

Science-Industry-Linkages in China
– Motivation, Models and Success Factors
for collaborations of MNCs with Chinese Academia

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1 Motivation and background

According to the economic literature, there are at least two different motivations for companies to conduct parts of their research and development (R&D) abroad: market access or resource access (Belitz et al. 2006; Cantwell/Janne 1999; Dalton/Serapio 1999; Patel/Vega 1999; UNCTAD 2005). Market access implies a clear commercialization strategy, where the market is not only accessed from abroad but also from within the market. In addition to commercialization only, also market-specific R&D, especially development is conducted in the host country, whereby the products are adapted and tailored to the national market. This means that enterprises transfer at least certain parts of their R&D activities to the host country. Resource access means that either cost benefits or regulatory advantages exist in the host country or relevant and rather unique knowledge or competences can be found, which multinational enterprises seek to access and incorporate into their innovation chain. Also infrastructure such as certain research or testing facilities or natural resources are the driver to transfer R&D activities to the host country. Patel and Vega (1999) specifically address the issue of internationalization of technologies using patent data of a set of multinational enterprises. They find that companies tend to internationalize in areas of their individual strengths and they interpret this finding as proof of the adaption to the host market and an enrichment of the preceding production processes. In addition, this also supports the efforts to look for complementary technologies and knowledge.

Essentially, both motives often co-occur especially when the search for knowledge is one of the motives as market access comes as a byproduct. Market access, on the other hand, might also occur without knowledge access, but this is still the exception and not the rule (Belitz et al. 2006; Patel/Vega 1999; UNCTAD 2005). In other words, when a market exists then the corresponding knowledge might also develop. It is improbable that knowledge alone develops nationally without a national market.

The fact that in the recent decade or so the internationalization of knowledge has taken place, while in the previous decades – the 1980s and 1990s – the internationalization of markets was already established, increases the need for specialization of innovation activities and the specialization of knowledge. Taken together with the increased complexity of innovation processes and technologies, the pressure to collaborate internationally also increases.

Collaboration between multinational companies and the host country's scientific community requires absorptive capacities (Abramovitz 1986; Cohen/Levinthal 1990) and technological capabilities (Bell/Pavitt 1993; Lall 1992) on both sides. It is necessary on the side of the multinational companies to make use of local knowledge and compe-

tences. Teece (1994) formulated a strategy how companies are able to include such knowledge in their value and innovation chain. Technology acquisition and international cooperation also play an important role in the debate about technological catch-up and leapfrogging (Dosi et al. 1990; Perez/Soete 1988; Soete 1985). Technological cooperation focuses on the knowledge base required by the technologies and on enabling competences in the countries.

This study is embedded in this economic background, as China has increased its absorptive capacity as well as its international connectedness in recent years. With the adoption of the National Mid-to-long-term Plan for Science and Technology (MLPST 2006-2020) in 2006 China has marked its shift to the goal of becoming an innovation-led country by 2020. Since then, innovation has been viewed as vital for China's development for the past decade and the government has invested considerably in R&D since 2006 with annual growth rates of 20 percent for R&D investments. By 2013, the R&D expenditures per GDP reached 2 percent, thus surpassing the EU average.

Since the early 1980s science and technology has been regarded as the most important production force for economic growth. The Chinese government has been heavily funding science and technology since then. The strategy was to rely mainly on government-funded R&D projects to nurture domestic S&T capability, and preferential FDI policies to attract flow-in of advanced foreign technology. As the amount of FDI into China grew each year, its role in driving technological change also became increasingly significant.

The collaboration between multinational companies and Chinese universities has to be understood against this background of internationalizing markets and technology as well as increasing the absorptive capacity in Chinese academia.

The presented report describes and analyzes the results of a survey among 30 foreign invested enterprises in China in 2014. The survey was conducted once before in 2011/2012 and the update in 2014 was specifically designed to create a better understanding of the recent dynamics in innovation in China, especially in the collaboration between MNCS and Chinese universities and research institutes. The main questions the survey wants to answer are: who are the key drivers for collaboration, what are the key success factors and which are the most recent developments in these industry-science-collaborations. The survey also answers the question of what policy makers could do to increase the collaboration and to reinforce spill-over effects into the Chinese science system as well as to create a supportive environment for MCNs R&D activities in China.

2 Description and Analysis of Results

2.1 Recent trends in research, development and innovation in multi-national companies in China

Before looking into the science-industry collaboration it is important to understand the companies' R&D activities. Since when are they doing R&D in China, or do they still prefer doing R&D outside of China and rather do more development and adjustments? How do they see their own activities in China? Will investment in R&D grow or not and what do companies expect in the coming years for their own R&D activities? These questions shall be answered in the following.

The majority of companies interviewed started to establish their R&D centers in China after the year 2000. Six companies started already in the late nineties and have had nearly 20 years of R&D experience in China. Five companies established their new R&D center in China after 2010. These five R&D centers are in the automotive and the chemical industry. Four of the 30 companies interviewed currently have no R&D center in China.

2.1.1 R&D centers serve different markets

The existing R&D centers mostly have a mixed role serving the global market as well as the Chinese or Asian-Pacific market (12 companies). The percentages, to which they serve the different markets, vary hugely and no pattern can be observed. For those serving only one specific market or region, five R&D centers serve only the Chinese market, five serve only the global market and four companies only serve the Asian-Pacific market. No clear trend can be seen when it comes to the strategies of companies' R&D centers with regards to which markets to serve. While some companies have just shifted from what they call 'global for local' to 'local for global', other companies have done exactly the opposite.

For example, the automotive and transportation companies started with a global for local strategy, meaning that they developed their cars outside of China and then sold them on the Chinese market. This has become more and more difficult, due to changes in customer behavior, and they are currently shifting to developing locally for the local market (local for local). For the future, all companies from the transportation sector expect that they can roll out local (Chinese) developments globally in the next step (local for global).

On the other hand, there are also companies whose R&D centers currently move into the opposite direction, from 'local for local' to 'global for local'. One company from the

consumer product sector explained that they used to have 400 researchers in their R&D Center in Shanghai to develop their products according to the needs of their Chinese customers. But in 2014 they changed their global strategy in order to make their entire R&D more efficient and decided that they will only develop one product for the whole world, as the core of their products is the same anywhere; and then accompany this with smaller local adaptations catering for local tastes and packaging needs. As a result of this global strategy change, 380 of their researchers in Shanghai are now conducting research and development for their global products and only 20 are engaged in local adaptations for Chinese customers.

The manager interviewed explained it like this: 'we have undertaken restructuring ... and decided to only have global products and role them out in as many countries as possible. Local adaptations are possible, but not to the basic product. So we abandoned the local R&D teams and we have now 20 people left for local adaptation, but not for R&D.'

2.1.2 Basic versus applied research and innovation in or outside of China

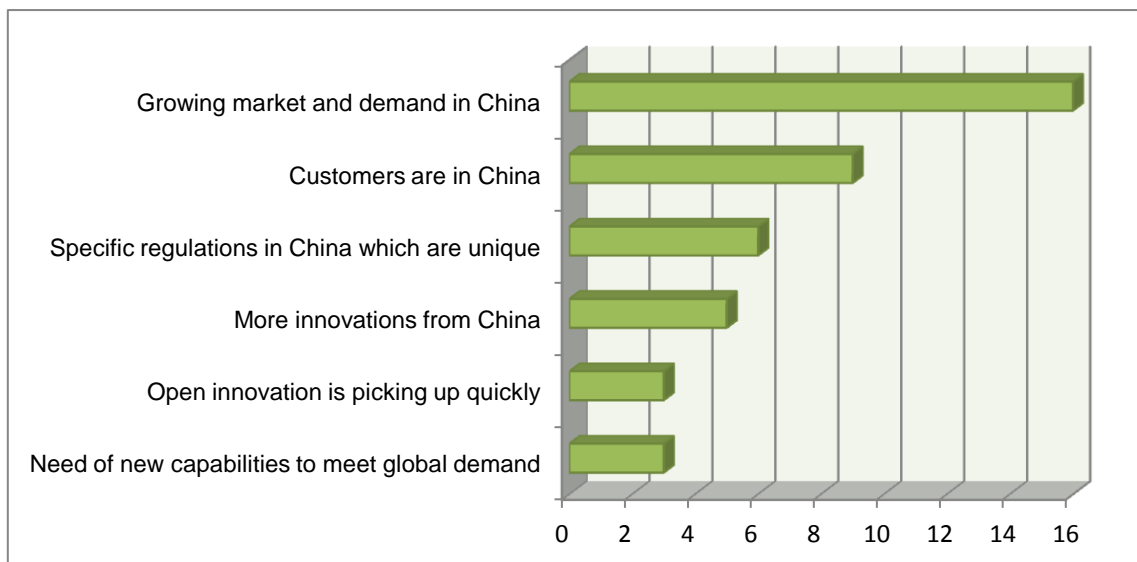
The majority of the 26 companies with R&D centers uses them mainly for development and devotes 30 percent or less to what they themselves call 'research' (19 companies). Four companies are doing 100 percent development, while one company is doing 90 percent of research in its R&D center. Hence it is not surprising that 22 companies state that considering all the innovation activities in their companies, still most innovations come from outside of China. Three companies are already seeing a small part of their innovations coming from their R&D center in China and for two companies a significant part of innovation comes from China. Both companies use their R&D center in China to serve the global market. Even though the data collected are too small to draw a scientific conclusion, there seems to be anecdotal evidence that those centers with a stronger focus on the global market are stronger in innovations than those focusing on the Chinese market.

This can be supported by the statement of an electronics company, which uses its Chinese R&D center to develop highly innovative products and services for the global market, because their 'Chinese customers are not willing to pay the price for these innovations – yet'.

2.1.3 Future expectations for R&D development

The majority of companies are planning to increase their investment in R&D in China in the future, only three companies will not increase investments and four companies are unsure. For those who are uncertain and will not invest, the main reasons are restructuring processes in the companies, which make it difficult to predict where R&D investment will be strengthened in the future, unsecure framework conditions in China and the fact that R&D has been growing fast in recent years and needs some consolidation. The main drivers to increase investment are the growing market demand in China, the growing number of customers and China-specific regulations, which make more R&D necessary (Figure 1).

Figure 1: Motivation for growth of research, development and innovation activities

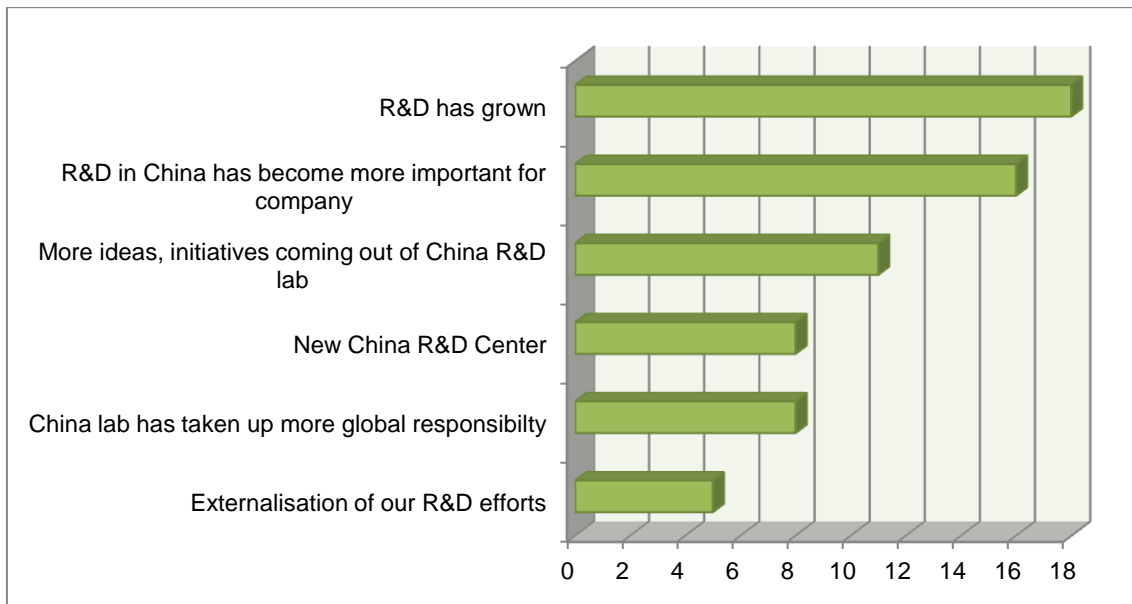


Source: Fraunhofer ISI, own data collection

2.1.4 Trends in the past and in the future

Looking at the trends in R&D and innovation in the past five years, companies have mostly intensified their R&D efforts in China, increased the importance of their R&D activities in China for the company and created more ideas and initiatives in their Chinese R&D labs (see Figure 2). Their expectations for the next five years are mixed; eight companies expect moderate growth, while three foresee their R&D activities to grow strongly. Seven companies believe that their R&D Center in China will take over more and more global responsibility for certain products and technological developments in their companies.

Figure 2: R&D trends in the past 5 years



Source: Fraunhofer ISI, own data collection

2.1.5 Differences in innovation in China

When it comes to innovation in China, there is quite some debate among managers whether China is different or not. While in the 2011/12 survey most companies did not perceive a big difference, the 2014 survey showed a different picture. More than two thirds of participants believe that there are important differences with regard to innovation in companies in China compared to their home countries and other R&D locations. The biggest difference is communication, which is experienced as very different, especially less open, and less trustful. This requires a much higher investment in different resources, not only human resources, into the internal as well as the external innovation process. The second difference that was mentioned is a difference in quality of the final product. It was mentioned that Chinese customers do not want to pay for an innovation which delivers the highest quality possible, but rather for a cheaper version that is just ahead of what was available in China before, so that they feel they have something new but without the high costs that come with the newest, cutting-edge technology. Still costs seem to drive their Chinese customers more than quality, even though they expect that this might be changing over time. This leads to another difference, which is innovation speed. Companies believe that they have to move faster in China than elsewhere, that they have no time to perfect their products to the best version, but bring their new products out fast. The fourth difference mentioned is the Chinese middle class, which is believed to drive future innovations like no other population in the world. This will require companies to adjust their innovations more to these customers

and become more customer-centered than elsewhere. At the same time, a small number of companies felt that the biggest difference is that in China there is not much 'real' innovation yet. Others have only recently started to engage in what they themselves call 'real' innovation, so that it is too early to draw comparisons.

