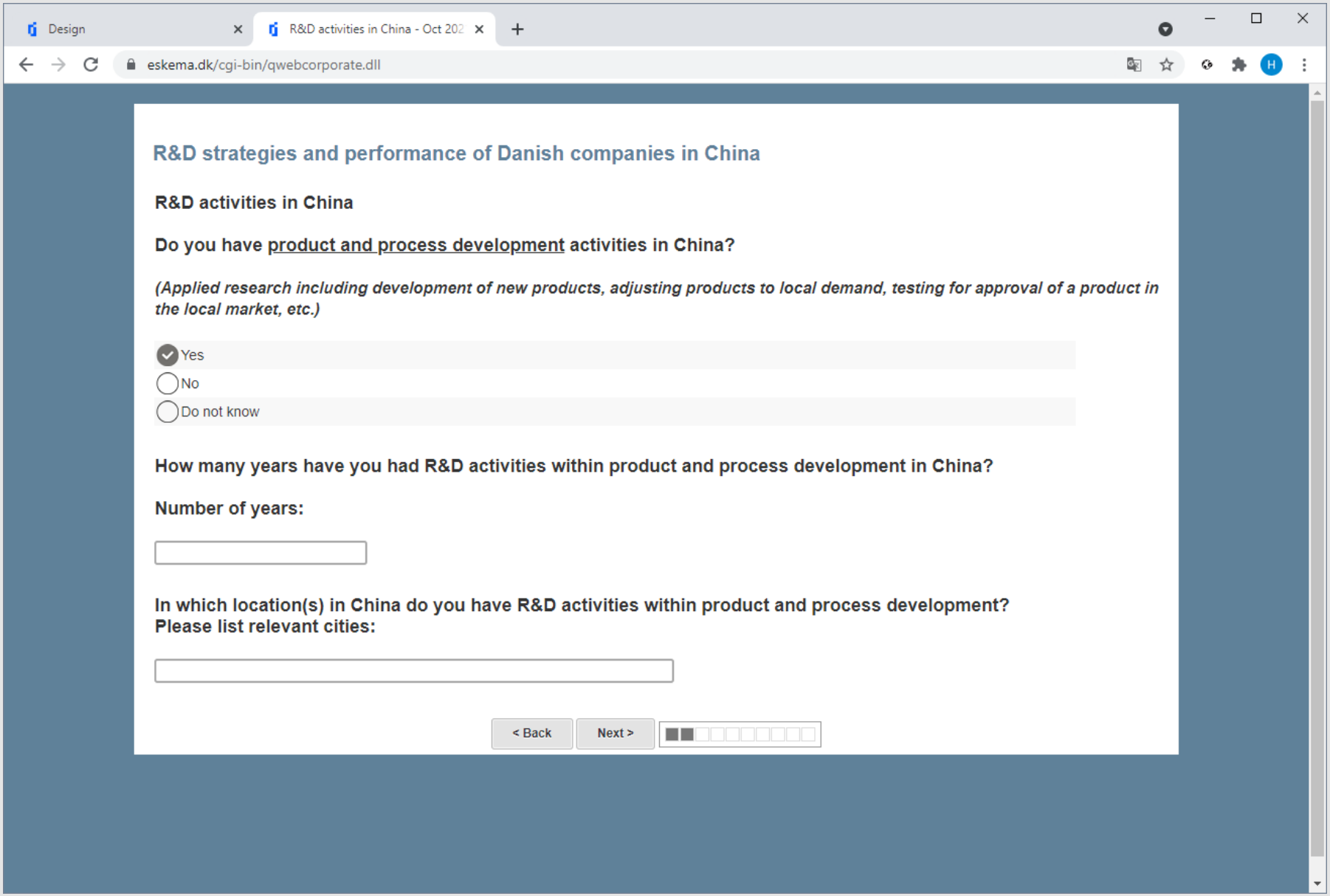

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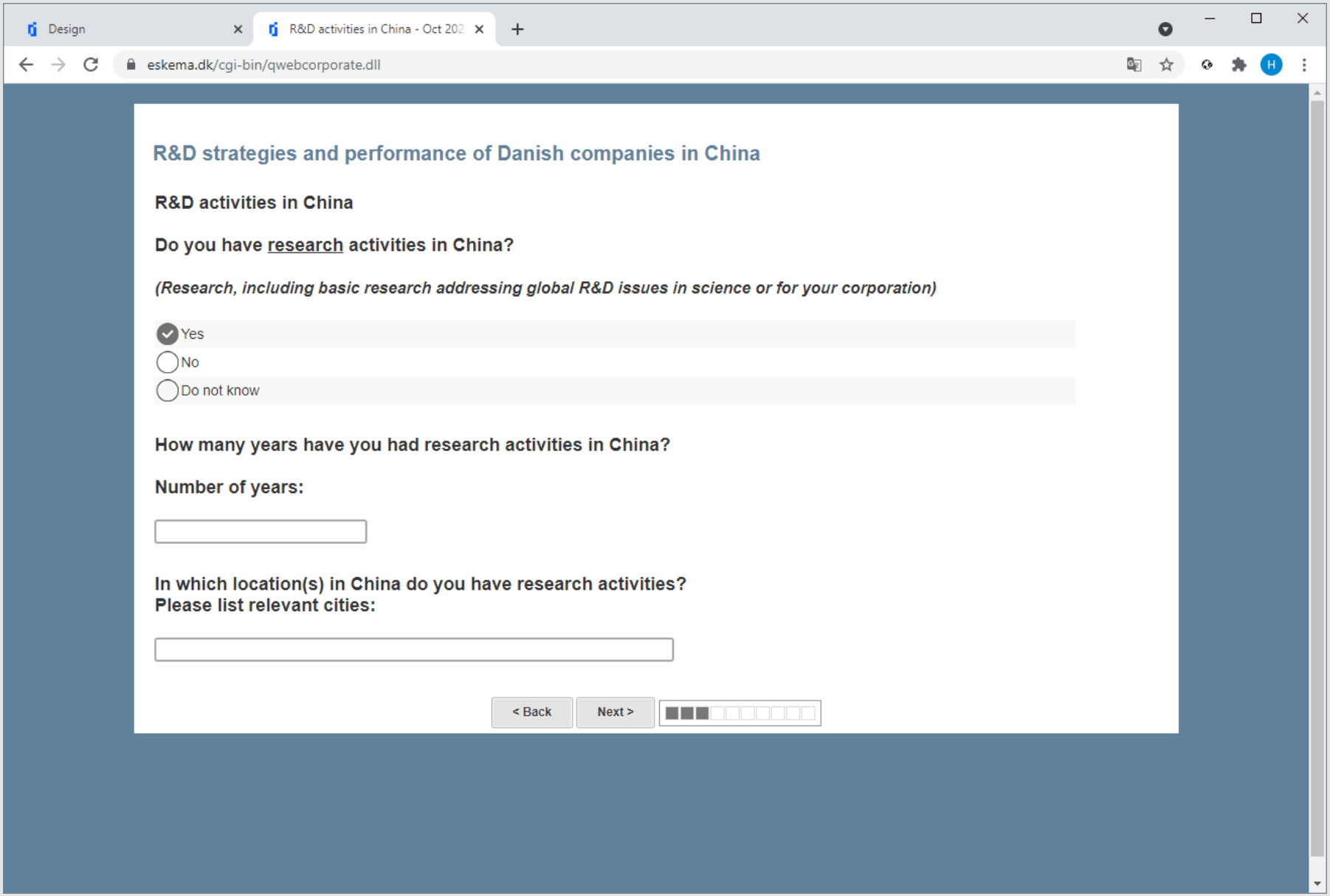

