Competitiveness through R&D internationalization

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patent- and interview data based studies on a latecomer in the telecommunications industry

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Abstract

In recent years, we have been observing an increase in knowledge-intensive activities from emerging market latecomer companies in established centers of state-of-the-art knowledge. This new direction of research and development (R&D) internationalization is still an under-researched strategy for latecomers to gain competitive advantage. In order to uncover these mechanisms, this dissertation uses the case of a Chinese latecomer that recently achieved a leading position in the global telecommunications market: Huawei Technologies. The focus of this dissertation is on the mechanisms that enabled the company to obtain strategic assets through R&D internationalization into leading markets. In a mixed-methods approach, quantitative patent data and qualitative interviews are combined to trace the company's development during its emancipation from a latecomer stage to an industry leader. The results show that Huawei does its most influential R&D at its offshore locations despite the risks and challenges of having core assets abroad. By doing so, the company focuses on greenfield investments instead of acquisitions by hiring experts at offshore locations. This way, Huawei leverages the experts' embeddedness in the networks of the global telecommunications industry, which helps the company to overcome liabilities of outsidership as well as challenges of legitimacy and become part of the global industry community. Since the company has caught up on technological and organizational knowledge, it now splits its R&D tasks between research in centers of state-of-the-art technologies and development in China, in order to transfer innovative ideas from abroad to its domestic locations. Thus, the company gains output capability by bridging the lack of innovative capability at its domestic R&D location by employing experienced and creative experts at its offshore locations.

Keywords: Chinese Latecomer, Research and Development Internationalization, Innovation Capability, Greenfield Investment, Mixed-Methods Approach, Patentdata

Zusammenfassung

In jüngster Zeit lässt sich in etablierten Wissenszentren eine Zunahmen wissensintensiver Aktivitäten durch Unternehmen aus aufstrebenden Märkten beobachten. Diese neue Richtung der Forschungs- und Entwicklungsinternationalisierung (FuEI) ist eine aktuell noch wenig erforschte Strategie für Latecomer Unternehmen um Wettbewerbsvorteile zu erlangen. Um die dahinterliegenden Mechanismen zu ergründen nutzt diese Studie den Fall eines chinesischen Latecomer Unternehmens, das erst kürzlich eine Führungsposition in der globalen Telekommunikationsindustrie eingenommen hat: Huawei Technologies. Der Fokus dieser Dissertation liegt auf den Mechanismen, die helfen strategische Assets durch FuEI in führende Märkte zu erwerben. Durch einen Mixed-Methods Ansatz der quantitative Patentdaten und qualitative Interviews kombiniert, wird die Entwicklung des Unternehmens vom Latecomer zum Industrieführer nachverfolgt. Die Ergebnisse zeigen, dass Huawei seine einflussreichste FuE an seinen Auslandsstandorten durchführt, trotz der Risiken Kerngeschäftsbereiche im Ausland zu unterhalten. Dabei liegt der Fokus auf Greenfield Investitionen anstelle von Akquisitionen, in dem gezielt ausländische Experten an den Auslandsstandorten eingestellt werden. Huawei nutzt die Einbettung dieser Experten in das Netzwerk der globalen Telekommunikationsindustrie um seine Außenseiterstellung und die Legitimitätsprobleme seiner Auslandsaktivitäten zu überwinden und Teil der globalen Industrie zu werden. Nachdem das Unternehmen seinen Rückstand an technischem und organisationalem Wissen inzwischen aufgeholt hat, teilt es nun seine FuE Tätigkeiten zwischen Forschung in etablierten Wissenszentren und Entwicklung in China auf, was den Transfer innovativer Ideen aus dem Ausland zu den Heimatstandorten befördert. Demnach erwirbt das Unternehmen die Fähigkeit innovative Produkte zu produzieren, in dem es fehlende innovative Fähigkeiten im Heimatland durch das Nutzen der Erfahrung und Kreativität ausländischer Experten überbrückt.

Schlagworte: Chinesische Latecomer, Forschungs- und Entwicklungsinternationalisierung, Innovationsfähigkeit, Greenfield Investitionen, Mixed-Methods Ansatz, Patentdaten

Preface

The most steady experiences I had during my research on "Huawei" was the continuous struggle of people trying to pronounce the company's name. The question of how to pronounce it still causes confusion, even among German radio news reporters who I usually turn to for pronouncing unfamiliar words. But other than that, a lot has changed since I started working on the topic six years ago.