2.2 Research collaborations with academia

From the overall sample of this study, four of the interviewed companies do have R&D activities in China, but do not collaborate with external Chinese partners. In two cases past experiences with Chinese universities have not been successful and were therefore ceased, the two other companies have only recently established their own R&D centers and are still in the establishment process, so that they have no resources for external collaborations yet.

More than half of the 26 companies with collaborations work with Chinese universities and the institutes of the Chinese Academy of Sciences (CAS). Six companies only collaborate with universities and no other research institute, the rest has different partners. While all companies seem to have a clear picture of what their university partners can deliver, the perception of the institutes of CAS are extremely diverse and sometimes even contradictory.

When asked about the differences between universities and CAS institutes, the majority (13) of companies do not see any differences, while nine of them do. The differences that were mentioned the most are that CAS is better in applied research than the universities, has more resources for research with regards to human resources and financial resources, and that on the other hand the universities are more flexible in co-operations. At the same time, some companies think that CAS is doing only basic research and others believe that CAS is so much closer to the government than the universities, in both cases rather restricting any collaboration. Another company mentioned that CAS is their partner for joint commercialization in joint ventures and they think that CAS is extremely good in this respect. This is a reflection of the broad scope of CAS and the huge differences between some institutes. Hence, it is helpful for MNCs to visit suitable CAS institutes and not follow general opinions their employees have about CAS, as their might be a good potential for high quality research cooperation that is still unused.

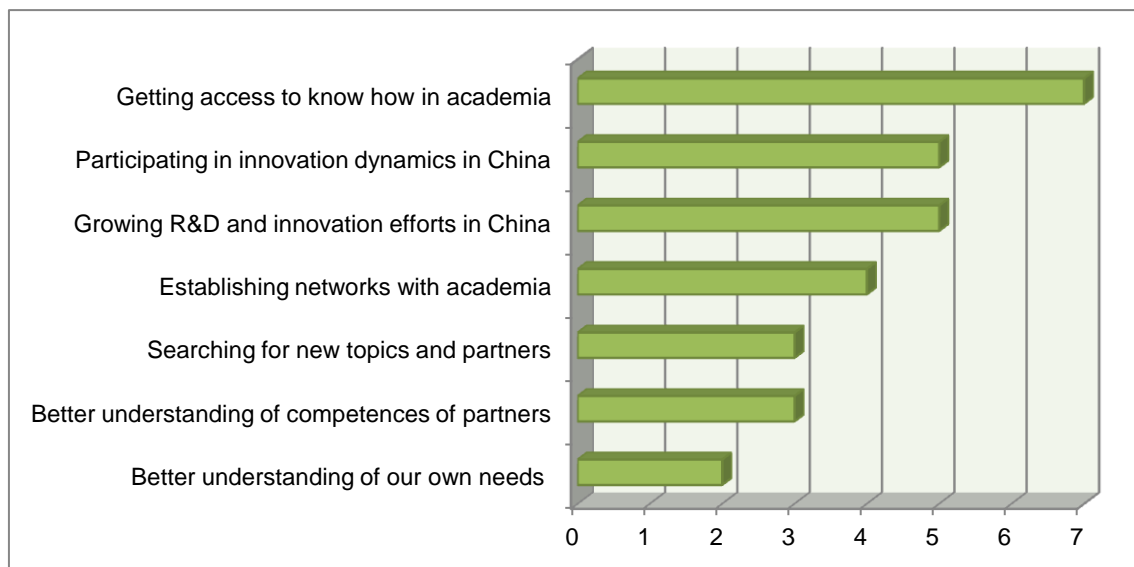
Half of the companies are doing applied or mostly applied research with their external partners, while eight companies are doing more basic research. Six companies are doing half basic and half applied research in their R&D collaborations in China. There

seems to be no tendency towards either of them, it depends strongly on the companies' rationale for external collaborations.

Looking at the number of research collaborations, most companies have around ten collaborations per year, seven companies have around 20 collaborations and very few have more. Even though most companies stated that they will grow their R&D activities in China (23), this does not automatically include an increase of their collaborations. 17 companies are planning to expand their collaborations with academic partners in future, while 11 do not want to increase them and one company is unsure because of internal reorganization process.

The three main drivers for increasing collaborations are: getting access to know-how in Chinese academia, participating in the innovation dynamics in China and supporting their own growing R&D efforts in China (as shown in Figure 3).

Figure 3: Main Reasons for increasing collaborations



Source: Fraunhofer ISI, own data collection

Those companies who do not intend to increase their collaborations mention their need for deeper and more intense collaborations with their existing partners as being more important than increasing the number of collaborations. It was mentioned many times during the interviews that the collaborations with Chinese universities and partners need much more time and human resources than those in other countries. One manager put it as follows: 'If you think about our collaborations between our German research team and university partners in Singapore, where we meet once in the beginning and then let things go until we meet for the final presentation and where we have no local staff at all, that is impossible with Chinese partners. I even think that it will

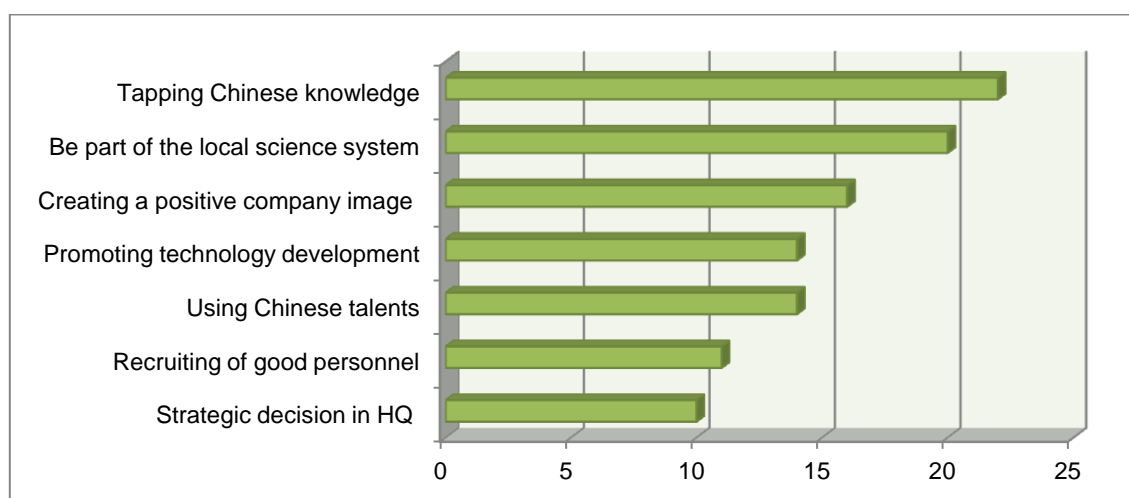
never be similar in China, we will always need local staff. Here [in China] we need to check in permanently, engage constantly, monitor precisely and make sure the partners do their work'.

2.3 Collaboration Drivers

2.3.1 Company side

The managers interviewed for this survey never had to think long when asked about their main drivers for collaborating with academia. The question was asked in an open question first, where the interviewees should mention their three main drivers for collaboration. In the next questions, they were given a list of 13 key drivers which were derived from the first survey, out of which they should select up to 5 key drivers. As the results from the open question are identical with the closed question, only the results of the closed question are shown in Figure 4.

Figure 4: Key drivers of MNCs for collaboration (> 10 times mentioned)



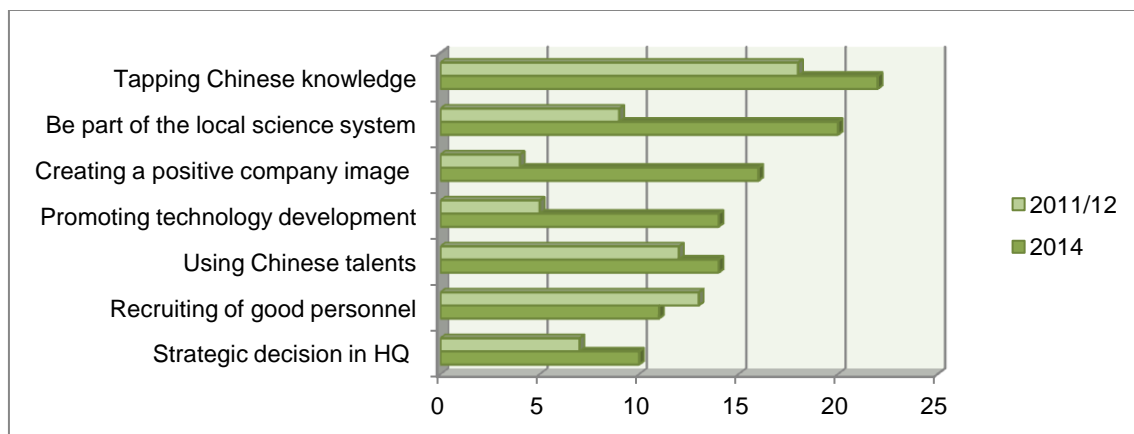
Source: Fraunhofer ISI, own data collection

As Figure 5 shows, the key driver for collaboration is tapping Chinese knowledge (22), followed closely by being part of the local science system (20). Creating a positive image of the company, promoting technology development in China and using Chinese talents are the other three main drivers (16, 14, 14). Recruiting plays a role (11) as do strategic decisions in headquarters, which ask the companies' scientists to collaborate externally (10).

When comparing these results with the data from the 2011/12 survey, a change in motivation can be observed, which reflects the changes in academia and how the compa-

nies perceive them (see Figure 5). In the earlier survey recruiting and human resources/talents were much more important than in 2014. Being part of the local science system, as in most other countries these companies are present, gained in importance in 2014 and ranks second only to tapping Chinese knowledge through collaboration. It is also interesting to see that in 2014 R&D collaborations are also driven by the need to create a positive image of the company, an issue that was much less prominent three years ago.

Figure 5: Comparison of key drivers of MNCs for collaboration, 2011/12 and 2014



Source: Fraunhofer ISI, own data collection

2.3.2 Academic side

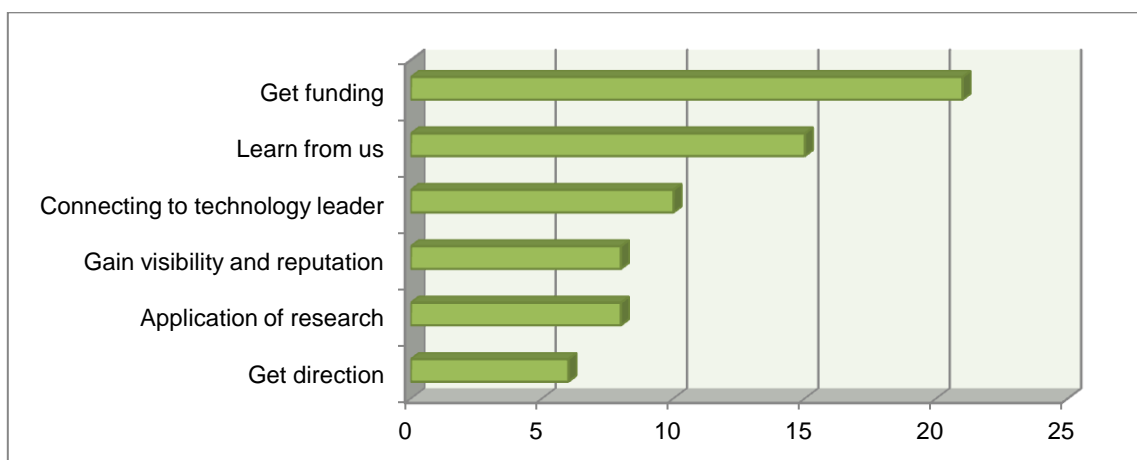
While it was not possible to interview the scientific partners for this survey, the MNCs were asked about what according to their understanding drives their scientific partners to collaborate with them. Figure 6 depicts the answers to this question.

Even though all interviewees responded that money is not important for the universities and institutes any more, 21 of them still mentioned it as one of three main drivers for collaboration. While this is quite contradictory, some managers explained that even though they believe funding is not the key driver, the money from industry gives the professors much more flexibility than the government funds, so that it is still attractive for them. So they might not see it as the most important driver, but it still is perceived as one. If money is not the main driver, what else motivates the academic partners?

Half of the companies believe that their partners are motivated by the fact that they can learn something from the companies (see Figure 6). This does not necessarily have to be know-how or technology, this can also include how to commercialize products, how to define research directions and more strategic research management. The other driver is the technology leadership of the company. Ten companies are convinced that

their leading position motivates their partners to collaborate with them. Eight companies believe that their partners can gain visibility and reputation from collaborating with MNCs, through which they might distinguish themselves from other professors at their universities or institutes. Eight companies think that the driving force for their professors is that they want to see their research being applied and actually used. Six companies think that their academic partners collaborate with them in order to get research direction from industry, in order to better understand in which direction they should go with their research.

Figure 6: Key motivation for academic partners to collaborate with MNCs



Source: Fraunhofer ISI, own data collection

When asked about the trends in academia's motivation, half of the companies had experienced a change in the past five years, while eight had not. There were only three explanations given how these motivations had changed, and one clearly stands out. 14 companies answered that in the past five years money has become less and less important for their partners. They observe that the universities have a lot of funding and they usually need other reasons for collaborating than just the funding. As mentioned before, once these other drivers are in place, then also money does motivate to some extent. But generally speaking, the interviewees feel that there is so much government money in the system that the universities are not mainly motivated by funds. One manager voiced his concern over the huge amount of money some universities ask for if they cooperate. He explained that if they want to start collaborations with smaller projects that the universities are 'reluctant to go for it'. This picture is completed by the other two explanations that in the past five years universities have looked more and more for win-win collaborations and that IP has become more important.

Asked about which future trends companies expect for the motivation of their partners, 17 companies believe that they might change, while 9 do not expect a change in motivation. Those who expect a change mostly expect that their academic partners will look

even more for application of their research, for technology and for doing business. Four companies expect that their partners will pay more attention to the research content in future, which they deem a very positive trend. Four companies expect that funding will become even less important than today, as they believe that the Chinese government will continue to put a lot of money into the science system. This is not seen as positive as some of the other trends, as some believe that the quality of research will drop with too much money in the system. Another manager said that he believes that in future, universities might ask for even larger projects from the MNCs which motivate them to collaborate and which would make cooperation for the MNCs more difficult. It would be particularly difficult to start co-operations with new partners, as companies always tend to start with smaller projects first.