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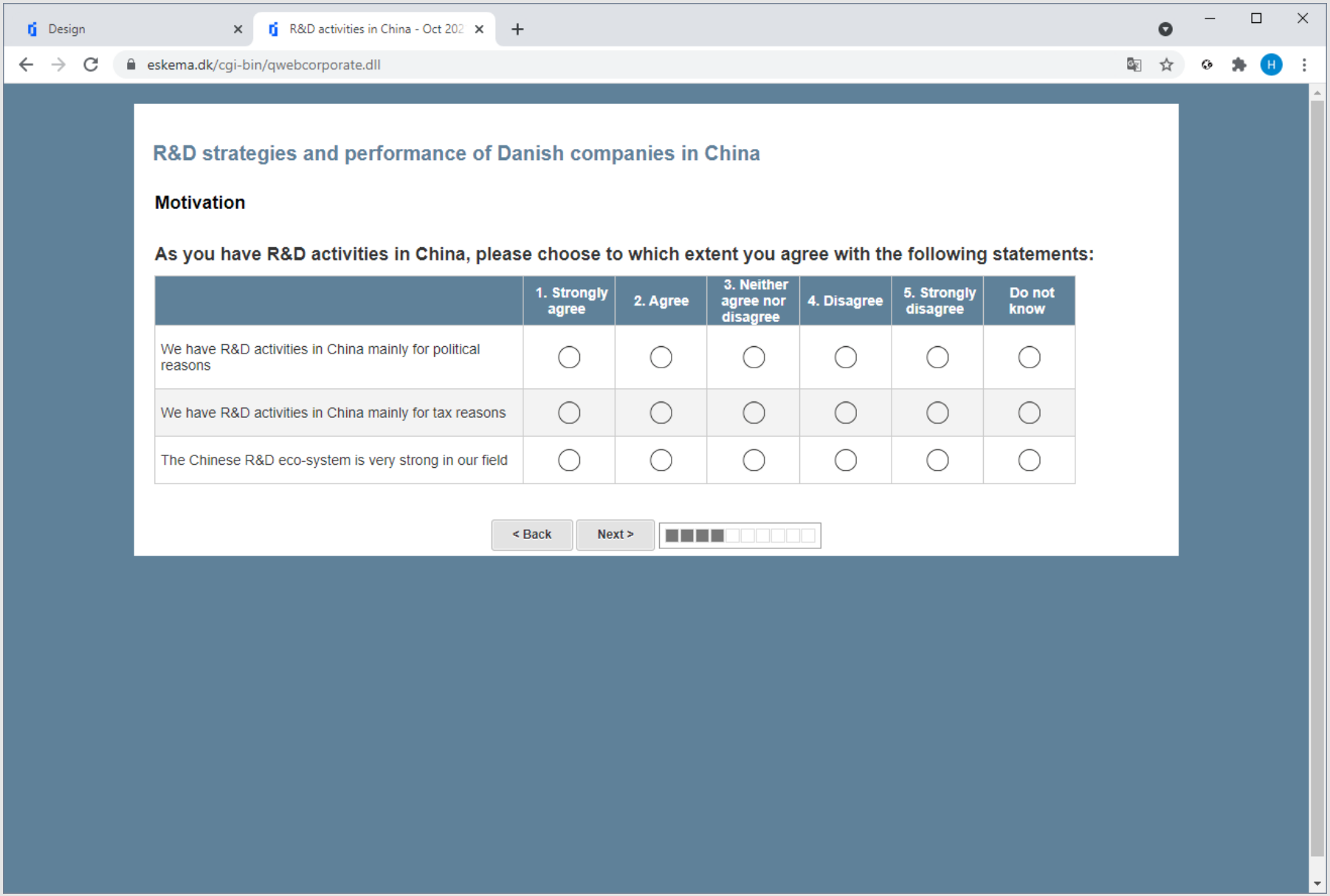

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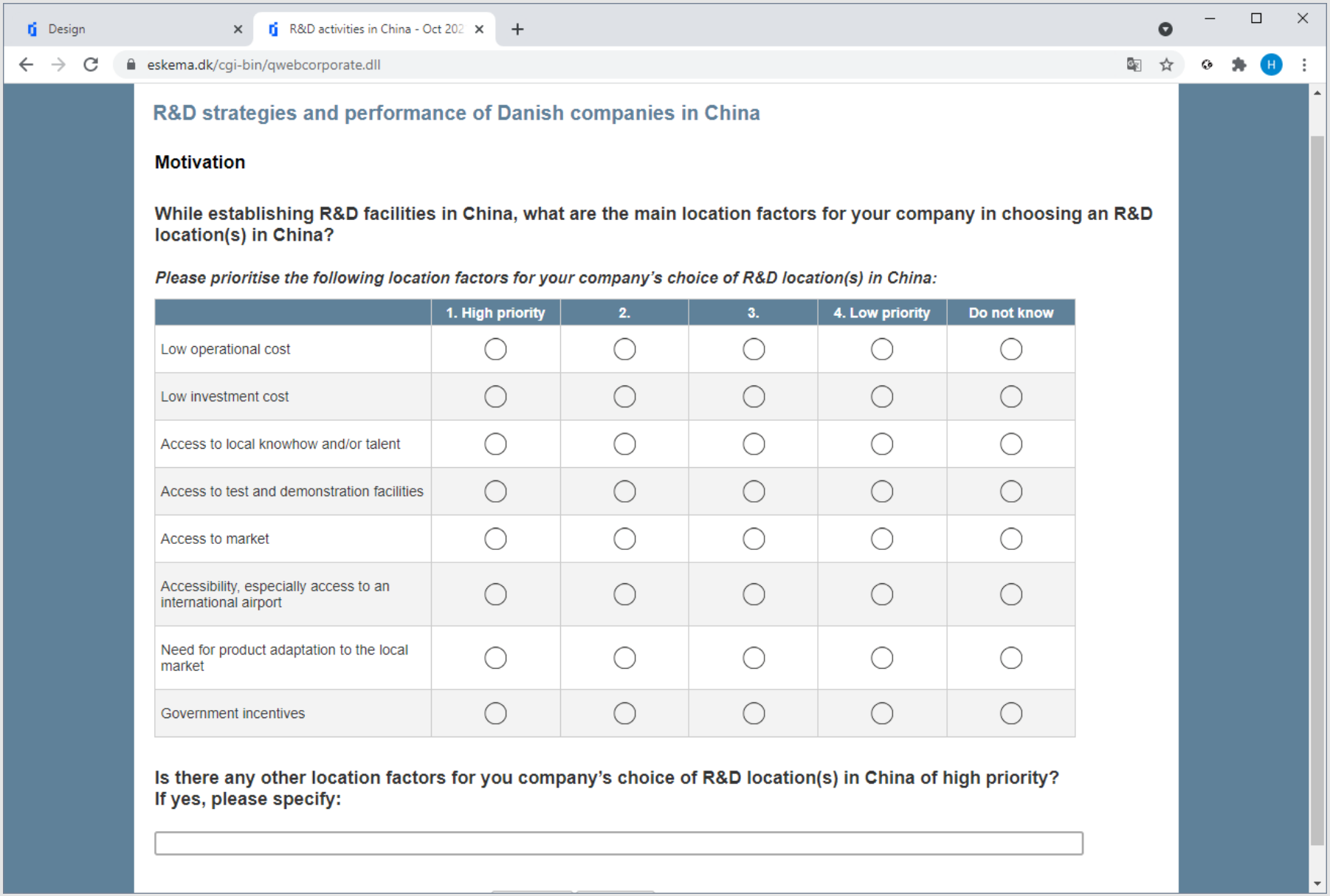

R&D strategies and performance of Danish companies in China

Motivation

While establishing R&D facilities in China, what are the main location factors for your company in choosing an R&D location(s) in China?

Please prioritise the following location factors for your company's choice of R&D location(s) in China:

	1. High priority	2.	3.	4. Low priority	Do not know
Low operational cost	○	○	○	○	○
Low investment cost	○	○	○	○	○
Access to local knowhow and/or talent	○	○	○	○	○
Access to test and demonstration facilities	○	○	○	○	○
Access to market	○	○	○	○	○
Accessibility, especially access to an international airport	○	○	○	○	○
Need for product adaptation to the local market	○	○	○	○	○
Government incentives	○	○	○	○	○

Is there any other location factors for you company's choice of R&D location(s) in China of high priority?
If yes, please specify:

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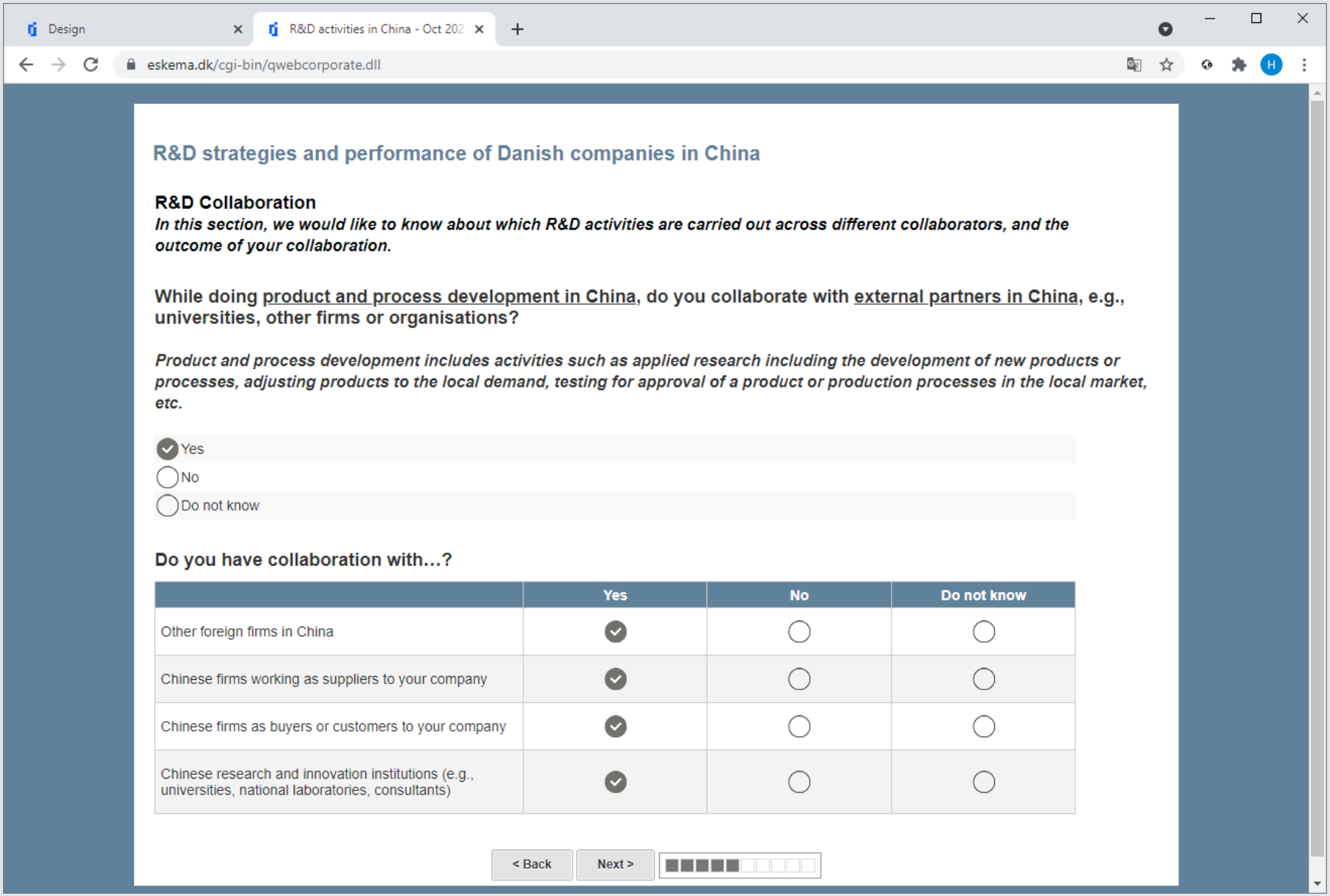

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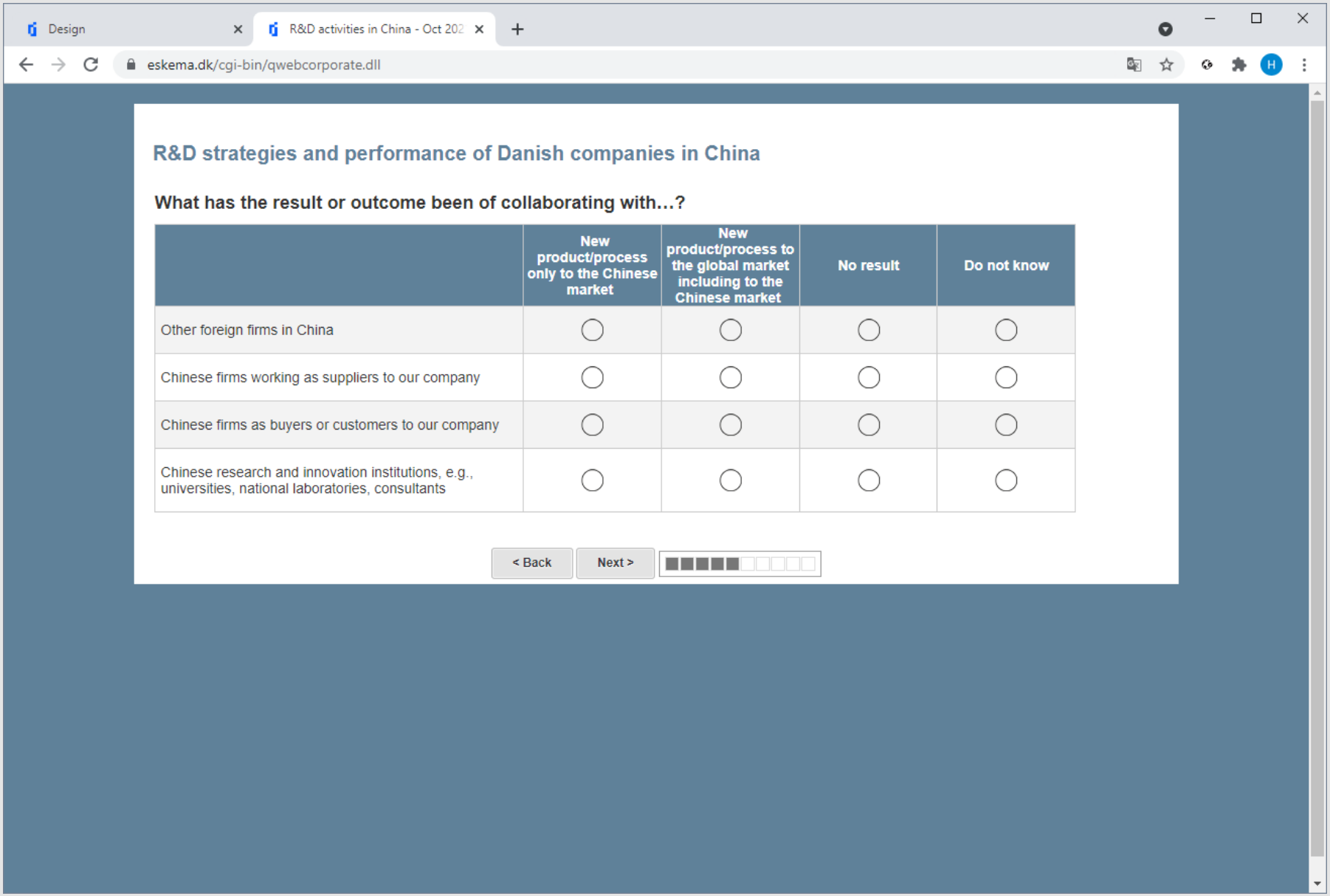

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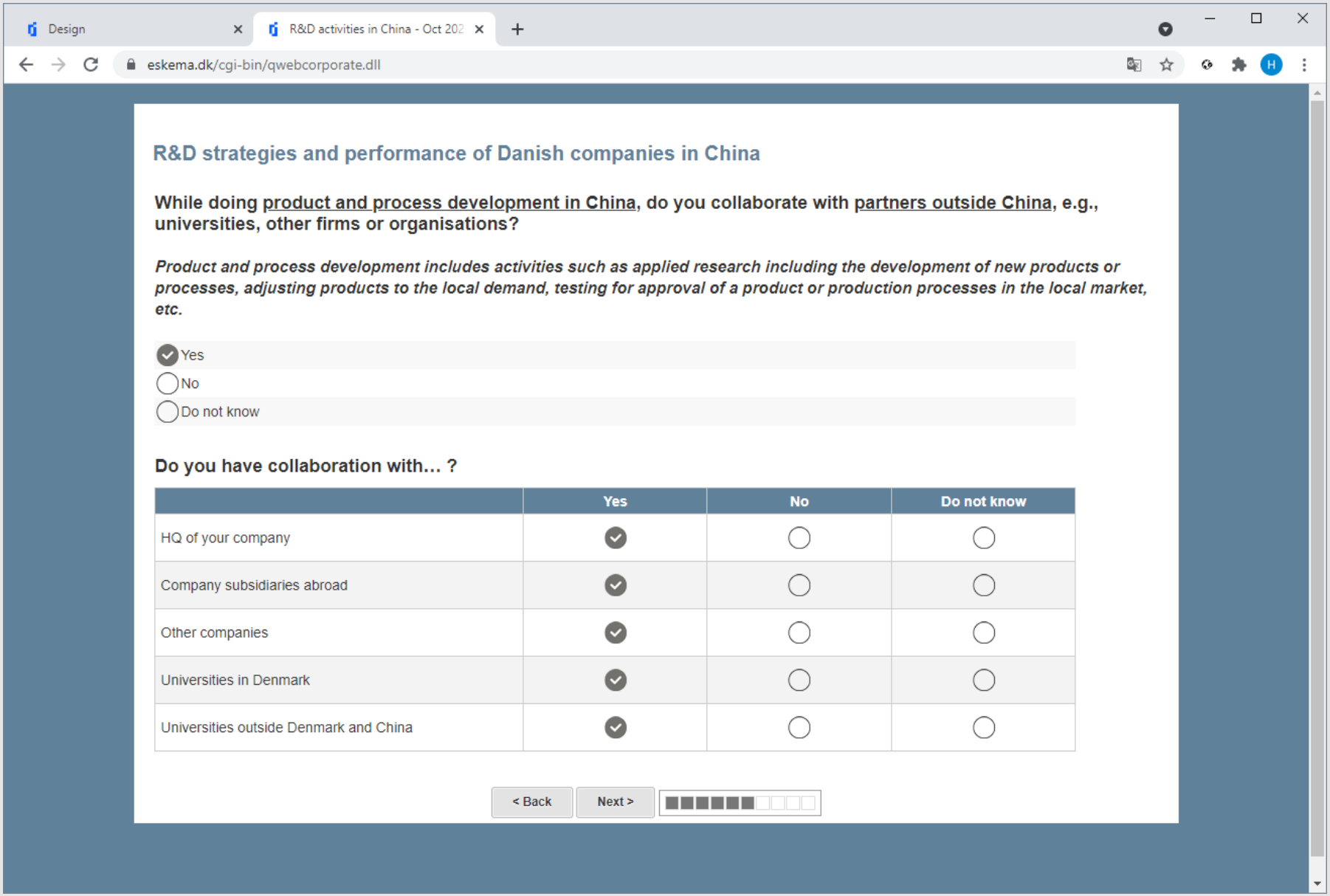