At the time I started working on this dissertation, Huawei Technologies was not a company many people had heard of. When I started to go to conferences and talk to other researchers about my project, few had heard of the Chinese telecommunications giant before. This was particularly true for my US-American colleagues, who even as Huawei was becoming a popular brand for smartphones in Europe, would not believe that this Chinese company might be seriously chasing after Apple's technological leadership. Nevertheless, Huawei recently achieved popularity for its infrastructure business from the headlines about its struggles with the US government rather than for its ground-breaking 5G technology. The observations I made for this dissertation in 2017 would be difficult to make today after Huawei has become such a heated topic, as the recent political struggles might have overshadowed the insights about Huawei's unique path as a latecomer gained from the interviews. Nevertheless, the recent headwind Huawei received shows that even despite being able to catch-up in the industry, sensitive markets such as communication infrastructure are not won by technological competence alone as they are also subject to political risk.

To come back to the main question you all have probably been eager to get answered, the suggested English pronunciation for "Huawei" is "Wah-Way", as the company explains in an official YouTube video. Even if Chinese-speakers emphasize the missing silent H in this version, it is also the version used by the international employees I spoke with. I therefore decided to stick with it.

Acknowledgments

Of course, the undertaking of a dissertation is not a single-person job. First, I would like to thank all my colleagues in Hannover for their support with extra thanks to Louis and Lukas. Special thanks also goes out to Lars Mewes for his support, cheerful academic discussions and for keeping me on my toes. I would like to thank my (former) research assistants Lennart Schott and Jana Almstedt for their excellent work and for keeping me sane. I would like to thank Kerstin Nolte and Stefan Hennemann for being my role models and mentors. I would like to thank Zoë Vercelli for writing therapy and my SciMento peergroup including our mentor Simone Wies for giving me the confidence to take a leap. I would like to thank the Gottfried Wilhelm Leibniz Library Hannover for providing a quiet place during times of construction. I would also like to thank David Rigby and his group, in particular Melissa, Chris, Christopher and Frank, for their hospitality and friendship during and beyond my visit at UCLA. Moreover, I would like to thank Andrea Ascani for inviting me to Utrecht Universiteit and his moral support in the end phase of my project. I would also like to thank my fellow PhD students around the globe who inspire and motivate me the most for this job: Marcin Rataj, Rahel Meili, Regina Lenz, Jaap Van Slagere, Toni Habersetzer, Amir Maghssudipour, Benjamin Klement, Jakob Eder, Cathrin Söllner, Jonathan Eberle and the Young Economic Geographers Network.

I would like to thank my supervisor Ingo Liefner for always supporting me and giving me the space, confidence and resources to develop and follow my ideas. Moreover, I would like to thank my friends who looked out for me during this exciting times: Katharina, Steph & Malte, Manu & Tine, Grace & Kevin, Artur, Artem & Yeter and my sister Ann-Christin. I would also like to thank my parents who always, not matter what, have my back.

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Chapter 1

Introduction

1.1 Motivation

In our knowledge-based economy reliant on growth and technological progress, the gradient in innovation capability between regions is heavily contributing to the unequal distribution of economic wealth and welfare (Romer, 1990). Leading global players usually come from regions with ample access to innovation capabilities, but we recently observe that companies from formerly more economically peripheral regions, who are lacking innovation capability in their home region, strive to become competitive towards established global players in knowledge-intensive industries (Buckley & Hashai, 2014; Chen et al., 2012; Hsu et al., 2015). An indicator for this development is the growing presence of outward foreign direct investment (OFDI) from emerging markets directed at accessing knowledge and innovation capability in established markets (Gammeltoft, 2008; Poon et al., 2006; Mathews, 2002). The recent World Bank Report on Global Investment Competitiveness shows an immense growth of OFDI from emerging markets, a trend heavily driven by China, which made up more than a third of all emerging markets' OFDI stock in 2015 (Perea & Stephenson, 2019). If emerging-market multinational enterprises (EMNEs) are able to leverage these investments made through the internationalization of their research and development (R&D) activities, they might be able to build innovation capability themselves in the long run. This is important as it might change the high percentage of low value-added tasks of jobs in emerging regions towards more knowledge-intensive and higher value-added tasks (Mudambi, 2008; Gereffi & Lee, 2012), thus increasing economic wealth and welfare in the EMNE's home regions.