2.4 Cooperation Models

Besides the activities in the R&D centers and labs, this study is looking especially at the collaborations between the MNCs and Chinese partners. What do these collaborations look like, which are the preferred and successful ways of collaboration, where can lessons be learned?

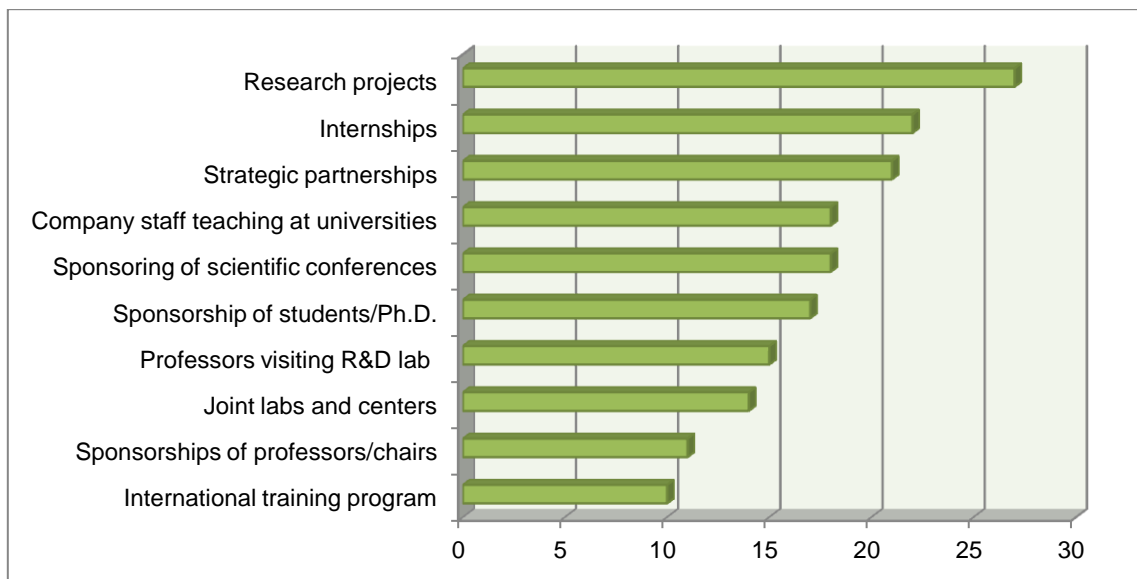
Bilateral research projects are by far the dominant way of collaboration. Here companies and scientists collaborate under a contract with clear goals, deadlines, milestones and deliverables.

In this case it is remarkable that those 26 companies with research collaborations are not exactly those with an R&D center in China. Also companies without research centers establish research collaborations with their teams in Europe or the US and Chinese universities or institutes. As a matter of fact, these companies often have strong and stable collaborations. At the same time, not all companies with an R&D center in China engage with Chinese academia.

As Figure 7 shows, internships and strategic partnerships are also used to connect with academia. Strategic partnerships can be described as long-term collaborations, where an agreement defines the framework for collaboration within the next three to five years. Under such strategic framework agreements different projects as well as other supportive measures can be taken, e.g. sponsorships and awards.

In addition, more than half of the companies sponsor conferences or students and Ph.D. students as well as teach at universities and invite professors to give lectures for the companies' researchers. Almost equal importance is given to joint labs or centers (14 companies), which link the partners closer together than any other of the aforementioned collaboration modes.

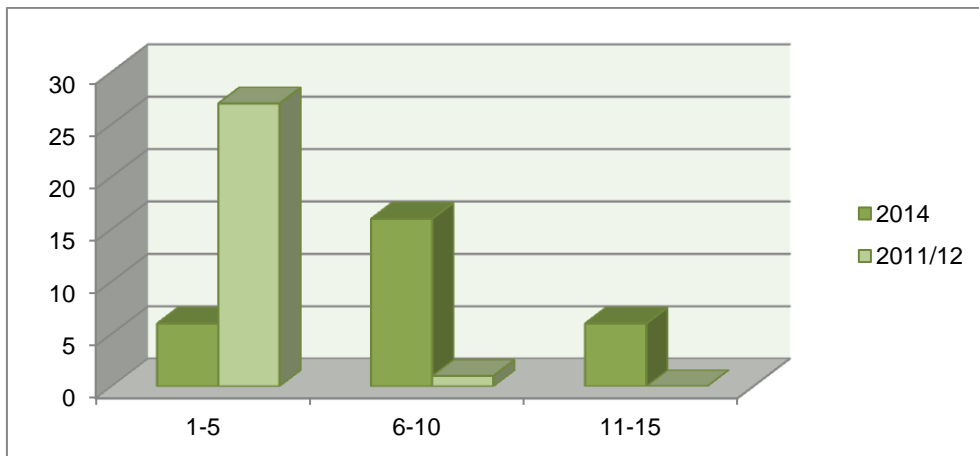
Figure 7: Types of collaboration (used by more than 10 companies)



Source: Fraunhofer ISI, own data collection

Comparing the results from the 2014 survey with those from 2011/12, it becomes obvious that companies are using more types of collaboration today than they did three years ago (Figure 5). In 2011/12, only one company made use of more than five different modes of collaboration and the majority applied only two or three different modes, while in 2014 the majority of companies used between six and ten different types in parallel, and six companies used between 11 and 15 different ways of collaboration. This shows that the extent to which MNCs collaborate with Chinese academic institutions has deepened over the last three years. It also shows that their collaborations go far beyond the research projects and that interaction on many different levels has grown. This can also be seen as an indication that in order to get good results from the research projects, an engagement on many different levels seems to be necessary.

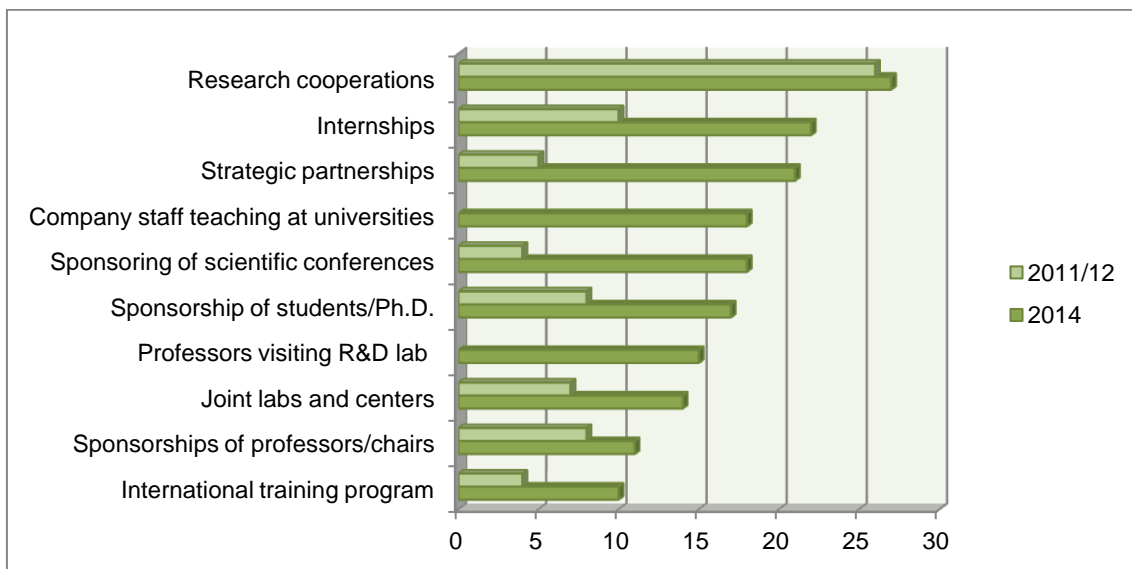
Figure 8: Comparison of number of parallel research collaborations, 2011/12 and 2014



Source: Fraunhofer ISI, own data collection

Looking at the types of collaboration that were used more than 10 times in 2014, Figure 9 compares the results from 2011/12 to those in 2014. In both surveys, research collaborations and internships are the two types of collaboration which are used most. But while the number of research collaborations is almost exactly the same, the number of companies using internships has more than doubled. Strategic partnerships rank third place in the 2014 survey and have increased more than fourfold from five to 21.

Figure 9: Comparison of types of collaborations, 2011/12 and 2014



Source: Fraunhofer ISI, own data collection

Company staff that is teaching at universities ranks on place four in 2014 and was not mentioned in 2011/2012. Also not mentioned before were professors visiting the com-

panies' labs in order to give lectures in front of the companies' researchers, while today half of companies are making use of this. Today more than half of the companies sponsor scientific conferences, while only a few had done so three years ago. The number of joint labs and centers has doubled in the three years between the surveys and risen from seven to 14. Sponsorship of professors in contrast has not grown much, which can be explained by the fact that most companies believe that professors are quite affluent. International training programs were hardly used in 2011/12, but gained importance in 2014. These training programs focus on high potential researchers, often Ph.D. students, which are sent to the foreign mother company for training. Such training is motivated by the idea that these young scientists will increase their understanding of the company and therefore perform better in the collaboration. More importantly these scientists might also become future employees.

There are many other ways of collaboration, which are often used by only one or two companies. In some companies, professors are invited to the lab and receive some kind of training there, which supports their own research as well as the collaboration. Awards are often used for young scientists or for groups of scientists who compete with each for these awards. In all cases it has been reported that it is a good way to connect with good scientists. Some companies organize summer schools for Ph.D. students, yet these are usually organized on the global level and Chinese Ph.D. students can apply for them. Summer schools for Chinese applicants only are still rare. Less important is the sponsorship of equipment. In alignment with other statements about the amount of money that is available in the Chinese science system, universities and institutes usually are very well equipped and hence have not much interest in sponsoring equipment. Good experiences have also been made with the organization of scientific competitions for existing problems or specific questions in the company. The advantage of such big, open competitions is the fact that research teams from all over the country apply for them and not only those which the company has already known before. Through these means companies can open their network and identify potential new collaboration teams across China.

When asked about their lessons learned from the modes of collaboration, most companies answered that all of them are useful and fulfill different goals. Two thirds of the companies will continue to use all of the different types they currently have in place. Yet some companies mentioned that research collaborations have the best results and will be increased compared to the other types (4). Others felt that strategic partnerships (5) and joint labs (4) are the best ways of collaboration, with the prerequisite that they are set up in a mutual beneficial way and filled with life.

2.5 Identification of Collaboration Partners in Academia

In general, companies find it easy to find the right partners in academia. They use systematic patent and publication analysis to identify the best scientists in their research field. International conferences are also one of the best ways to identify who can do what in China (and elsewhere). While in the 2011/12 survey most companies used their employees' network for identification, this has slightly changed in 2014. Even though it is still one of the good ways for partner identification, there have been voices among the interviewees that they cannot rely much on their employees' opinion, that they themselves or those in charge of the overall external collaboration need to have their own understanding and network in order to find the best partners. Rather they prefer to consult with the key opinion leaders in their companies on a certain topic and obtain their recommendations.

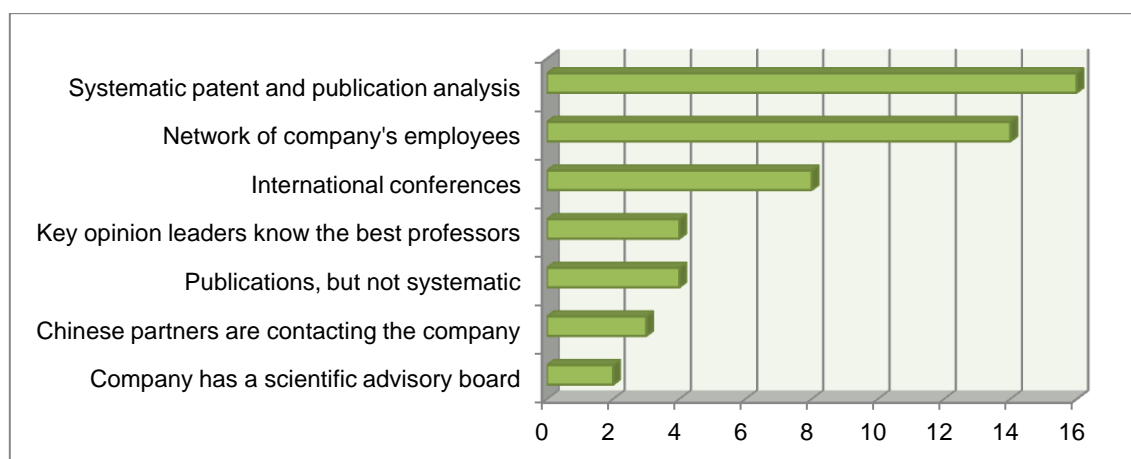
Some companies are less systematic, but still watch out for good publications by Chinese scientists. In a few cases, the universities were also actively contacting the companies in order to collaborate. Yet one manager made a clear statement that the company does not collaborate with those universities, as these are usually the less good ones. The best professors know that they are good and do not need to actively look for partners, they can carefully select among those companies that approach them. Another very effective, but still not frequently used way of identifying the best scientists is a scientific advisory for the company. This can be on the company level or the R&D center, and it is usually comprised of outstanding professors from the respective fields. While of course these board members themselves can become potential collaboration partners, they are also very familiar with the Chinese scientific capabilities of their peers and can recommend and even connect with the most suitable research partners (see Figure 10).

One of the most striking differences between the two surveys is that in 2014 there were so many more ways used for identification than three years earlier. Even though the following means were only used by one single company in the survey, they offer insights into the broad variety of options companies have. For example one company is buying an external 'TechWatch' Service for their specific fields and gets daily updates of what is going on in the Chinese science system. Another company was connected through the local government with their current collaboration partner, and it seems to have worked out very well. Yet from the first meeting to the first collaboration with this university it took more than three years, as the development of trust and understanding took a rather long time. The observation of the big national R&D programs 863 and 973 are a good way for another company. They monitor which professor and which institute is working in which of these programs, because they believe that only the best scien-

tists can get funding from the central government. Knowing the Chinese science system, this might not necessarily be the case, as peer review is seldom applied here, but at least one knows which scientists are closely linked with the government, which in itself can be important information.