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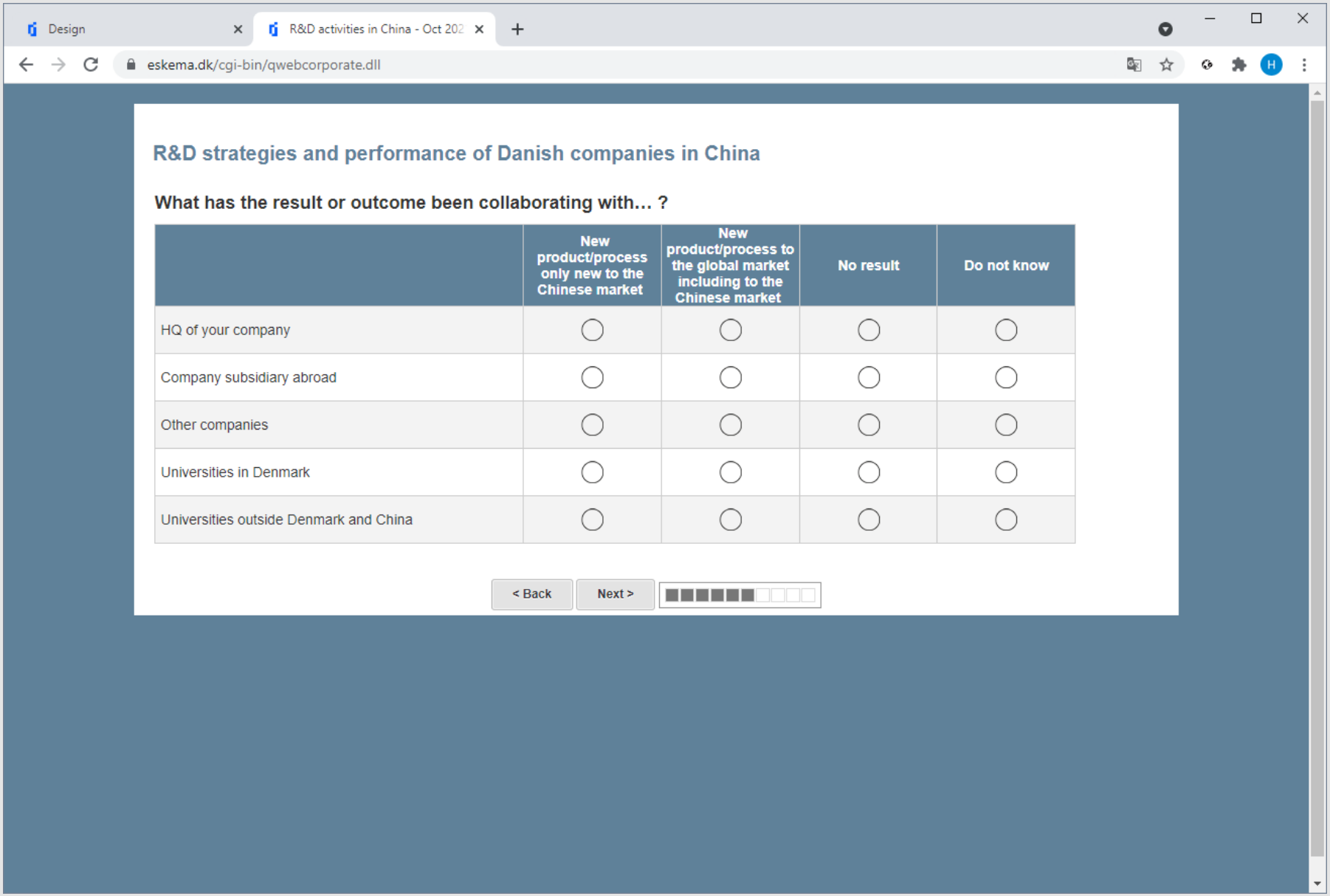

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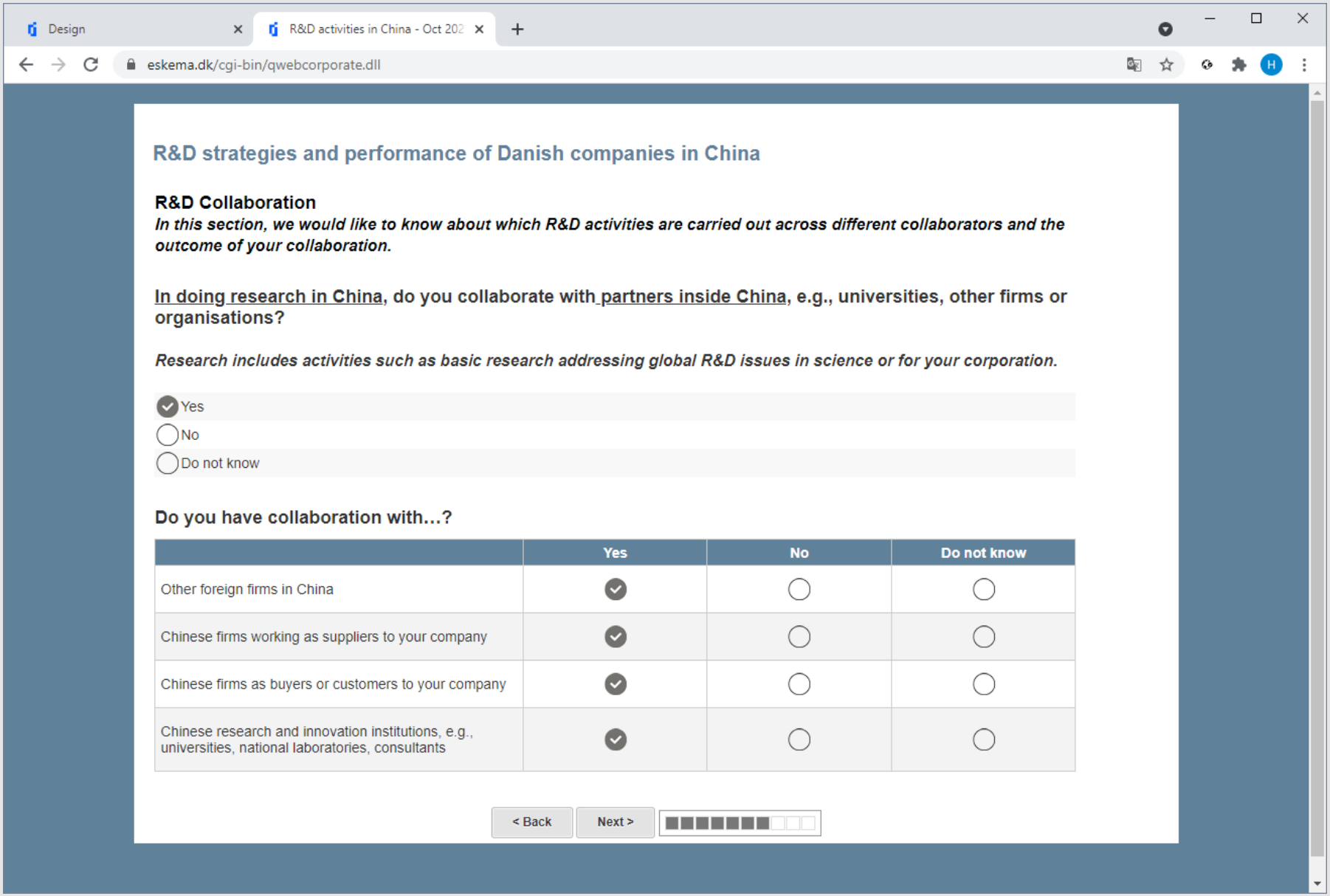