Despite the growing presence of EMNEs on the global stage, we still know too little about how actual upgrading through R&D internationalization works (Awate et al., 2015). This is particularly the question for latecomers among EMNEs, entering mature industries, because they have to catch up to already established players and enter markets that are already being served (Mathews, 2002; Luo & Tung, 2007, 2018). This dissertation therefore sheds light on the under-researched mechanisms of latecomers gaining competitiveness through R&D internationalization. It does so by studying the case of a latecomer from China that recently became a technological and market leader in telecommunications: Huawei Technologies Co., Ltd. (Huawei).

1.2 Theory and Research Gaps

Iammarino & McCann (2013) emphasizes that the origin of most global R&D has long been majorly established countries such as the triad of the US, EU and Japan. The now increasing participation of EMNEs in global R&D is one of the main drivers for the changing economic geography of the world. Locating in centers of state-of-the-art knowledge is highly important for high value activities, and emerging regions without access to knowledge assets are at risk of being left behind with low value-added activities (Iammarino & McCann, 2013). The global split of tasks in multinational enterprises (MNE) increasingly follows the value chain stage of the activity to the most effective host location (Crescenzi et al., 2014). This bears risks but also chances for EMNEs and their home regions, as it affects regional connectivity and dependencies between regions on a global level (Crescenzi & Iammarino, 2017). MNEs are influencing regional development by orchestrating knowledge flows across space and are an important source for technology transfer between regions, in particular in cases in which regions have different levels of innovation capabilities.

Among the discussions on internationalization of EMNEs, the activities of Chinese MNEs abroad have received special attention in the literature. Previous work on this topic includes the study of OFDI from China (Kolstad & Wiig, 2012; Si & Liefner, 2014; Si et al., 2013; Buckley et al., 2018, 2007; Luo et al., 2010; Child & Rodriguez, 2005; Luo & Lemanski, 2016; Deng, 2013; Di Minin et al., 2012) and in particular the understanding of Chinese OFDI done by mergers and acquisitions (Rui & Yip, 2008; Richter-Tokar, 2019; Haasis & Liefner, 2019; Haasis et al., 2018; Amendolagine et al., 2018). Based on the literature's growing interest in the topic, Ramamurti & Hillemann (2018) study which features make Chinese MNE a special case. They conclude that government-created advantages and the very big home-market are the key features that distiguishes Chinese MNEs from most other EMNEs. The dynamically growing consumer market in China has attracted incoming foreign direct investment (IFDI), which some scholars argue jump-started the upgrading process of Chinese companies by exposing them to state-of-the-art technology and increasing the pressure on them in their home market (Hsu et al., 2015). This mechanism is also discussed in theories of latecomer catch-up (Mathews, 2002; Luo & Tung, 2018).

The terminology used in studies on EMNEs' R&D internationalization indicates that this is a rather new phenomenon. For instance, the term *reverse* knowledge transfer for transfer from offshore subsidiaries to the headquarters, instead of the more common direction from the headquarters to the subsidiary, shows that the prevalent perspective is the perspective of established MNEs and their headquarters (Ambos et al., 2006; Liu & Meyer, 2018; Awate et al., 2015). Another example is the use of the term *offshoring* in this dissertation. The term is usually used for established MNEs offshoring labor-intensive tasks to low-income regions to benefit from lower costs of local employees. In this dissertation, the term is used for an EMNE internationalizing R&D activities into global centers of knowledge in order to benefit from higher innovativeness of local employees. Nevertheless, there is an ongoing debate among scholars whether there is a need for new theories for EMNEs, or if the theories developed for established MNEs already cover the recently observed developments (Hernandez & Guillén, 2018).

Continuing on terminology, the terms EMNE and latecomer used here have similar but not equal meanings. Mathews (2002) describes a latecomer as a company from an emerging market entering an already established industry, which bears particular advantages such as lower production costs and higher flexibility compared to incumbents. On the flipside, the disadvantages are lack of technological expertise and outsidership from the market. The strategic focus of latecomers is on catching up to incumbents. In contrast, EMNEs are not necessarily latecomers, for example if they are operating in an industry that is young and not yet established. Which term is used depends on whether the context is the catch-up process or the origin and organization of the company.