An example which worked well and which one company shared was to connect with the highest level of an organization, either a university or CAS (e.g. president or vice president), and then agree on future collaboration on this institutional level. Then the Chinese partners will identify the suitable professors and scientists for the respective cooperation. This obviously works very well with CAS and opens access to all the different CAS institutes. This top down approach saves the company the time and effort to approach each institute individually. In another case, a chemical company made very good experiences in connecting with academia through becoming a member of the board of universities and scientific advisory board of associations. While serving on these boards they gain insights which they would have no chance of getting otherwise and they establish good connections on different levels. It seems to be a good way of improving the companies' understanding of the Chinese science system and knowing with whom to connect for collaboration.

Figure 10: Different ways of identifying suitable academic partners



Source: Fraunhofer ISI, own data collection

2.6 Success factors

The majority of companies believe that there are differences in innovation in China and abroad, and this extends to their collaborations with academia as well. One could assume that collaborations between academia and industry face the same challenges globally, for example the difference in work styles or the amount of scientific freedom versus the need to transfer research to products that succeed in the market. Yet the

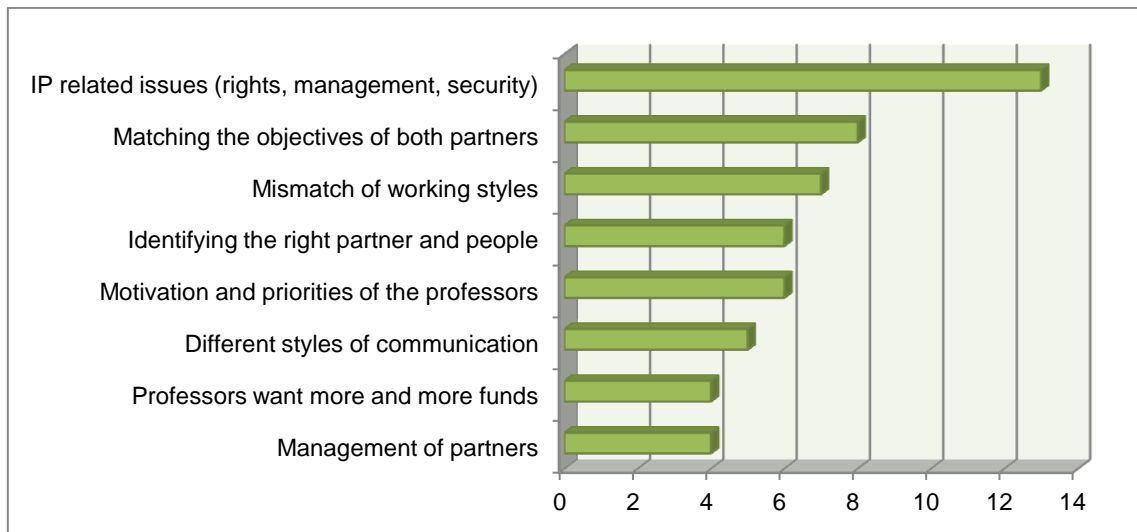
interviews reveal that MNCs have experienced certain challenges when it comes to collaborating with academic partners in China that are different to other countries.

Before judging their own success factors, MNCs were asked to describe on a more general basis what they believe to be the biggest challenges for MNCs in collaboration with academic partners in China.

The biggest challenge seems to be IP related issues (13), including IP management, IP security and IP rights. Even though in Europe and the US IP issues are also important for research collaborations, the issue is much lower on the agenda than in China. Matching the objectives of both partners is the second biggest challenge (8) and interviewees have described that they find it more difficult in China to deduce what the real expectations of their partners are. In addition, very often what is said is not what is meant. It can be assumed that this is also connected to the challenge of different communications styles, also including language, but mostly referring to the more implicit communication style in China. The third biggest challenge is the mismatch of working styles, which all respondents said to be much bigger than in other countries. The gap between universities and institutes on the one hand and industry on the other hand with regard to research organization, management and implementation seems to be very distinctive in China. Hence, companies need to invest a lot of time and resources to bridge these gaps.

Figure 11 shows the major challenges for MNCs in the past five years when collaborating with Chinese research partners. In addition to the above-mentioned issues, the motivation and the priorities of the professors have also been identified as a challenge. Some professors seem to take on projects with companies, but then lack either motivation or their priorities move to other topics, so that the collaboration becomes difficult.

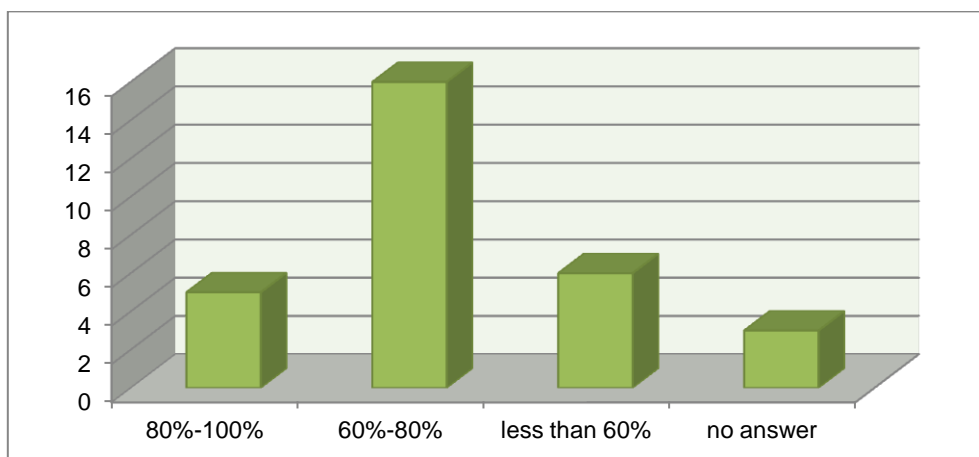
Figure 11: Main challenges for MNCs collaborating with Chinese academia in the past 5 years



Source: Fraunhofer ISI, own data collection

This raises the question of how many of the collaborations of the companies have been successful in the past five years¹. 16 companies, or more than half of them, have a success rate between 60-80 percent, while five companies have a success rate above 80 percent. Six companies have less than 60 percent of successful collaborations, which can be seen as an indication that it is still not easy in China to create successful cooperations (see Figure 12).

Figure 12: Success rates of collaborations



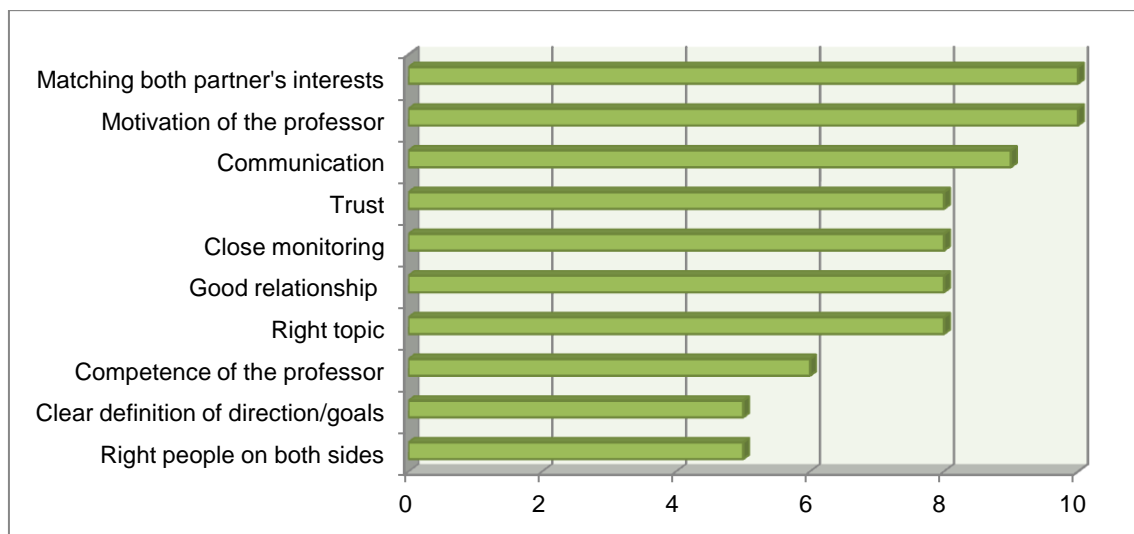
Source: Fraunhofer ISI, own data collection

¹ No comparison to 2011/12 survey possible due to insufficient answers.

This leads to the question what makes collaborations with academia in China successful or not. The answers from the 2011/12 survey were used as suggestions for identifying the five most important success factors per company in the 2014 survey. The result is shown in Figure 13. Yet before offering the multiple choice questions, the interviewees were asked if they could name their own three key requirements for successful collaborations. The answers differ to some extent from the multiple choice answers and are shown in Figure 14. They also differ from what is generally perceived as the key challenges for MNCs (see above).

Matching both partners' interests and expectations as well as the professors' motivation and commitment are the top success factors. Being able to communicate successfully with each other and creating trust between each other are nearly as important, as are close monitoring of the collaborations, having a good relationship and choosing the right topic for collaboration. In other words, if companies are able to match their own expectations with those of the academic partners and find a professor who is motivated by the topic, they need to create a trustful relationship and monitor the projects closely in order to have a good chance of collaborating successfully.

Figure 13: Key factors for successful collaborations (open questions)

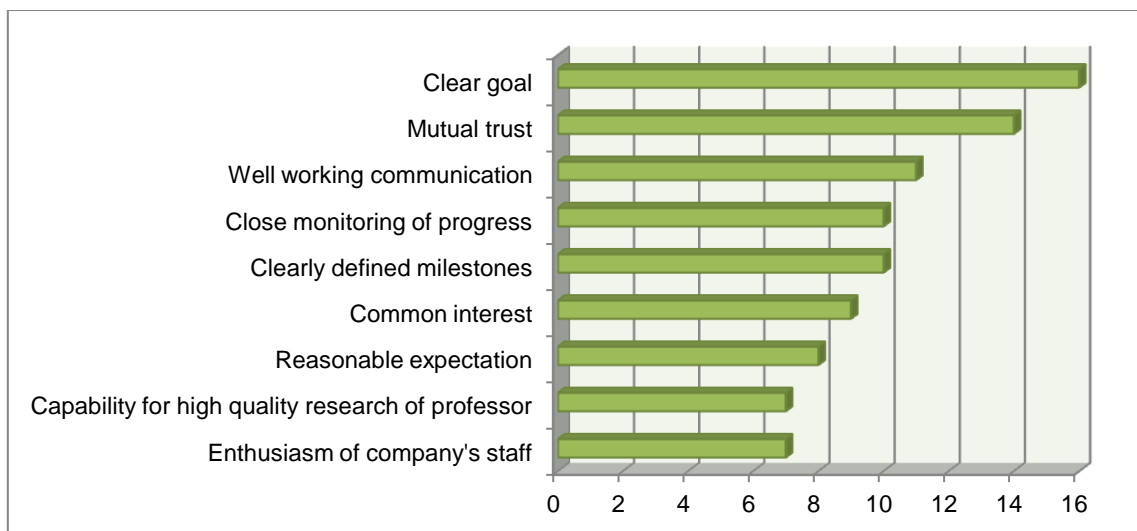


Source: Fraunhofer ISI, own data collection

The results from the multiple choice questions differ to some extent, but show a similar picture (see Figure 14). A clear goal, mutual trust and communication which works well are the three key success factors according to the multiple choice questions. Close monitoring of research progress, clearly defined milestones and deliverables follow in importance. Common interest and having reasonable expectations of what the collaboration can deliver are also quite important. The importance given to the capability of the

professors to do high quality research comes from the companies' experience that sometimes their partners have not been able to deliver what they promised and it takes some time before the start of a collaboration to understand the scientific capability of the academic partners. The same importance is attached to the motivation and enthusiasm of the company's own staff, which is also needed to ensure that the collaborations work well. This is connected with the previous results that collaborations in China take a lot of resources in the companies themselves and close monitoring, too. So companies' staff need to be constantly engaged, otherwise it becomes difficult to keep the collaborations on track.

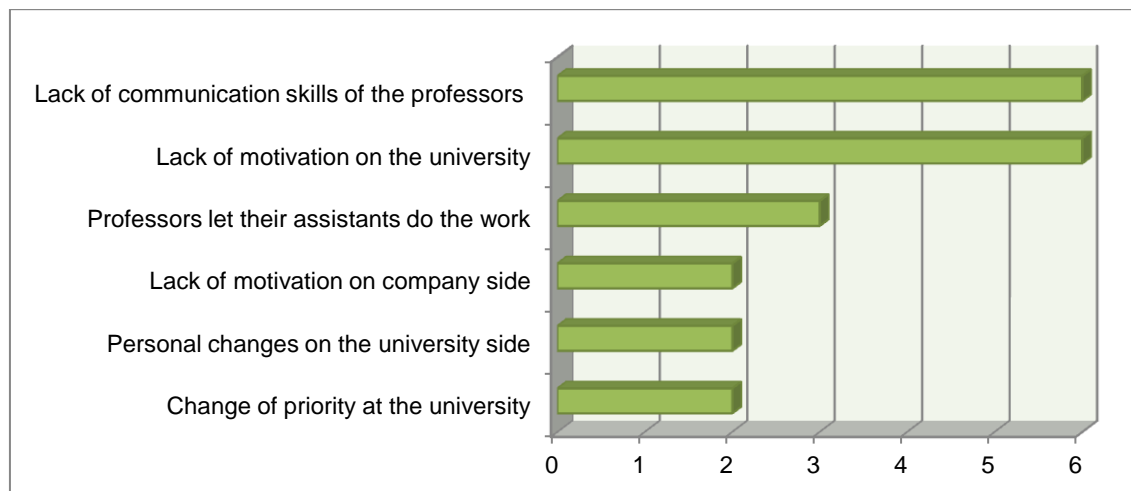
Figure 14: Key factors for successful collaborations (multiple choice answers)



Source: Fraunhofer ISI, own data collection

The survey also tried to identify the specific reasons for weak or unsuccessful collaborations, shown in Figure 15. Most respondents could not identify those factors specifically and felt that if the success factors were lacking (e.g. communication, motivation, etc.), then the collaborations would be unsuccessful. Yet a few interviewees named additional issues which make collaborations difficult. One is the common practice that professors will let their students do the work (which can also be connected with a lack of motivation or interest) and the other one is that often personal changes at the universities occur which pose a risk for collaborations. It was mentioned that this also happens in other countries or the company itself, but that there better mechanisms seem to be in place than in the Chinese universities that guarantee that the projects are continued.