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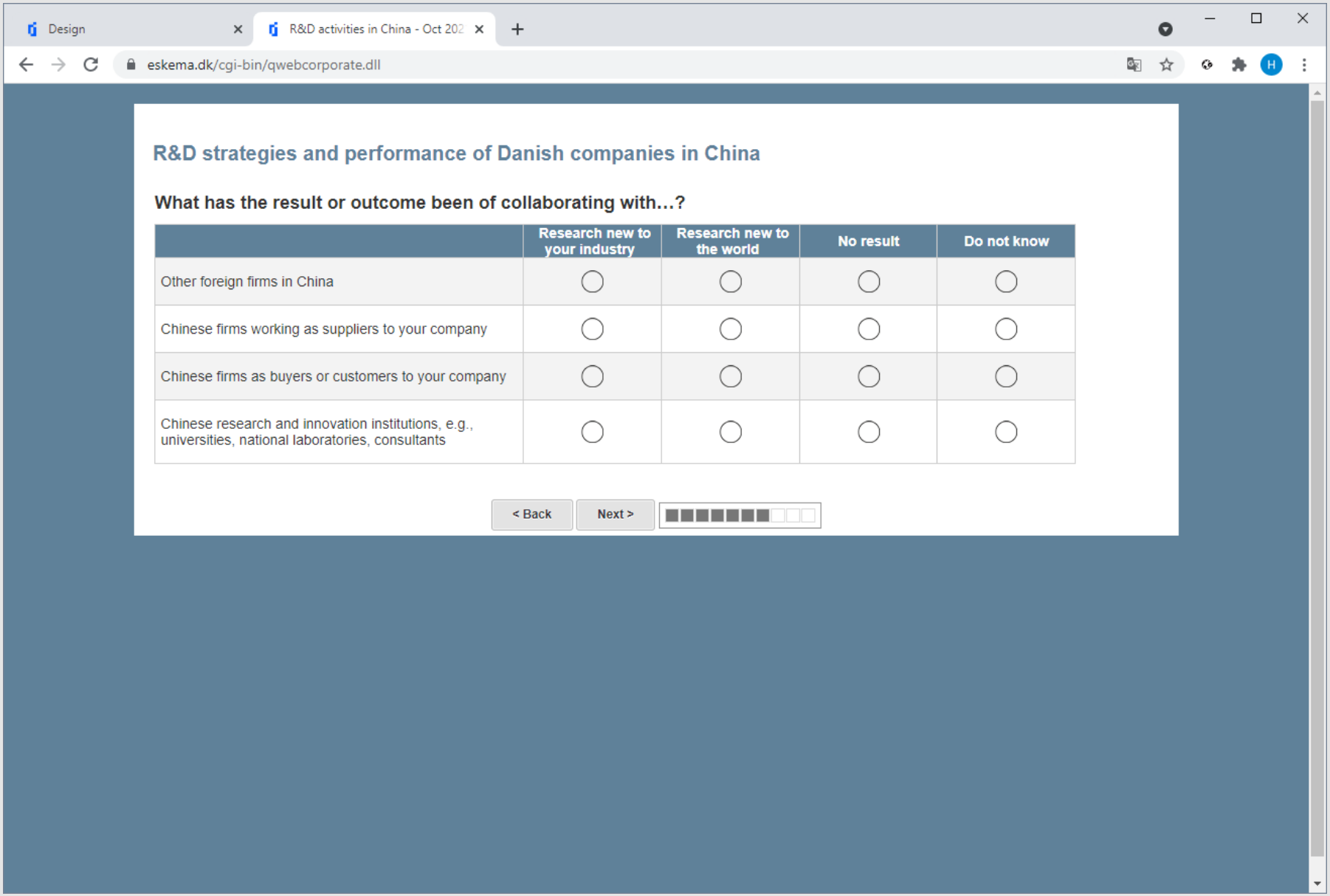

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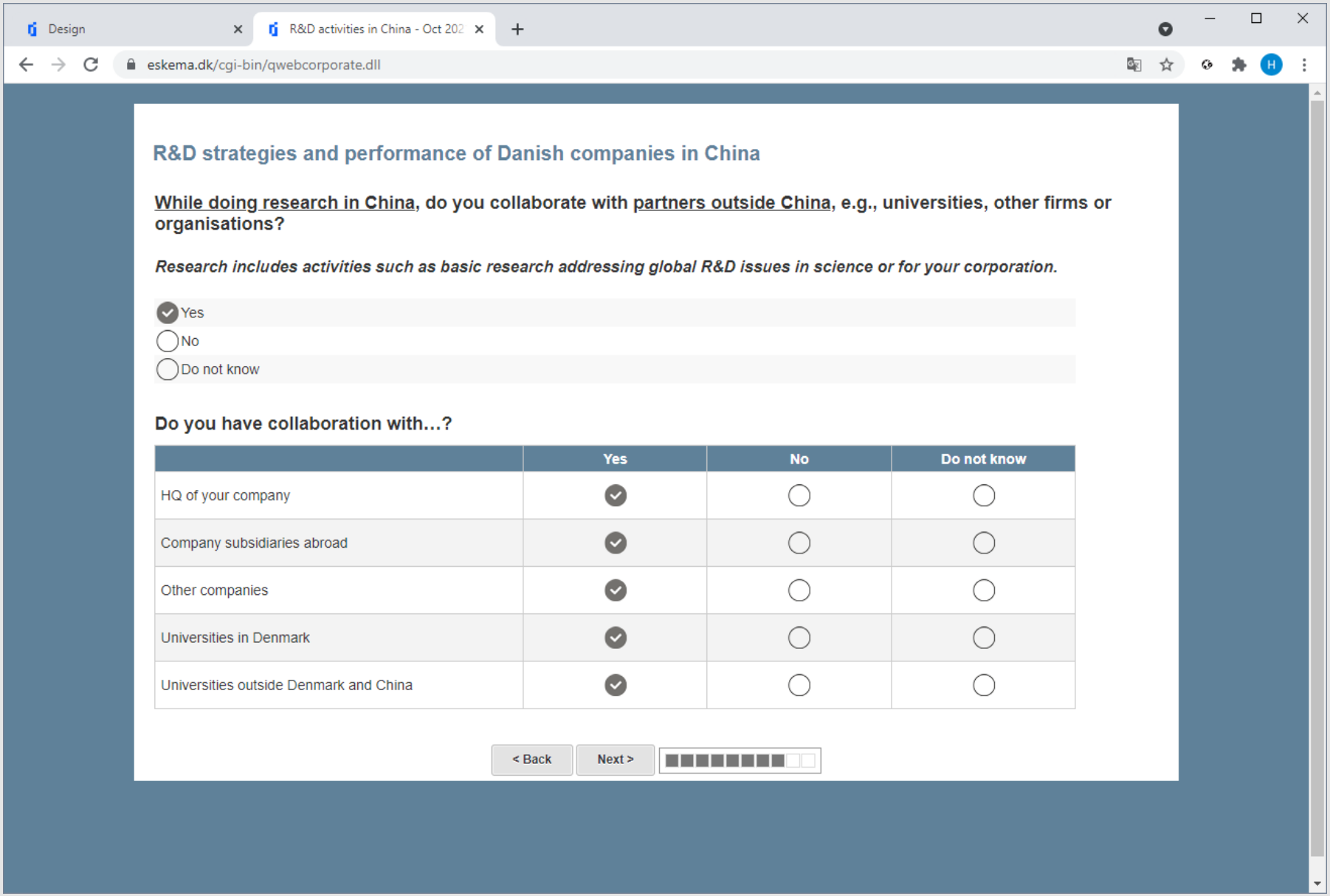