The core theoretical frameworks explaining the catch-up of latecomer firms are the linking, leverage and learning of the LLL-framework (Mathews, 2002) and the springboard-perspective (Luo & Tung, 2007, 2018). On the one hand, these approaches are based on the more static resource-based view (RBV) of the firm (Barney, 1991; Wernerfelt, 1984; Penrose, 1959) that explains the competitiveness of a firm from its resources, in particular knowledge. On the other hand, they are based on the RBV's more flexible extension which is the dynamic capabilities argument (Teece et al., 1997; Teece, 2007), which explains how firms can maintain competitive advantage in dynamically changing environments by being able to renew their competences. It puts particular emphasis on the importance of management structures and organizational learning.

The LLL-framework explains how latecomers in high-tech industries can upgrade their knowledge base and production by absorbing knowledge from technologically advanced business partners (Mathews, 2002). The three steps described in the framework are *linking* with advanced partners, actively *leveraging* the cooperation for knowledge spill-over effects and *learning* by integrating the knowledge through repeated application of the steps ahead. This creates dynamic capabilities for the latecomer firm. However, this framework is more focused on learning and does not explain how latecomers might be able to build innovation capabilities in the process. Moreover, it is less focused on the process of internationalizing for the purpose of catch-up.

The springboard-perspective explains how EMNEs use their internationalization to acquire resources abroad and avoid home market constraints to catch up with incumbents (Luo & Tung, 2007). The theory describes how EMNEs take higher risks and are less prone to follow the more cautious internationalization paths observed for established MNEs. Moreover, one of their main aims is tight integration of outward and domestic activities. Their investments abroad are directed at advanced technology and production as well as brands for which they use in most cases acquisitions. Many springboard-companies have already gained some international experience through IFDI into their home countries, which is nevertheless not sufficient for catch-up as it does not help to overcome liabilities of foreignness for selling products in established market (Luo & Tung, 2007). Similar to the LLL-framework, Luo & Tung (2007) explain that the springboard-processes are recurrent. This point is emphasized in a recent extension of the theory in which the upward spiral concept is introduced. The concept describes how first inward internationalization, second OFDI, third transferring resources back to the home market and finally capability upgrading in the home market boost the latecomers capabilities (Luo & Tung, 2018). Even if this theory gives us a better understanding of the processes, it is very much focused on acquisitions as an entry mode compared to other forms of internationalization such as greenfield investments, which the authors themselves acknowledge (Luo & Tung, 2018). Moreover, it does not attend to the micro-level processes of the catch-up process and the arising inter-dependencies between the affected locations connected through the latecomer MNE, which still lack evidence and need to be studied more.

The field of latecomers catching up on innovative capability still raises many questions. The following section summarizes the most pressing questions identified in recent literature reviews to motivate the broader research questions for this dissertation. Hernandez & Guillén (2018) state that the fundamental issue scholars should be studying about EMNEs is how they develop globally valuable capabilities in the first place by studying their *emerging* phase. Those findings might be applicable not just to EMNEs but also to the early stages of now established MNEs. Papanastassiou et al. (2019) identify three key concepts that researchers should study more closely in the future to better understand R&D internationalization and innovation: cross-border knowledge-sourcing strategies, the change in the geography of R&D and innovativeness, and international fragmentation of R&D activities. In a similar vein, Iammarino & McCann (2013) claim that the geography of MNE innovation has been largely under-studied. Awate et al. (2015) point out that even among the recently emerging literature on EMNEs, little attention has been paid to understanding EMNEs' R&D internationalization. Asakawa et al. (2018) claim that we need more studies on MNEs that focus on subsidiary knowledge sourcing abroad.