Figure 15: Key factors for unsuccessful collaborations



Source: Fraunhofer ISI, own data collection

2.7 Collaboration Results

The previous chapter gave us an understanding of the factors for successful collaborations. Yet the question is not answered how this success can be measured or what the companies want as a result from their collaborations. While more than half of the companies (17) have already received publications and patents from their collaborations, even more (18) acknowledged that they also have other goals for collaborations, which cannot be measured in patents or publications.

These other goals are acceleration of product development (9), clarifications of own requirements (4) and a better understanding of scientific research in China (4). So while patents and publications are important results companies want to secure from their collaborations, they also have other goals. This is the same as for collaborations in other countries, as for example the study by Edmondson et.al. (2012, p. 11) shows.

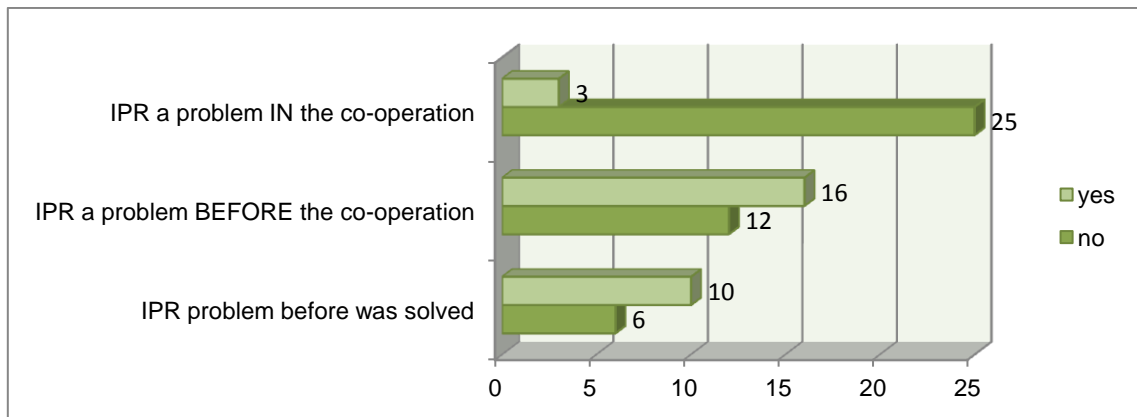
2.8 Intellectual Property Rights in Collaborations

2.8.1 Difficulties with IP-related issues

Any discussion about patents immediately leads to the question of the importance of intellectual property rights and the IP environment in China. In the 2014 survey more than half of the companies stated that IP has been a problem for collaborations for them, while 13 answered that it was not a problem. Out of the 16 companies that had a problem, 13 answered that it was a problem before the collaboration, while three companies also had problems during the collaborations. This is a slight difference to the

2011/12 survey, where none of the companies had any IP-related issues during the collaboration. Out of those 16 companies that had IP problems, 10 were able to solve them and start the cooperation, while six companies could not continue the planned collaboration due to these IP problems, as shown in Figure 16.

Figure 16: Problems related to IPR issues



Source: Fraunhofer ISI, own data collection

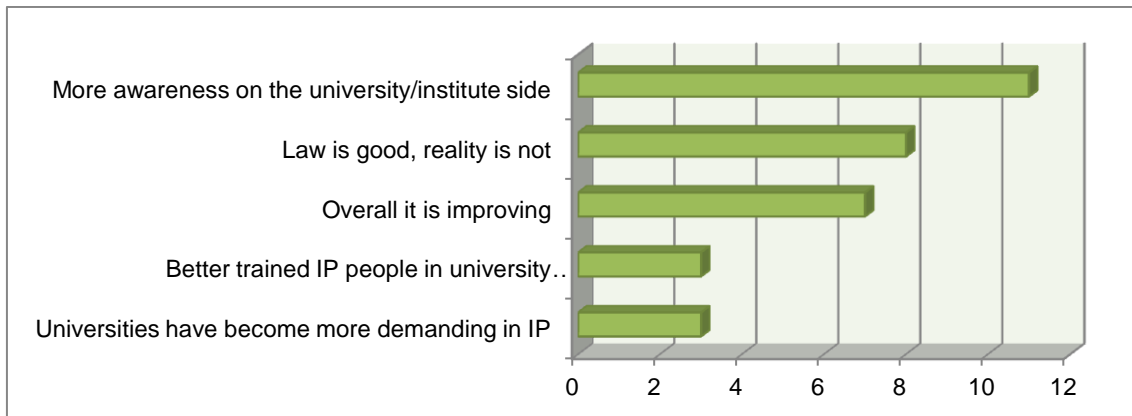
Interestingly, Tsinghua University was the only partner that has been specifically mentioned by a number of companies as being extremely difficult or highly uncooperative with regards to IP issues. While it is seen as a positive trend in general that universities are more aware of their IP rights and employ IP lawyers, Tsinghua seems to overstretch their expectations with regard to how much ownership a joint project can deliver. On the other hand it has also been mentioned that especially less experienced second tier universities lack qualified staff in their administrations to deal with IP issues and they sometimes also have unrealistic expectations when it comes to IP ownership or IP issues in general.

2.8.2 Past trends and future expectations in the IP environment related to collaborations

The major trend in the past five years that companies have observed is a higher awareness of IP issues at the universities and institutes, which they all consider a positive development, even though it can make negotiations more difficult (see Figure 17). The overall feeling is that the IP environment has improved and that slowly universities have better trained IP experts in their administrations, which again is seen as a positive trend. There also seems to be a slight trend that universities become more demanding in IP matters, which was mentioned in a rather negative way, meaning the universities have developed a tendency to claim unreasonable (from the perspective of the company) IP rights. Some companies have mentioned a few cases where their partners

wanted to even own the background IP of the company, which is simply unrealistic. In other cases the universities wanted to own the IP all by themselves, even though research would have been done jointly. Yet this does definitely not hold for the majority of universities and generally speaking companies have seen a welcoming trend to an improved IP environment.

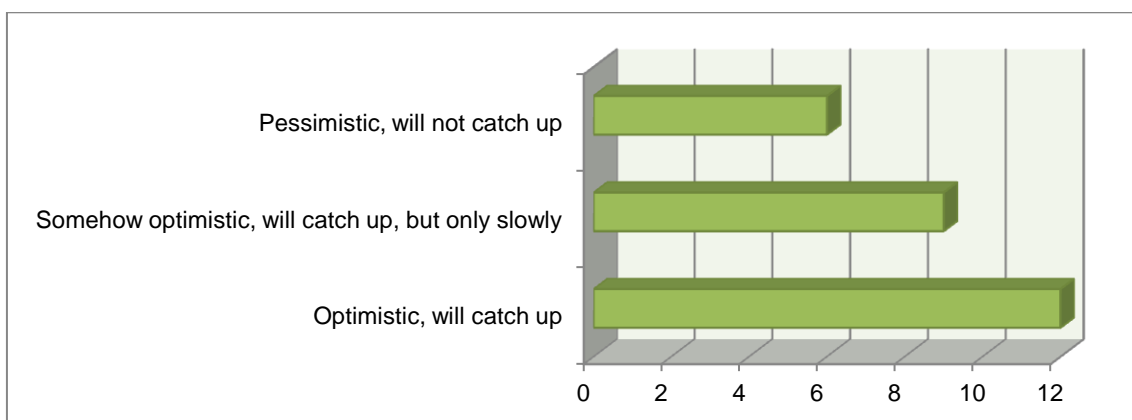
Figure 17: Major trends in the IP environment for collaborations in China



Source: Fraunhofer ISI, own data collection

When it comes to the expectations about the IP environment in the next 5-10 years, the opinions differ from being very optimistic to being very pessimistic (see Figure 18). Six companies believe that in the next five to ten years the IP system in China will not be able to reach international standards or levels. Yet the majority of companies expect positive trends towards this goal, with nine companies being somehow optimistic, expecting a rather slow catch-up progress, and twelve companies being optimistic that in five to ten years China will have a similar IP environment to Europe or the US.

Figure 18: Expectation of IP environment for the next 5 to 10 years



Source: Fraunhofer ISI, own data collection

2.8.3 Influence on IP strategy in China

So far the above-mentioned trends and expectations do seem to influence the companies' IP strategies in China to a certain extent. 14 companies answered that they are seeing influences on their IP strategies, while 11 do not see them.

Yet this result is difficult to interpret. The fact that a company 'follows a global strategy' was both, influenced by the Chinese IP system and not influenced by it. In some cases companies did have a specific China IP strategy in the past, but now follow the same strategy globally, so the changes in the IP environment in China have had an impact on their strategy. At the same time, some companies have never had a China specific IP strategy. The fact that they follow the global IP strategy is an expression of that company's IP strategy and not specifically influenced by the IP environment in China.

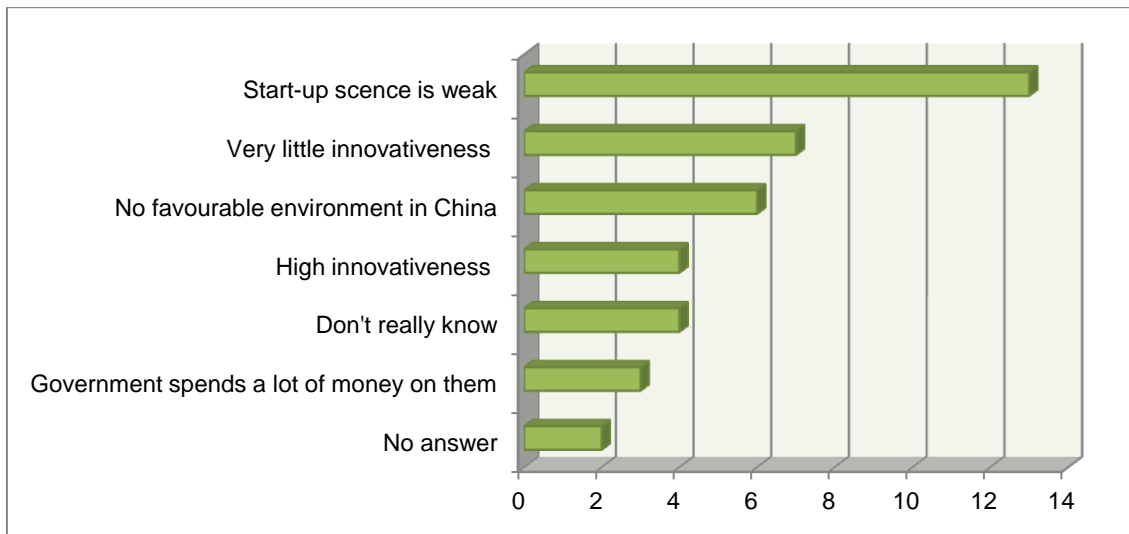
What can be said though is that four companies are more cautious in China when it comes to IP than in other countries. Three companies mentioned that they do have a specific IP China strategy, which is different to their global strategy. Yet 14 companies follow their global IP strategy.

2.9 Start-up scene and innovation

The knowledge of the start-up scene in China was not as high as expected before the interviews. There were only a few managers who had clear experience and a firm opinion of the start-up scene due to company internal venture funds for which they had done due diligence or surveys. One manager had worked for the VC fund for two and a half years before and knew the situation very well. Most of the others had no personal experience with Chinese start-ups. Another group of Chinese managers had no professional experience with start-ups either, but had an opinion about the start-up scene based on their friends' experiences. Mostly these friends were coming back from abroad setting up businesses in China. It has been observed that these managers, who reported more about their friends' activities, all had the impression that the start-up scene is rather vibrant and innovative and even close to the US. In direct contrast were the answers of those highly experienced managers, who think that the start-up scene is still weak, that not much innovation is happening and that it will take years to catch up with start-ups in Europe or the US, especially because they cannot find a nurturing environment in China yet (see Figure 19).

One manager answered that they observed that the start-ups which come out of Chinese universities, are generally not a potential cooperation partner for the company and they have their doubts if these start-ups will contribute to innovation and growth in China. Another manager mentioned that they see these start-ups as wanting to have 'me-too innovations', but not creating any true innovations.

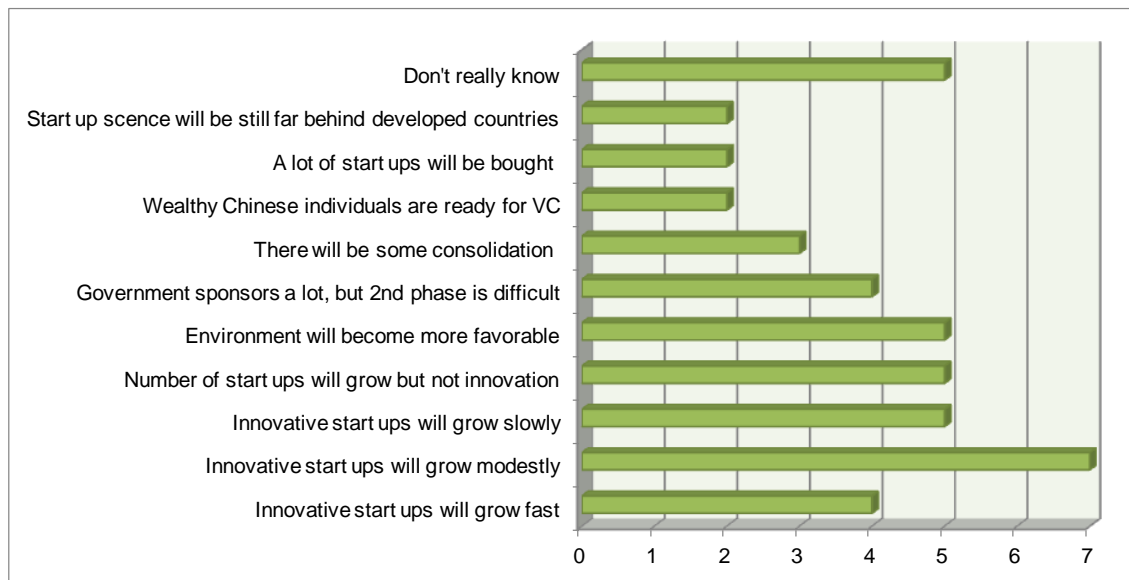
Figure 19: Perception of China's current start-up scene



Source: Fraunhofer ISI, own data collection

The answers differ even more when asked about the future and their expectations where the start-ups scene might be in five years. Seven managers believe that innovative start-ups will grow modestly, while four believe in a fast and five in a slow growth. Another five managers believe that only the number will grow but not innovativeness (see Figure 20).