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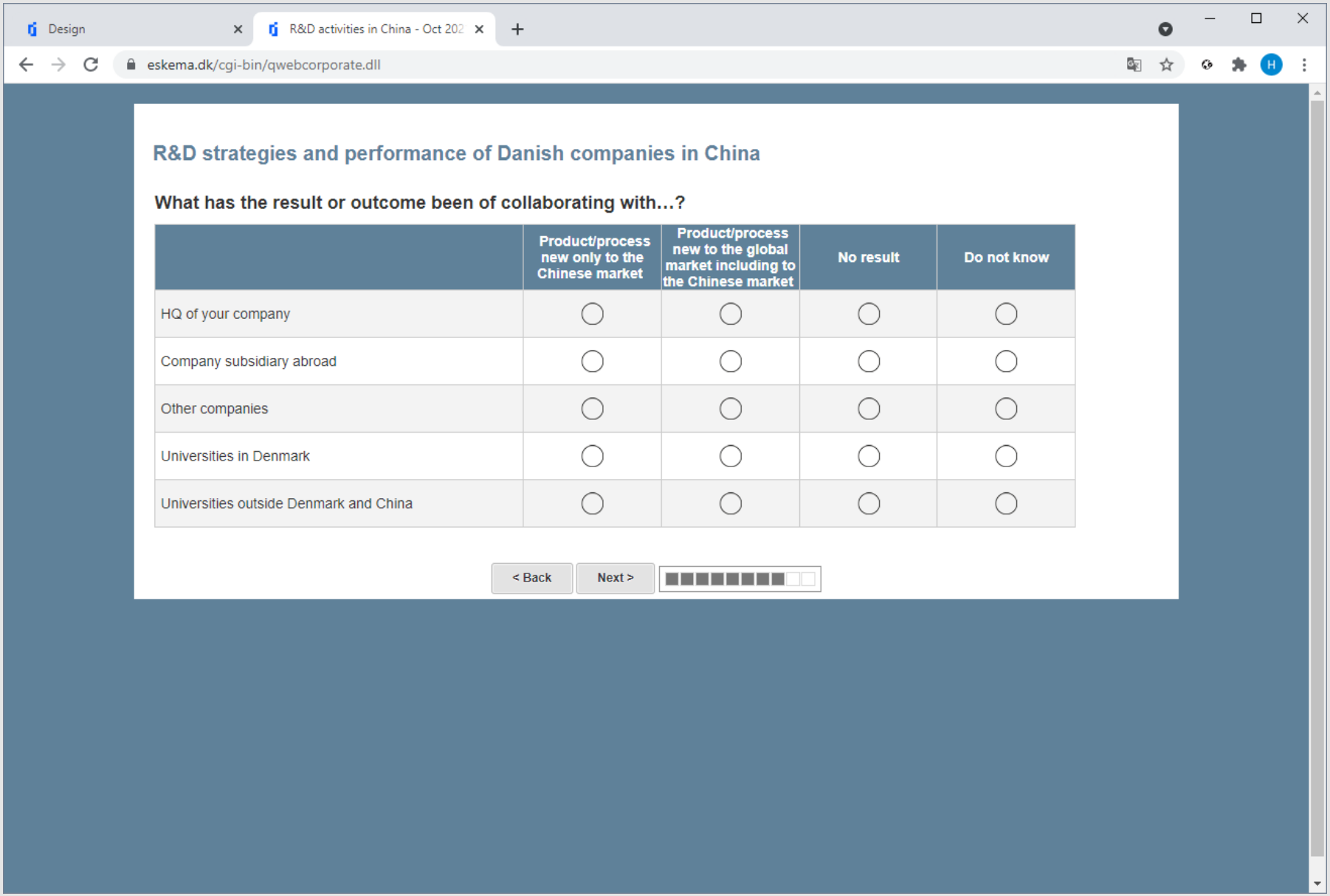

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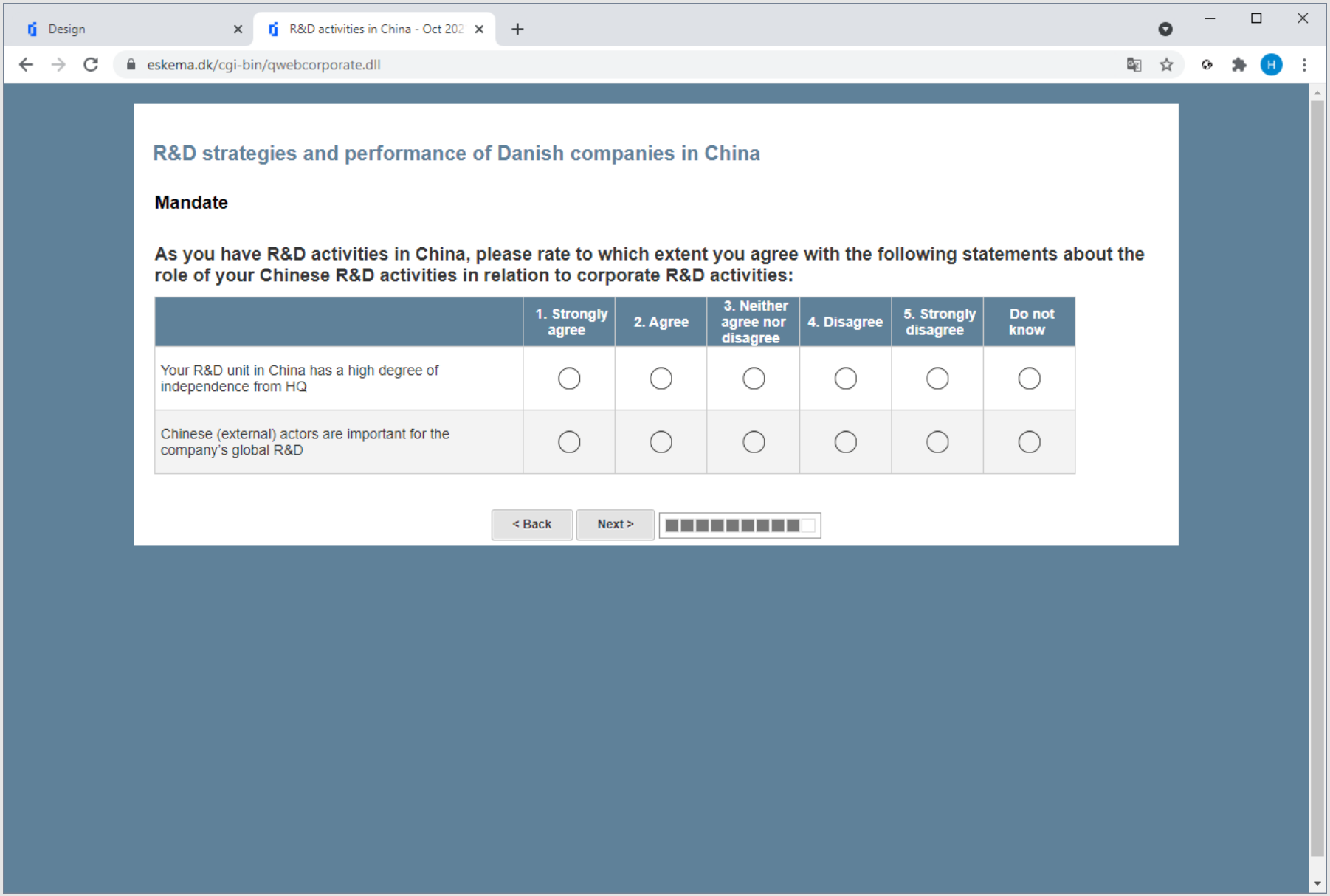

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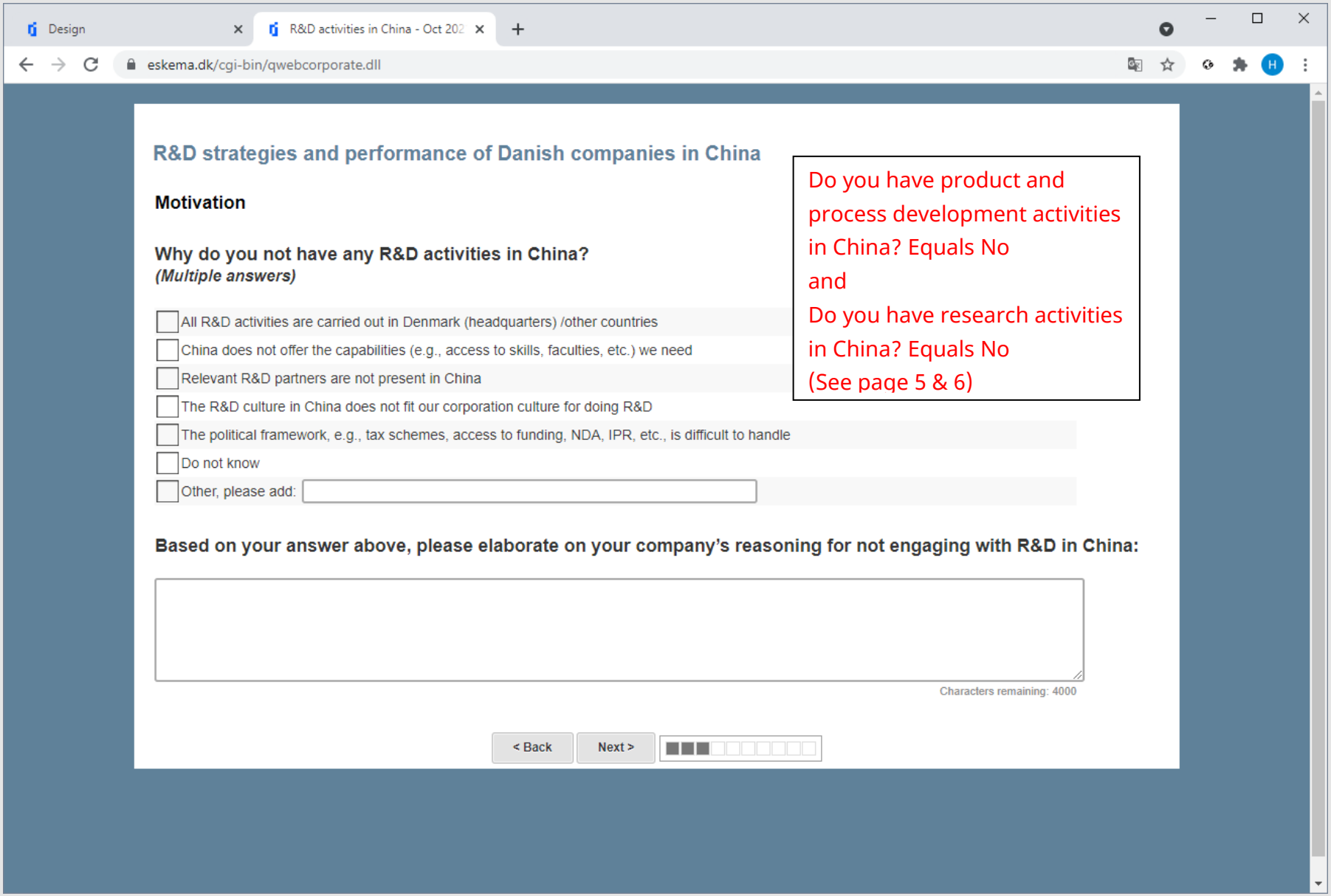