In summary, we still do not know exactly how latecomer companies become globally competitive, and there is lacking evidence from the micro- or individual-level as to the mechanisms enabling this development. Moreover, the reasoning that EMNEs internationalize their R&D into centers of state-of-the-art knowledge in order to access knowledge and markets needs more in-depth investigation. This dissertation investigates these research gaps by looking deeper into the micro-mechanisms of R&D internationalization and analyzing its spatial pattern for understanding the upgrading mechanisms of innovative activities in the latecomer context. In order to gain in-depth insights into those mechanisms, I am using Huawei as a case study because it is a recent example of an EMNE and latecomer that has focused on R&D internationalization through greenfield investments, an understudied entry mode. The main questions leading the investigations are the following:

- How can latecomers use R&D internationalization for catching up in established industries?
- How can latecomers build innovation capabilities through R&D internationalization?
- What are the mechanisms of catching up through R&D internationalization by greenfield investments?
- How can EMNEs orchestrate innovative R&D activity in multiple locations?

These questions are the underlying research interest addressed in three consecutive articles that build the main part of this dissertation. Each article has its own, more narrow research questions, that taken together answer the broader questions. This study contributes to the literature by unfolding strategies of a latecomer setting up and operating global R&D networks to gain international competitiveness.

I.3 Economic Geography and International Business

This dissertation is placed at the intersection between the disciplines of Economic Geography (EG) and International Business (IB), two disciplines that have long evolved in parallel and only in the recent decade started to deliberately draw from each others' perspective. Economic Geographers have traditionally been borrowing theoretical concepts from management and IB as they do from other disciplines such as economics or social science. What is new is the rise of reciprocated

interest of other disciplines in traditional research fields of Economic Geographers (Liefner & Schätzl, 2017). The particular interest of IB scholars has sparked a bilateral dialog of both disciplines and the deliberate claim to contribute to and learn from one another.
The recent surge of special issues in Journal of Economic Geography and Journal of International Business Studies on bringing the two disciplines together are indicators for rising mutual interest. Moreover, discussion forums and conferences such as the annual conference on International Business, Economic Geography and Innovation (iBEGIN) or special sessions at conferences, a recent example being a panel discussion at the Academy of International Business (AIB) Annual Meeting 2019 about "Economic Geography and International Business: Building Bridges", show an increasing interest of scholars from both disciplines to interact. Jones (2018) argues in *Progress in Human Geography* that this recent trend might be driven by a shift towards spatial thinking in IB and management studies from which both sides benefit. For instance, a recent attempt to deliberately integrate RBV and dynamic capabilities with EG's buzz and pipelines comes from Fitjar et al. (2013) in their study on the effect of manager attitudes and firm capabilities on innovation. Jones (2018) argues that Economic Geographers have been using the firm-level for analysis from a geographical perspective ever since the 1990s, and have long been going beyond the study of regional competitive advantage and spatial decision-making in firms. Moreover, Economic Geographers do not necessarily take the location as unit of analysis but views phenomena from a spatial perspective which means including concepts of space, interrelation and distance in their take on research issues.
A particularly insightful object to study in both disciplines are MNEs as a major force for shaping the geography of the world economy (Iammarino & McCann, 2013). Understanding their behavior and the processes triggered by it is crucial to understand the mechanisms that shape the geography of today's interconnected economy. Changes in MNEs' strategies quickly translate into changes in the geography of economic wealth and welfare. Therefore, regional economic growth today can be heavily influenced by MNEs connecting the regional with the global level. One of the arguments Elisa Giuliani made at the AIB panel is that even if Economic Geographers are often interested in large-scale and aggregated phenomena, they should take into account the mechanisms happening at the firm level. In a similar vein, Beugelsdijk et al. (2010) claim that for

a long time a shortcoming of EG used to be ignoring the complex spatial behavior of MNEs. Combining both perspectives can better explain the recent shift we see in the geography of participants in knowledge-intensive industries and brings together the tools needed to understand the emerging knowledge economy (Mudambi et al., 2018). Further, it allows us to understand innovation as an outcome of the interaction between industry dynamics and locations of knowledge creation (Cohendet et al., 2018). For example, MNEs' location decision on R&D activities influences the distribution of knowledge and reinforces existing location (dis)advantages. However, Bathelt et al. (2018) suggest that we need to take into account that the concept of knowledge differs between the two disciplines. While knowledge is rather seen as a private good in IB, as it is the foundation of competitive advantage for many firms, it is mostly seen as a public good in EG, as it is created and shared in and between locations of knowledge. Nevertheless, the globalization of capability building and creative processes influences both the company and regional level and their interconnectedness needs to be taken into account when researching this phenomenon. The competitive advantage of companies and regions is affected by increasingly international capability building and knowledge creation. This dissertation draws from both disciplines by observing firm-level micro-processes that help to better understand spatial dependency and current dynamics in the division of market shares between established and emerging MNEs.