Figure 20: Expected development of start-ups in the next 5 years



Source: Fraunhofer ISI, own data collection

As there was so little experience with start-ups, the opinion of those few managers with working experience with Chinese start-ups shall be highlighted in the following.

One manager described the situation as follows: 'The start-up market is still not very transparent, and few companies are innovative'. Another experienced manager in the field also mentioned the difficulties Chinese start-ups face when it comes to the second round of financing: 'We see lot of seeding, because the government puts so much money for it on the table. The real stage is the 2nd round and that's difficult, this process is not well structured in China'.

For the future, they expect a lot of consolidation instead of fast growth. 'The existing ones will become better in quality, but it will be more difficult than before to create sustainable start-ups', says one manager. She also sees that 'There are lots of rich people here but they don't know in which technology to invest. Only the IT industry is different, there are some good companies we can find in the IT industry'.

In future these companies have the potential to be a collaboration partner, as the majority of interviewees think that Chinese start-ups might become their future collaboration partners. Only two managers were seeing them as future competitors and seven managers could see them developing into both, partners as well as competitors. Six companies did not answer because they did not feel competent enough.

2.10 Innovation Policies and Framework Conditions for Collaborations

2.10.1 Impact of Innovation Policies on companies

This chapter looks at the suggestions what policy makers could do to support scientific collaborations between MNCs and academia in China. The interviewees were asked to think spontaneously, like creating a wish list for the Chinese government where changes would help them. They were asked not to consider whether they believe this is feasible in the near future or not.

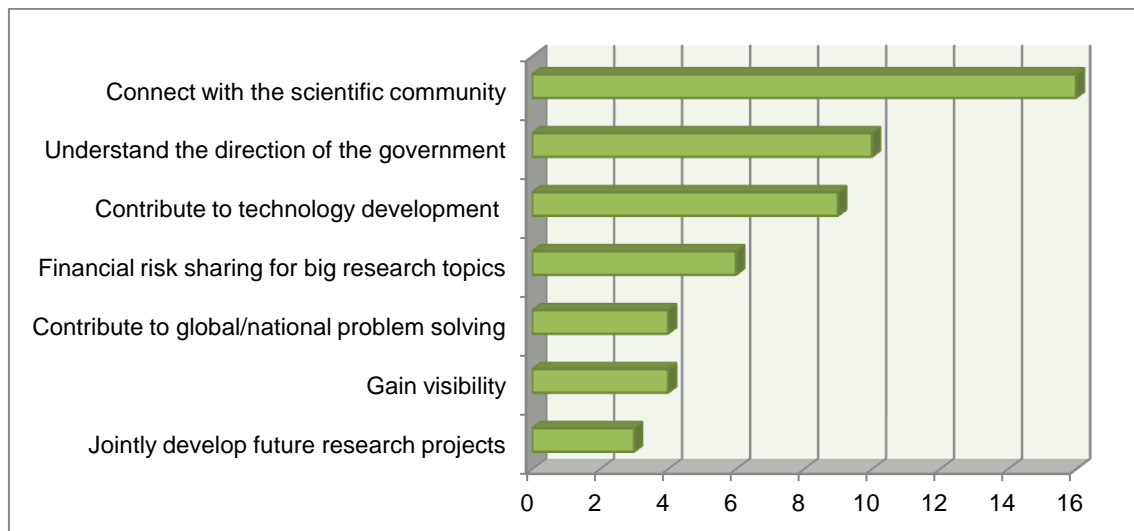
When it comes to previous participation in the national R&D programs, none of the companies has ever participated in them with a research task. Only one company has participated in one project so far. The company made clear that unfortunately they were not considered as a research partner in this project, but were only able to deliver a certain service to the project.

19 of the 30 companies would be very eager to participate in the national research programs, while ten said they might not want to participate.

The reasons why companies would like to participate in the national (and regional) public research programs are shown in Figure 21. The most important motivation for such participation is the potential to connect with the scientific community in China. This includes building relationships with the scientists and a better understanding of who can do what in Chinese academia. Companies could therefore establish linkages with a larger number of academic partners through these projects, which would support collaboration. This is especially important because the survey also shows that collaboration in China comes with a high need for resources and therefore their growth and extent is limited.

Ten companies believe that they would be able to get a better understanding of the direction of the Chinese government in research and development, which would help them to make better decisions generally but also with regard to their research collaborations. Nine companies want to participate in order to contribute to the overall technology development in China. Financial risk sharing is an important issue for six companies, followed by contributing to national and global challenges, gaining visibility toward partners and the government, and jointly develop future research projects.

Figure 21: Motivations for MNCs to join national R&D programs in China



Source: Fraunhofer ISI, own data collection

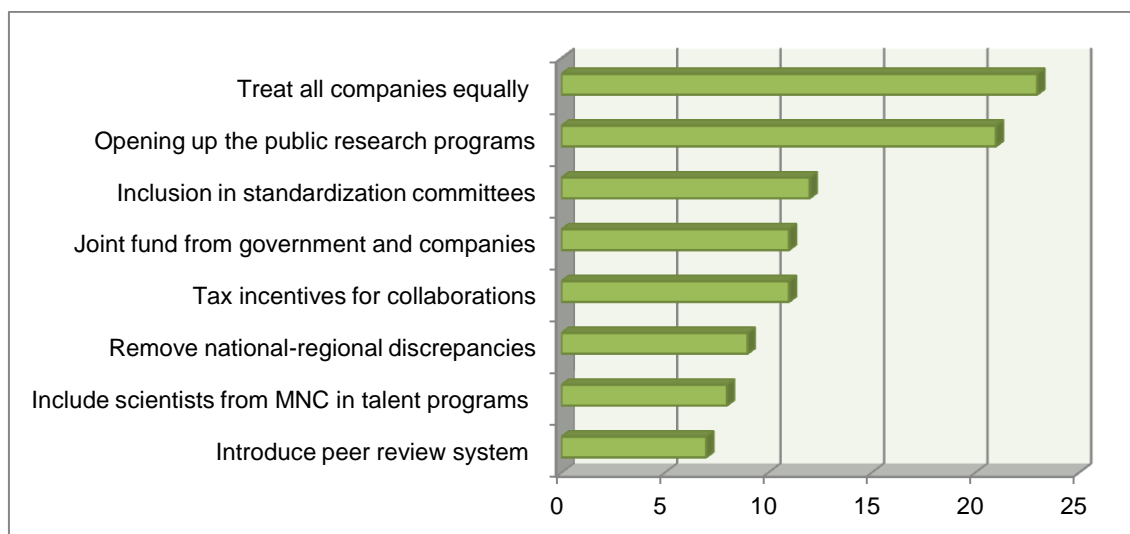
Two thirds of the companies are mainly driven in their China strategy for innovation and research by either their headquarters or the market. Few companies mentioned the existing talent pool ('we can only do as much as the talents in China can do'), the Chinese innovation policies and the global development of technologies as their driving forces. Chinese innovation policies are rather seen as a framework condition, which influences talents, IP etc. and not as a direct determinant of companies' strategies.

2.10.2 Summary of Changes in Innovation Policies

In the following, the companies were asked which policies they would like to change or introduce in China in order to help them to intensify and extend their research collaborations with Chinese academia (see Figure 22). This is a summary of all changes that were wished for, mentioned by more than one third of the interviewees. They will be discussed in more detail in the following chapters.

More than two thirds of the companies believe that the biggest obstacles for collaboration would be removed if all companies in China were treated equally, no matter whether Chinese or foreign invested, and if they were able to participate in the national R&D programs. More than ten companies identify the inclusion of MNCs in standardization committees as being important, because many of their research partners seem to be involved there and hence collaboration would be supported. The establishment of joint funding schemes between the government and the companies, maybe even including foundations, similar to public-private partnerships known from other countries, were mentioned by 11 companies. The same number of companies would like to see tax incentives for collaborations, followed by the removal of the difference between national policies and regional implementation. This difference causes companies some difficulties, as they find it difficult to understand where regional implementation is different from the national policies and often can only find it out 'the hard way', by 'trying and failing'. This has also an impact on the collaborations, as companies do often not engage if the overall situation is not clear or uncertain in order to minimize their risks. Including the scientists in the MNCs in the Chinese talent programs was also recommended, as was the introduction of a peer review system in the resource allocation of government funds.

Figure 22: Changes in innovation policies recommended by the companies (> 10 times mentioned)



Source: Fraunhofer ISI, own data collection

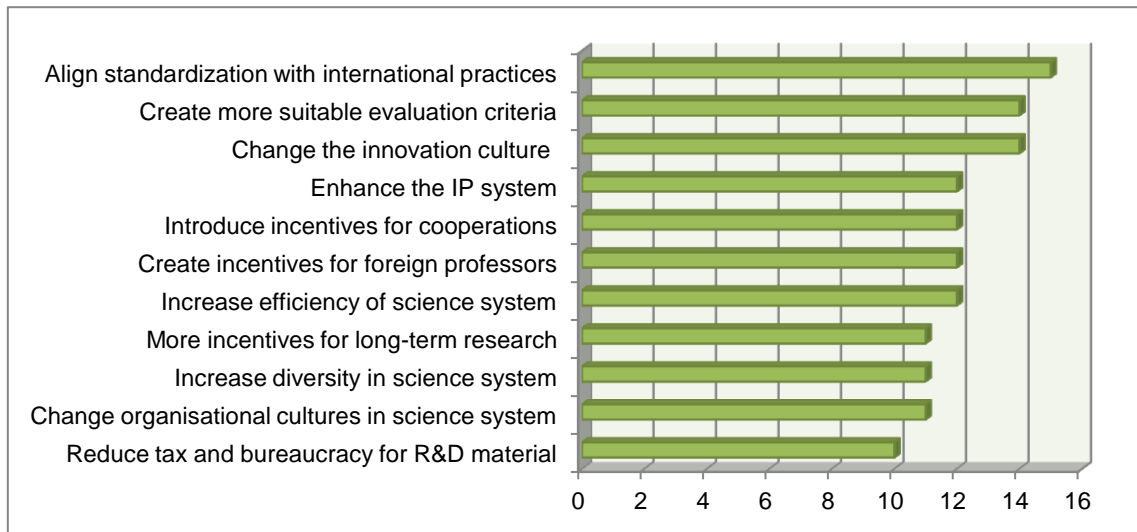
The following chapters will look into the different policy categories and the respective recommendations in more detail.

2.10.3 Changes in framework conditions

When it comes to desired changes in framework conditions the managers have a clear idea of what should be changed in order to support more collaboration. This should be seen in the light of practices these managers might know from other countries, where they experienced the importance of the government in setting the right framework conditions for innovation.

The most important issue identified was the alignment of standardization processes in China with international practices. Until today most interviewees have had the experience that standardization in China is used as a policy tool to support the government and not to protect the users regarding costs, diffusion and especially safety. Almost similar importance is given to the need for more suitable evaluation criteria in academia today, as the number of patents and the number of publications has mainly increased the quantity but not the quality of research output. A change in the innovation culture towards transparency, integrity, trust, compliance also stands very high on the agenda of changes necessary for more collaboration. This change of innovation culture especially includes the acceptance of failures in the science system, an issue where China is still very weak (see Figure 23).

Figure 23: Changes in framework conditions recommended by the companies

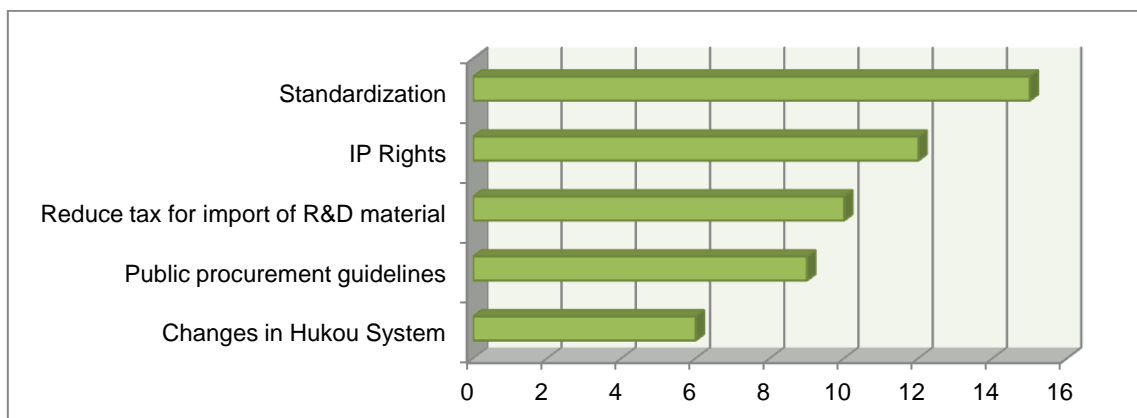


Source: Fraunhofer ISI, own data collection

2.10.4 Changes in legislation and regulation

In the field of legislation and regulation, the number one issue was again standardization, where current regulation prohibits foreign invested companies in eye-level participation. Intellectual Property Rights was mentioned more than 12 times. Maybe influenced to a certain degree by the bias towards the chemical industry in the survey, the reduction of taxes and reduction of bureaucracy for import as well as transport of small quantities of R&D materials was mentioned in third place. This seems to bother chemical companies more than other companies. Some companies struggle with public procurement guidelines and others have problems keeping their own good personnel due to problems in giving them the local household registration (Hukou), which then affects the collaborations and networks these people have established for the company (see Figure 24).