Do you have product and process development activities in China? Equals No
and
Do you have research activities in China? Equals No
(See page 5 & 6)

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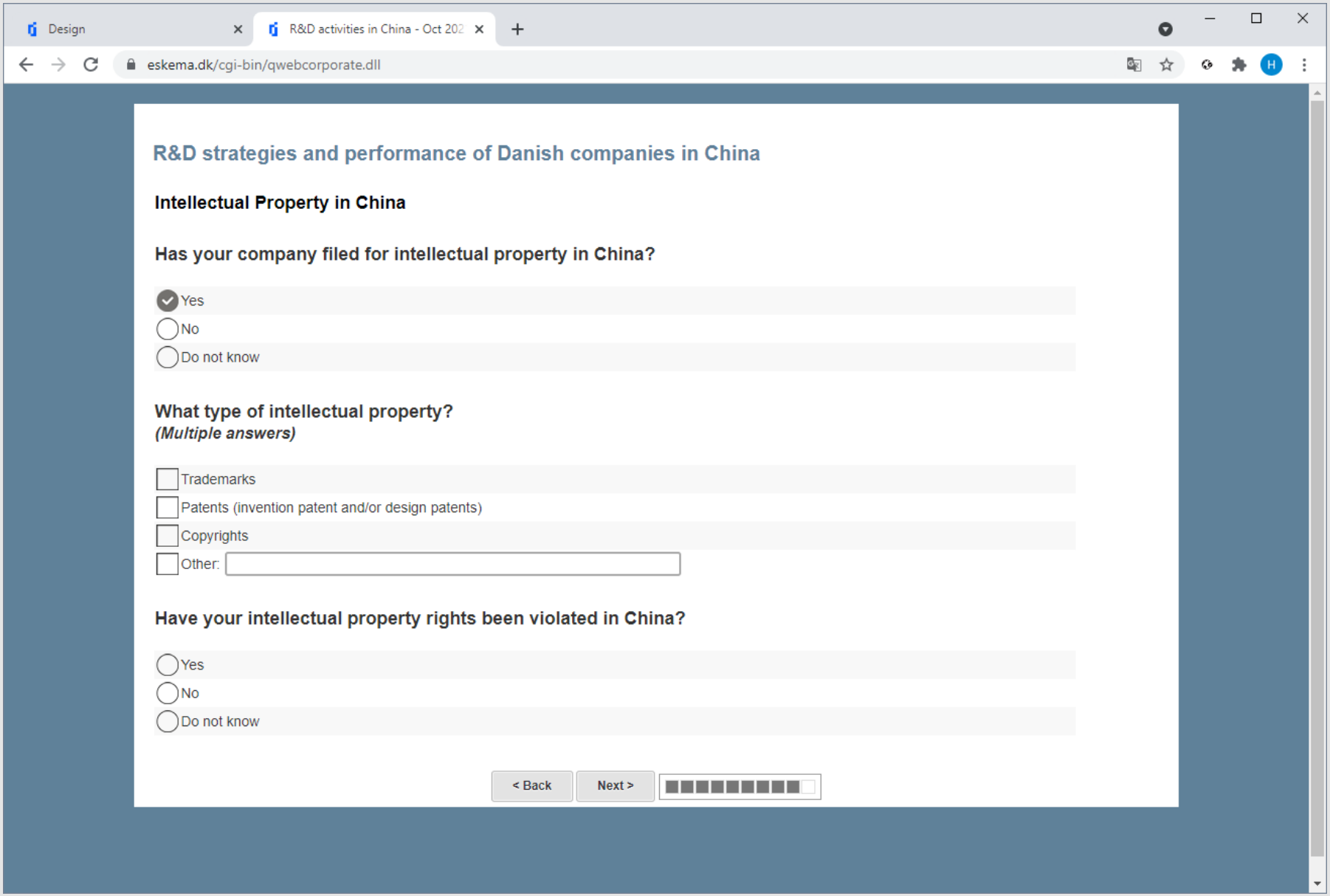

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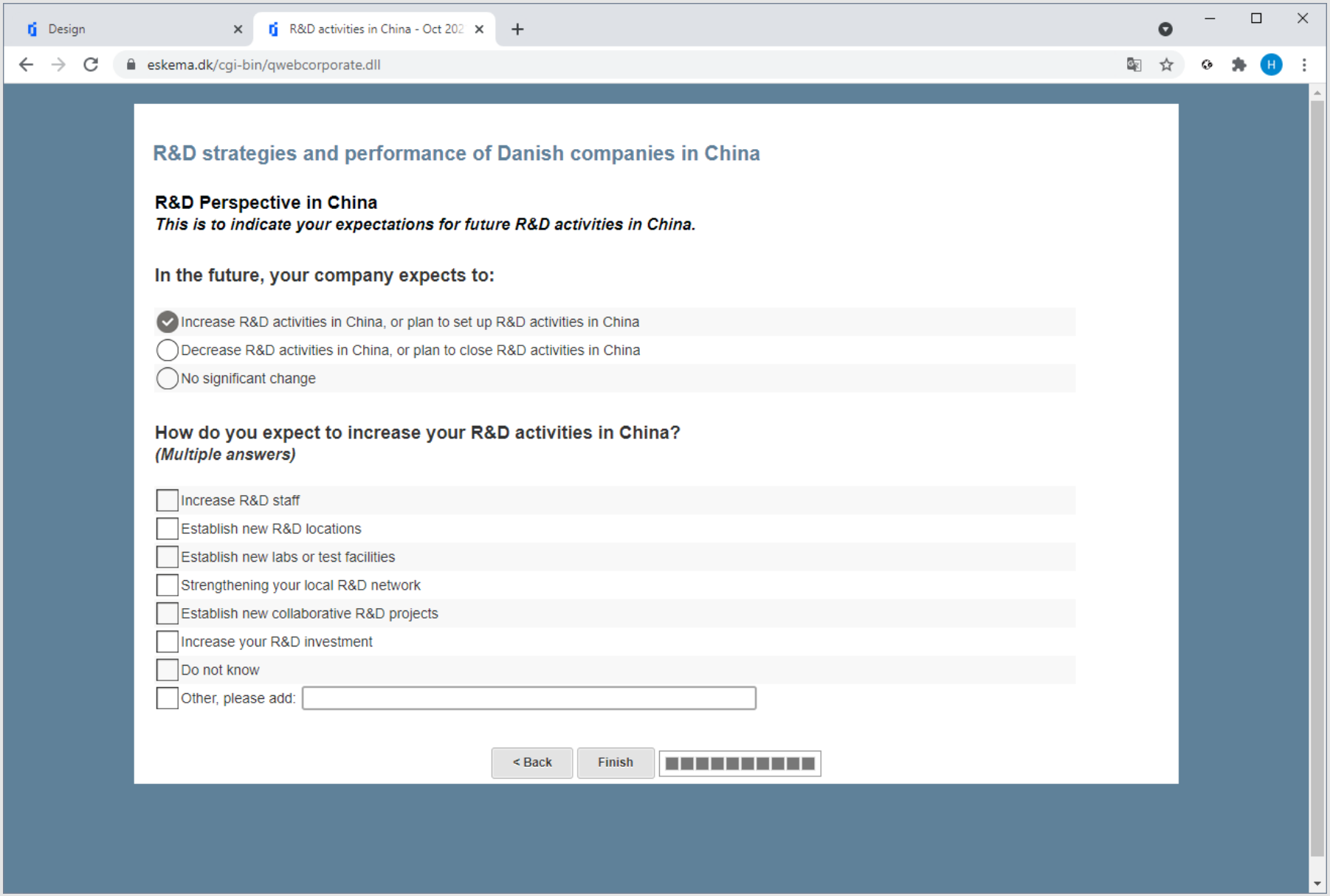