Figure 24: Changes in legislation and regulation recommended by the companies

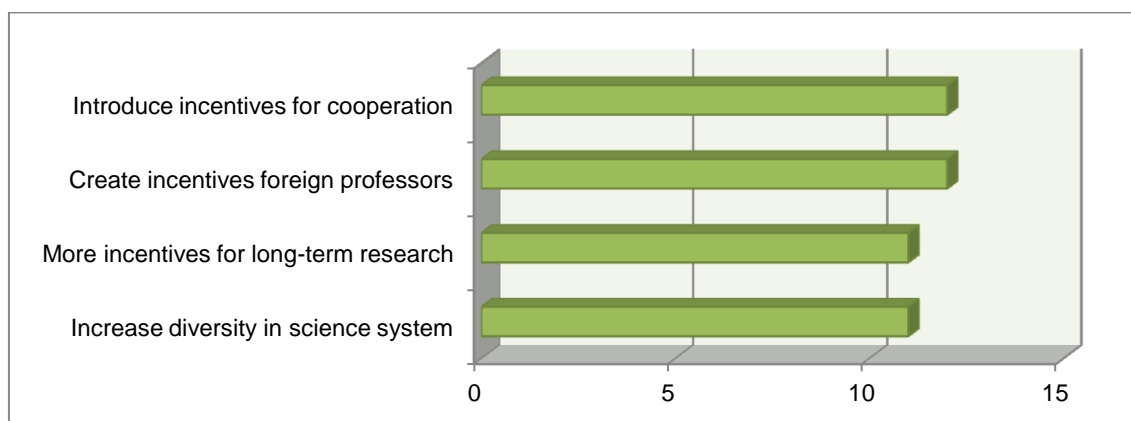


Source: Fraunhofer ISI, own data collection

2.10.5 Changes in public promotion programmes

One third of the companies suggests that the government could introduce incentives (not only in a monetary way) for cooperations between MNCs and academia. While in the early years of FDI it was seen as a sign of quality when a university or institute collaborated with an MNC, many government officials today mainly value collaborations with Chinese invested companies, independent of the outcome. If foreign professors got some incentives to collaborate with Chinese academia and the MNCs, that would also support more collaboration. In addition, more incentives in the Chinese science system to engage in long-term research would be beneficial, as would a more general increase in the diversity of the Chinese science system, which is often perceived as only supporting 'one type of personality' as well as people with similar instead of rather diverse backgrounds (see Figure 25).

Figure 25: Changes in public R&D programs recommended by the companies

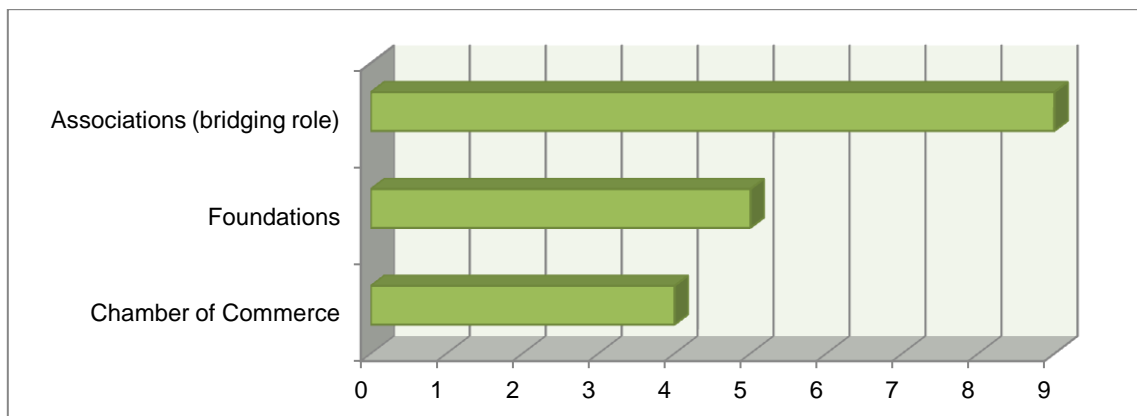


Source: Fraunhofer ISI, own data collection

2.10.6 Changes in intermediary structures

A lot of companies did not answer the question regarding their need for more, better or different intermediary structures to support their collaborations. They commented their choice of not answering by stating that they 'have found our way in China to connect with the local science system and therefore do not need any changes'. Yet nearly a third of the managers replied that it would be very helpful if associations in China could play a bridging role between industry and academia as they do in many other countries (see Figure 26). This would reduce some of the high efforts they have to make to understand and connect with academia before they can start any kind of collaboration and hence reduce their opportunity costs for collaboration.

Figure 26: Changes in intermediary structures recommended by the companies

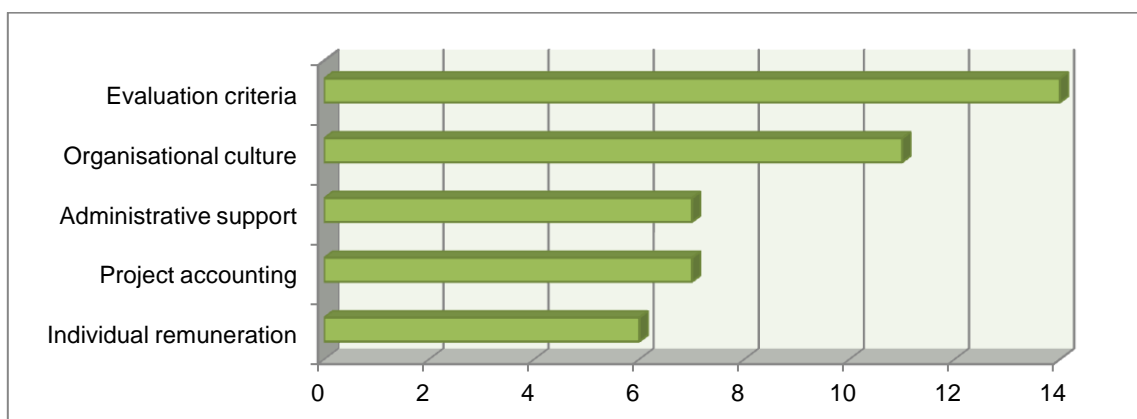


Source: Fraunhofer ISI, own data collection

2.10.7 Changes in institutional settings

Asked about the changes in the institutional settings of universities and institutes evaluation criteria of professors and scientists have been mentioned by almost half the companies. The focus on the number of publications and number of patents, in addition to the number of students and number of Ph.D. students for the evaluation of scientists has created an atmosphere in academia, where the pursuit of research moves into the background (see Figure 27). This is connected with the second recommendation to change the organizational culture, especially with regard to the flexibility of the professors and students on how to collaborate with MNCs. An increase in administrative support for the scientists, a more professional project accounting and an increase in the general remuneration of scientists are also considered important changes which would help to enhance industry-science collaboration.

Figure 27: Changes in institutional settings recommended by the companies

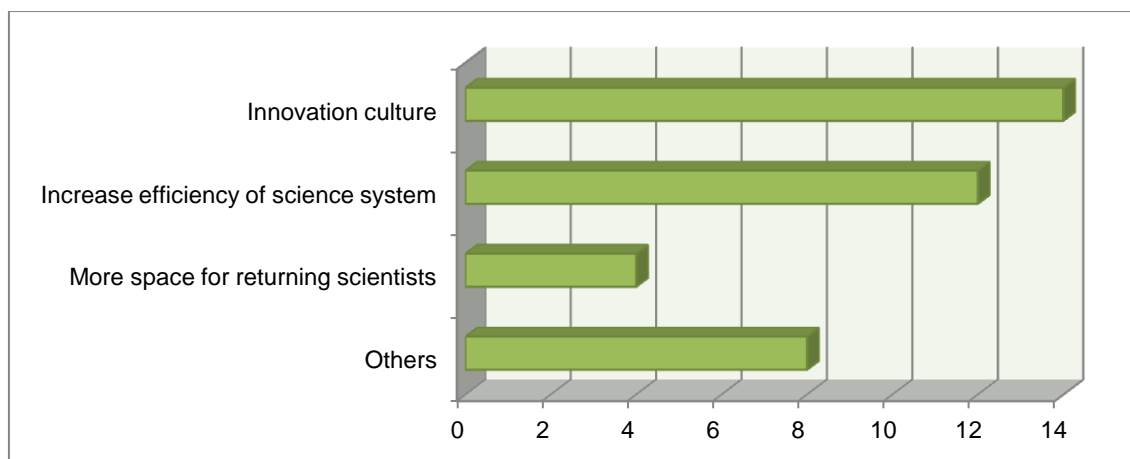


Source: Fraunhofer ISI, own data collection

2.10.8 Changes in the innovation system

The overall innovation culture in China is also a field where policy makers could have some influence. Almost half of the companies would find it beneficial for more collaboration if the innovation culture in China could be further developed, especially with regards to trust, transparency, compliance, and accepting failures (see Figure 28). In a few cases it was mentioned that returning scientists have not much space in the Chinese science system to make use of the knowledge and expertise they have gained abroad and therefore have not much impact on improving the overall innovation system in China.

Figure 28: Changes in the innovation system recommended by the companies



Source: Fraunhofer ISI, own data collection

Interestingly, the question about the recommended changes in the innovation system prompted many managers to share their personal views on the current system. All of the following answers have been given only by one person each, yet help to understand the overall situation.

A manager from a health care company would like to see changes in the way research funds are allocated so that they become more transparent and fair. Therefore peer review and much less influence of the academicians from the Chinese Academy of Sciences and the Chinese Academy of Engineering would be absolutely necessary. Also dealing with financial issues, but from another perspective, is the view of a manager from a chemical company, who believes that 'as long as universities can make money, they will not focus on their research. This blocks effective collaboration with the Chinese universities.' Another manager from an automotive company encourages a change in the social acceptance of people who focus only on one specific topic, as he finds that today these people get less recognition and acceptance than scientists that

engage in many different fields, maybe even comparable to Chinese state-owned companies who often have an incredibly large portfolio and not many companies are specializing in specific technologies or business areas. The key performance indicators have been mentioned before in the section about the institutional changes. A manager of a biotechnical company has put the biggest challenges in his own words: 'The biggest problem of the Chinese science system is that it has been hijacked for political reasons. This is the biggest obstacle for collaborations.' Closely connected to this is the statement of another manager, who said 'Policy transparency is the key to more success of innovation in China'. Without transparency, we will not be able to catch up with the leading nations in innovation. This is supported by a third statement from a manager from the information and communication industry: 'The problem in China is that the government intervenes too much in the freedom of scientific research; S&T in China is strictly government by the government, not by the scientists, this is the biggest problem.'

3 Discussion

3.1 Recent trends in R&D center development

When looking only at the R&D activities of the MNCs themselves, without looking at their collaborations, also numerous changes can be seen. The MNCs interviewed mostly have their own R&D centers in China, only four of those interviewed do not have one. Since 2011/12 a clear trend can be observed in the automotive industry, where market growth in China has outnumbered most other markets and where customer behavior has changed tremendously. In 2011 car manufactures answered that they do not need research in China, as Chinese customers prefer to buy imported cars as they are produced in abroad. In 2014 they said, that their Chinese customers have become 'extremely picky', that they have numerous special wishes and that some features, that are perceived positive in the west, e.g. the 'new' smell of a car, are seen negatively, or even, in the case of the new smell, as a threat to health. A second trend that drives the automotive industry to establish R&D in China is the integration of more IT towards a 'smart car', where Chinese customers seem to be pushing more and are more open to completely new ideas than in some Western countries. Assisted driving is one of these topics, autonomous driving might the next topic to be driven by Chinese customers. Some people argue, that these topics are easier to pursue in China, as there is no long tradition of driving a car anyway and also because legal regulations are less strict. This is difficult to evaluate, but the fact that China is a leading IT producer and developer and that Chinese people are very open to new IT applications might support this.

While the reasons for the more recent establishment of R&D centers in the automotive sector are obvious and clearly linked to the market and customer development, they are not so clear for the chemical industry. The different timing of establishing an R&D center in the chemical industry can also not be explained by their place in the value chain, as companies in the same place (e.g. upstream or downstream) have come to very different decisions. It seems that their decision to establish an R&D center in China depends heavily on the headquarters' strategy towards China. This shall be explained with the following example. One of the chemical companies interviewed in both surveys for example answered in 2011 that they cannot find a reason, why their R&D should move to China, and that it is more efficient to bring a hundred Chinese scientists and engineers into their overseas labs. Only two years later, in 2013, the same company established their R&D center in China and now has more than 400 employees and is still growing. This growth strategy is part of a global strategy defined in the headquarters abroad. While these decisions are of course guided by market developments and reflect a market growth in China, they are less driven by the requirements of the customers than in the automotive industry and more driven by other, more strategic considerations at the headquarters.

The number of R&D centers invested by foreign owned enterprises, including Hong Kong, Macao and Taiwan, reached more than 10.000 centers in 2013 (China Statistical Yearbook, 2014). This number was around 7000 in 2009, up almost 50% in those four years (China Statistical Yearbook 2010). The reasons for this growth is that in many industries China have grown tremendously in the past decade and while in the beginning it was easy to sell what was developed somewhere else, the market and the demand have now changed as has the local competition, which requires more and more adaptation. And only recently can we observe another change, as now adaptations are often not enough anymore and new developments are necessary to either serve the customer needs or to gain an advantage against competitors. With the 'new normal' of around 7% of GDP growth and rising labor costs in China, products need to move up the value chain in order to remain competitive, as they will not be by price alone anymore. This will definitely lead to even more R&D being necessary for MNCs in China, as long as their markets are still here and Chinese customers are willing or able to buy these products. In short, unless China is caught in the mid-income trap, the need for more R&D by MNCs and some SMEs is expected to increase in China.

So far there is a clear observation that the innovativeness in those R&D centers, that serve the global market, are higher than in those that focus on the Chinese market. Managers interviewed explained this with the fact that the Chinese customers are not yet ready to buy some really leading edge technology innovations. Chinese customers in some areas seem to prefer a product or a technology that is better what they have

had so far, but it must or even should not be the best in the world, as they deem this too expensive. So what some call 'real' innovations are often not needed, but still an increase in product quality, product features, new combinations of existing technologies etc. are already well accepted. This goes hand in hand with their explanation that, once they are focusing on the global market, they have similar or even the same innovativeness than other R&D centers of their company, mostly in Europe or the US. In these cases, there is no doubt that Chinese researchers in these labs can deliver the same level of innovativeness. For some of these R&D centers, they even have taken over global leadership responsibility for either certain products or product platforms, while they also support the development of other products, where leadership lies within the other R&D centers. While some media abroad still speculate whether China can produce innovations or not, these companies already prove that there should be no doubt whatsoever about this.

The fact that we do not see more innovation, according to our understanding, has mainly two reasons. The first one is that the market has not required a lot of technological innovations in the past, as the key success factor for business was the price. This is already changing today and market development and market maturity will require more innovation in the future. The second reason is mainly the functioning or efficiency of the Chinese innovation system, which has also blocked innovation in certain ways, especially through a strong top-down-approach to innovation policy and the fact that government is both, regulator, supporter and actor in the innovation system.