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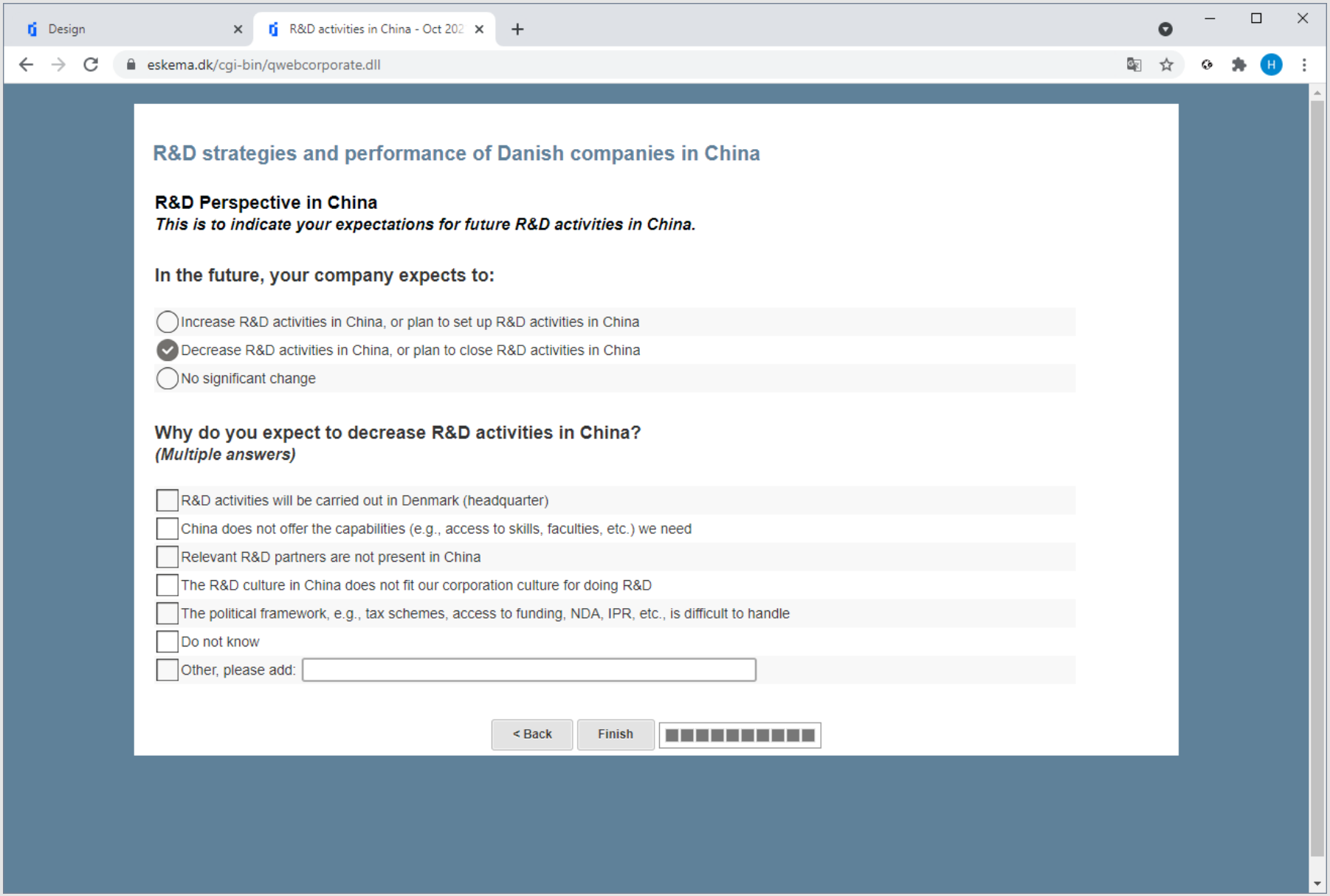

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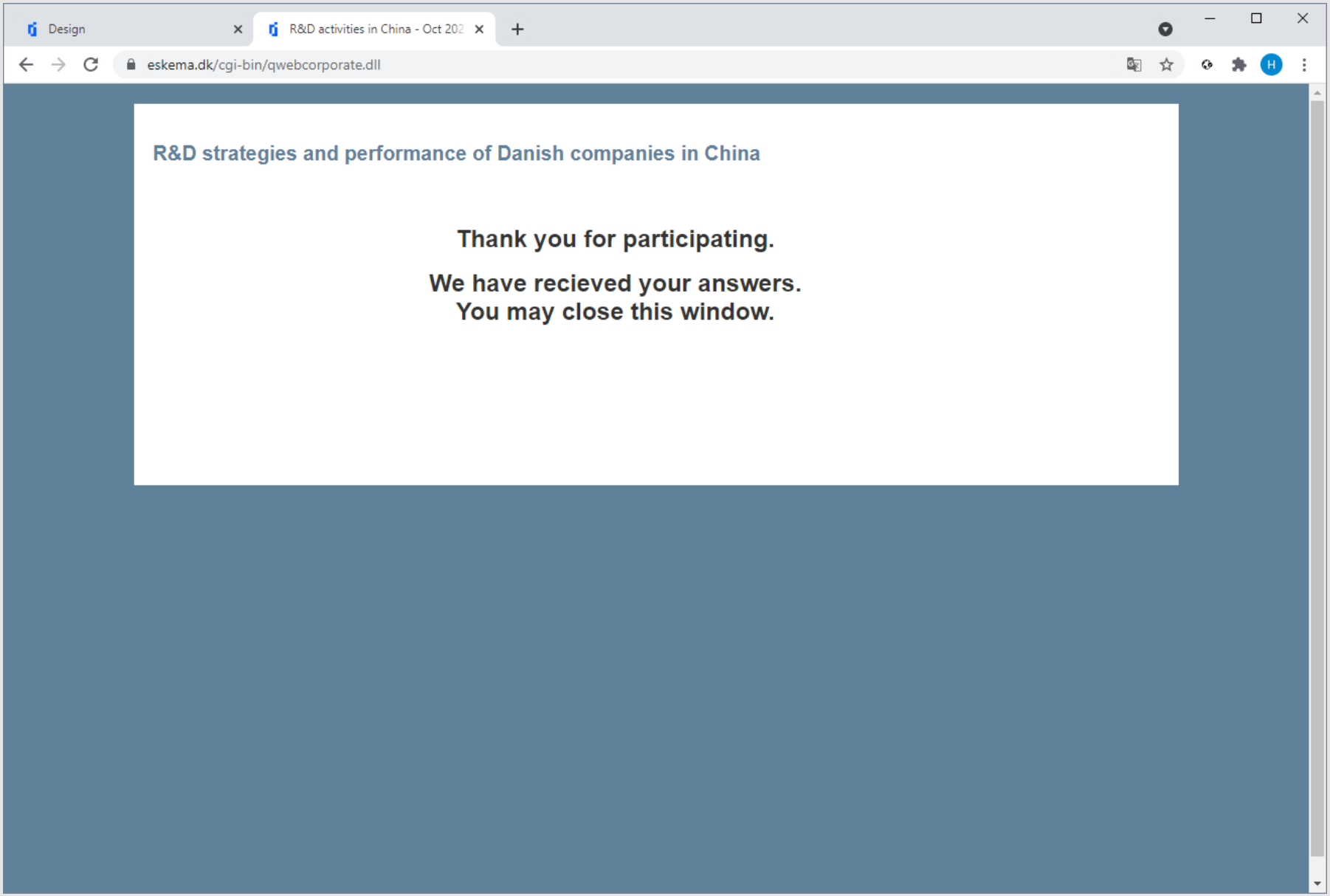

APPENDIX C: INTERVIEW GUIDE

Background to R&D in China

When did you establish R&D in China?

Why do you conduct R&D in China?

How did you start the innovation activities in China?

What did you establish support for the R&D activity in China (investments in facilities, networks, research partnerships, new technology, funding of research affiliates)?

R&D practices?

Which R&D partners do you work with and why?

To what extent have you tailored your R&D activities to Chinese conditions (incl. what was the reason for placing the R&D activities in the specific Chinese location)?

To what extent have you changed R&D partners over time?

How do you conduct the R&D activities?

How are the R&D activities integrated into the existing business?

Which R&D barriers have you experienced and how have you addressed them?

Chinese R&D outputs and results

What results have you achieved from Chinese R&D activities?

What are the benefits obtained from Chinese R&D activities?

How have you integrated Chinese R&D results into the business in China and elsewhere?

To what extent are R&D activities in China cost-effective?

To what extent are R&D activities in China key to the success of your business in China?

Relation to overall R&D Strategy

What is the relation to/mandate from headquarters of the R&D department in China?

How is the R&D strategy developed at the global and Chinese levels?

How do your Chinese R&D activities supplement activities elsewhere?

To what extent is the R&D strategy based on distributed efforts globally?

What R&D activities are not carried out in China and why?

In which way has the R&D strategy changed over time?

In the years to come, will you change your R&D strategy in relation to China?

Challenges in conducting R&D in China

Which difficulties did you face at the beginning and how did you address them?

Which difficulties do you face today and how are you addressing them?

What, if anything, will you change in the way you conduct your R&D practises in the future?