3.2 Relevant Changes over time

The comparison of the two surveys shows that one of the major topics that has changed over the 3 year period is the motivation for collaboration of the MNCs. While tapping Chinese knowledge remains the number one driving force with growing importance, the former second important driver, the recruiting of good personnel, has lost importance. This is not due to the fact that hiring has become easier, but that other reasons for collaborations, like being part of the local science system and creating a positive image have gained importance. Especially the positive image was almost negligible in 2012, but is seen as very important by half of the companies. It can only be speculated here, but it seems that the current negative press and voices about foreign companies in Chinese media increases their need to counteract this trend and show that their business does benefit China, too.

The interviews have made it obvious that the companies have gained more experience in collaborating with universities and institutes. While in 2011/12 quite a large number of companies had just started their collaborations and only had a few existing ones, this

picture has changed completely. Many of them run 10 to 20 collaborations in parallel, often with different partners. At the same time, all companies have implemented a variety of different forms of collaboration, all feeding into their overall goals from different perspectives. This shows that their understanding of 'what to do' with the universities and 'how to do' it, has improved and that they have gone through a steep learning curve in only three years.

Those companies who do not have significant collaborations are generally all those who have either only started to bring their R&D to China, which is often a big enough challenge, or those who serve more the global market than the local market, as their need for local knowledge seems less pronounced (they do collaborate with their company's other R&D labs and universities outside of China though) and where there is more fear of losing knowledge than gaining some.

There is also a strong connection between the goals of the collaboration and the different types of cooperation. Companies have understood that good networking and regular meetings are necessary for good collaborations. Yet once the creation of a positive image for the company becomes an important driver or goal of the collaboration, then of course the company needs to work on many different levels with the university, also on those not necessarily contributing to joint developments. At the same time, any activity and mutual exchange seem to be important to create mutual trust, which has been identified as one of the most important key success factors. So in the end, every type of collaboration and all the different levels (e.g. presidential level, professor level, student level) contribute to a well-working collaboration and will influence the research result. According to the managers interviewed, this is much more the case in China than anywhere else they have experienced.

3.3 Challenges for the next years

Special challenges for SMEs

Observing MNCs, this multi-level and multi-faceted collaboration mode seems to be no big problem. The situation might look different for SMEs, especially the small enterprises among them, which will not be able to afford such extensive exchanges and networking. Generally speaking, it is always more difficult for SMEs to collaborate with academia, and the special requirements of Chinese partners, e.g. the lack of trust, the different communication style etc., pose a need for additional resources of time and money on the SMEs. Hence, this might become a certain challenge for SMEs in the near future. This would be an issue, where governments and joint initiatives could step in.

Challenge of IP protection

The protection of intellectual property rights is still perceived as a challenge. As mentioned in chapter 2.8, even though the situation has become much better than before, companies still need to be very careful with whom to collaborate and how. They also need to pay a lot of attention to IP negotiations and not always both partners come to an agreement that meets both partners' expectations. The outlook on IP rights in China are rather heterogeneous, with a majority expecting the positive trend to continue. Here again one should bear in mind that the protection of IP is generally easier to handle for large companies than for small ones.

Start-up scene will need better framework conditions

Talking about innovation and science-industry linkages, usually start-up firms play an important role. Quite often, they begin in research institutes or universities, and even more so in China than in the Germany for example. They often are extremely innovative and they are looking closely to their former academic friends and partners for further development. So they are equally good partners for larger companies, as they are seen as more innovative, more flexible and more agile, and for academia, because they have closer connections with their former peers and not everything they want to do is ready for application yet. So looking at the start-up scene, this survey was able to provide only very limited insights, as most managers interviewed had no or almost no experience with Chinese start-ups. Yet those who had such experience were all rather disappointed, or at least not very optimistic. Private start-ups as well as venture capital are both rather new and young in China, and often the lack of transparency, or mixed ownership (between private persons and the state, local government or other non-private institutions), cause some difficulties. In the past years, the Chinese government has heavily supported especially technology start-ups, so getting the first round of financing seems to be rather easy. Problems really begin when the second round of money is needed.

Another observation in China is the fact that good start-ups are almost immediately bought up by larger firms, which are more often than not state-owned. As mentioned above, start-up companies have a number of qualities that are very hard to maintain when they grow, but seem even more difficult once they have been merged with a larger company, especially innovativeness. Even though no qualified result can be derived from the survey, it can be said that the development of a really vibrant start-up scene and good framework conditions for their future development will take some more time.

Inefficiency of the science system

The results of the survey show a clear trend that the amount of money that is available for Chinese scientists in the Chinese science system has increased considerably, which does not only have positive effects. This can also be shown by China's Science and Technology statistics, which show that China's total R&D expenditure grew by 22.6% per year on average in nominal terms between 1999 and 2013 (China Statistical Yearbook various years). As a result, R&D spending as a percentage of GDP increased from 0.83% in 2000 to 1.97% in 2012, and by 2013, it reached 2.08% (China Statistics Yearbook, various years). Furthermore, in 2012, China's R&D expenditure accounted for 20% of the total global R&D expenditure (in 2005 USD PPP), the second largest share in the world, after the US (OECD 2014).

The effect the MNCs observe is a lack the scientists' motivation to collaborate with MNCs, as they tend to have stricter goals, milestones, and control or evaluation mechanisms. MNCs usually start with smaller projects to build up understanding and trust of the scientists' capability, but report that many professors only want to have large projects, they have no interest in the small ones. Yet this is not a balanced observation, some companies still have motivated partners. Here the challenge seems to be bigger for companies that want to start new collaborations or venture into new areas where they have no established relationships yet.

This has led to a new strategy in some companies, which have stopped collaborating with the top 10 universities and instead look for outstanding scientists in less famous, but still rather good universities. These scientists seem to have less access to money, due to the current 'picking-the-winner-strategy' by the Chinese government (Liu et al, 2015, forthcoming). These scientists also still have more drive to achieve something, are new to the company and do not want to only commercialize what they have done already. So far, companies following this strategy have only reported positive results and are highly positive about their collaborations.

The currently discussed reforms of the science system might help to solve these issues in the mid-term, which would then be beneficial for any company collaborating with academia.

Opening up of national research programs

As mentioned before in chapter 2.10.2 it takes a lot of effort and resources in the companies to maintain well-working linkages with academia and to have long-lasting, successful research collaborations with them. As companies do not have an unlimited amount of resources available for such collaborations, their actions and the number of

collaborations remains limited. This is even more pronounced for SMEs, who are currently more or less left out of these industry-science collaborations in China. As a result of this huge input, we can also observe that some companies are very reluctant to invest in these collaborations because they had negative experiences in the past.

In many other countries, companies use government sponsored programs to connect with academia and to identify potential partners for bilateral research projects. In Germany there are numerous cases, where in such projects only the academic partners obtain government funding, and companies bring in their own funds or receive a very small percentage. The benefit of such projects really lies in the knowledge that can be shared and which can lead to the creation of new knowledge and a better technology transfer. As companies can link with many ideas and many partners, it can also help to reduce their costs compared to establishing research collaborations separately with each academic partner.

Hence, companies would see their collaboration potential unfold in China, once the Chinese government would open up their national research programs for all companies based in China, no matter where they come from, as already practiced in Europe. This would then also be a sign that one is on eye-level with each other, which can help build trust and contribute to more openness of the innovation system.

4 Summary

To summarize these findings, multinational companies have visibly increased their collaborations with Chinese academic partners in the past three to five years. They have more experience in how to approach and identify the most suitable partners and they collaborate in many different ways, something they did not do 3 years ago.

Companies are driven by the need to tap Chinese knowledge, to connect with the local science system and to create a positive image as well as to promote technology development in China. Their Chinese academic partners seem to be driven by the need to learn from companies, to apply their knowledge and to get project funding. Yet it has become clear that funding has lost its importance due to the large amount of money the Chinese government is pouring into the system.

IP issues are not seen as a big problem during the collaborations, but are carefully observed and can sometimes be a stumbling block before collaborations can start. Yet, the IPR topic generally remains one of the most difficult topics for doing R&D in China. The overall IP environment is paradoxically judged from having increased a lot to not having changed in reality, mainly based on the different past experiences of the per-

sons interviewed. Intellectual property rights remain a challenging topic for collaborations and each company needs to define its own, most suitable strategy in each case.

Still, multinational companies face some challenges in collaboration, which are related to trust, communication and understanding the partners' expectation. While all these difficulties can be overcome and companies have mostly found their way of 'doing things', it is a time-consuming and human resource intensive activity for all of them. This clearly limits the number and depth of collaborations and policy makers could create more favorable framework conditions if they want to increase the collaboration between MNCs in China and the Chinese academia.

More research should be done in the area of Chinese start-up companies. The interviews have shown that most managers have no clear idea of the situation, when at the same time the majority of them expect that these start-ups, or at least the innovative start-ups, will become their future collaboration partners for research and innovation. Hence it would be very helpful to provide the companies with further insights into this scene.

The currently discussed reforms of the Chinese science system might support industry-science linkages in the mid-term, yet at this point in time it is too early to say if problems will be only shifted or really solved. Yet for the Chinese innovation system, like for any other innovation system, a well-working linkage between the scientific and the industrial system are the key to its success. Hence, reforms should precisely target these connections and support the collaboration between Chinese academia and MNCs and SMEs, no matter where they come from. This would be the biggest benefit for China.

5 Reference List

- Abramovitz, M. (1986): Catching Up, Forging Ahead, and Falling Behind, *Journal of Economic History*, 46, 385-407.
- Belitz, H./Edler, J./Grenzmann, C. (2006): Internationalisation of Industrial R&D. In: Schmoch, U./Rammer, C./Legler, H. (Hrsg.): *National Systems of Innovation in Comparison. Structure and Performance Indicators for Knowledge Societies*. Dordrecht: Springer.
- Bell, M./Pavitt, K. (1993): Technological accumulation and industrial growth, pp. Contrasts between developed and developing countries, *Industrial and Corporate Change*, 2, 157-210.
- Cantwell, J./Janne, O. (1999): Technological globalisation and innovative centres: The role of corporate technological leadership and locational hierarchy, *Research Policy*, 28, 119-144.
- China Statistical Yearbook on Science and Technology, 2013, 2014

- Cohen, W.M./Levinthal, D. (1990): Absorptive Capacity: A new perspective on learning and innovation, *Administration Science Quarterly*, 35, 128-152.
- Dalton, D.H./Serapio, M.G. (1999): *Globalizing Industrial Research and Development*. Office of Technology Policy: U.S. Department of Commerce, September 1999.
- Dosi, G./Pavitt, K./Soete, L. (1990): *The Economics of Technical Change and International Trade*. New York: Harvester Wheatsheaf.
- Edmondson, G./Valigra, L/Kenward, M./Belfield, H. (2012): Making Industry-University Partnerships Work. Lessons from successful collaborations. *Science Business Innovation Board*, Belgium.
- Lall, S. (1992): Technological capabilities and industrialization, *World Development*, 20, 165-186.
- OECD (2014) "FDI in Figures. February 2014, <http://www.oecd.org/investment/FDI-in-Figures-Feb-2014.pdf>
- Patel, P./Vega, M. (1999): Patterns of Internationalisation of Corporate Technology: Location vs. Home Country advantages, *Research Policy*, 28, 145-155.
- Perez, C./Soete, L. (1988): Catching up in technology: entry barriers and windows of opportunity. In: Dosi, G./Freeman, C./Nelson, R./Silverberg, G./Soete, L. (Hrsg.): *Technical change and economic theory*. New York: Pinter, 458-479.
- Soete, L. (1985): International diffusion of technology, industrial development and technological leapfrogging, *World Development*, 13, 409-422.
- Teece, D./Pisano, G. (1994): The dynamic capabilities of firms: an introduction, *Industrial and Corporate Change*, 3, 537-556.
- UNCTAD (Hrsg.) (2005): *World Investment Report 2005: Transnational Companies and the Internationalisation of R&D*. Geneva: UNCTAD.

Annex 1: Sample description

2014 survey

The 2014 survey consists of 30 multinational enterprises in China, mainly in Beijing and Shanghai. Few MNCs have their R&D centers in other cities, so that only one in Wuhan and one in Shenzhen could be included in this survey. Attempts to include MNCs in Wuhan failed due to a lack of companies willing to be interviewed.

Out of the 30 companies, 26 MNCs currently have a global R&D center in China. The sector distribution is 12 companies from the chemical industry, 4 from the pharmaceutical industry, 4 from the transportation industry, 3 from the computer/ electronics industry, 1 from the IT industry, 1 from the food industry and 5 from companies which are active in multiple sectors. During the interviews it was obvious that collaborations with universities and institutes differ a lot across the industries. Even though it would be helpful for the overall assessment, the sample size of this survey does not yet allow for this distinction.

Countries of origin are biased towards Germany with half of the companies being headquartered in Germany, followed by France (7), US (3), Denmark and the Netherlands (2) each and Sweden (1).

20 companies or two thirds of the companies in the 2014 survey are identical with the 2011/12 companies. One third of companies dropped out mostly due to a lack of response to the request for interviews, so that 10 new companies had to be included. This clearly limits the comparability of both surveys and has to be kept in mind in those cases where comparisons are drawn. For this reason comparisons in this report between the two surveys are only made when they offer some insight into the change over time that has been confirmed by interviewees.

Innovation in this survey is following the OECD/Eurostat definition: "An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations." (OECD & Eurostat 2005: Oslo manual, 3rd edition).

2011/12 survey

The sample from 2011/12 also consists of 30 MNCs in China. 80 percent of the interviews were face-to-face interviews and took between one and three hours. In some cases a visit to the R&D lab was added. The sector distribution is as follows: chemicals

(7), pharmaceuticals (6), computer/electronics (4), multiple sectors (3), transportation (2), IT (2) and 6 from other sectors.

Countries of origin are biased towards western developed countries and especially towards Europe. About one third of the companies is headquartered in Germany (10), followed by France (6), US (5), Denmark (4), the Netherlands (4), Sweden (1).

The majority of the companies interviewed (21) have a global R&D center in China. This leaves 9 of the companies that do have collaborations with Chinese academia without their own R&D labs in China.