I.4 The case study

In this dissertation, the case study company Huawei is embedded in the highly dynamic environment of the telecommunications industry. This industry relies heavily on constant innovations as technology life cycles are rather short and game-changing and inventions quickly exhibit global impact. Therefore, it is crucial for incumbents in this field to keep up with the global state-of-the-art to maintain their position in this highly dynamic environment. So-called catch-up cycles can offer latecomers the chance to enter mature industries. These are cycles of regularly recurring windows of opportunity opening in cooling down phases of the industry when incumbents need to size down because of financial pressure (Lee & Malerba, 2017). This makes the innovation and learning strategies in this fast-paced industry an insightful object to study the catch-up of latecomers.

The case study of Huawei is particularly valuable because it is one of the few EMNEs that recently became a global technological leader. I mainly focus on the period between 2004 and 2016, when Huawei was rapidly expanding its global R&D activities and was about to leave its follower position to become competitive towards established players. In this, I follow Hernandez & Guillén (2018) who suggest that researchers should focus on EMNEs' *emerging phase*. A distinct factor for Huawei's development was the condition of China's domestic telecommunications market in the late 1980s at the time the company was founded. After the start of China's open door policy in 1984, particularly rural regions had a huge demand for telecommunication infrastructure (Mu & Lee, 2005). In the beginning, Huawei's strategy was to build up technological capabilities by selling low-end equipment in rural regions to avoid competition from technologically advanced foreign competitors who focused their activities on larger cities (Li & Cheong, 2016; Lee et al., 2016). This approach helped Huawei to avoid direct competition from global players while growing and building expertise. In a similar fashion, Huawei expanded its sales to other emerging markets first before taking on more established markets.

In contrast to its state-owned competitors, it was not until the mid-2000s that privately owned Huawei received financial incentives from the China Development Bank as part of the Chinese Going Global Policy. Around 2004, Huawei started to extend its R&D activities to global innovation centers overseas. Its strategy for doing so was remarkable because neither spatial, institutional nor cultural distance seemed to play a role for the sequence of its R&D internationalization. For instance, the company entered Silicon Valley as one of its first offshore locations (Fan, 2011). Nevertheless, the political climate in Western markets was not favorable for Huawei: The US government blocked its acquisition attempts multiple times and excluded the company from bidding for national network projects, causing Huawei to focus sales on the European, Canadian and Australian market (Nolan, 2014; Cooke, 2012; Chung & Mascitelli, 2015). In terms of technology, as a late entrant Huawei was able to have some of its technology included into the standards for the forth generation of cellular network technology (4G) and was a major driver for the development of the fifth generation (5G). Nevertheless, Huawei has struggled with liabilities of foreignness and outsidership in the West from the beginning and had major difficulties to become integrated into the global industry. Repeated espionage allegations from the US government damaged the company's global reputation. During the recent trade dispute with China, the US government repeatedly voiced security concerns about using Huawei's 5G infrastructure equipment and even pressured third-party governments not to buy it. Nevertheless, the hostility against the company is also reflective of the company's dynamic growth and success on the global market and its growing influence seems to be seen as a threat by industrial and political stakeholders.

Despite the recent political struggles, the question remains how Huawei was able to develop the capabilities that makes it a technological leader today. In order to give a first overview of Huawei's global R&D activities, figure 1.1 shows some of the most active offshore locations and their internal connections to other R&D locations. The figure shows the largest offshore locations in terms of publication activity in blue and their connection through co-publication to Huawei's Chinese locations in red. The size of the nodes and edges represents the frequency of the co-publication activity. This figure gives an overview of Huawei's internal R&D cooperation. We can see that Huawei's headquarters in Shenzhen are connected to almost all of the offshore locations. The figure also shows that the connections are very much centered towards China with less connections between offshore offices. This is reflective of the strategic orchestration of the intra-firm communication which is very much directed at transferring information towards China as much as possible and controlling the activities of its offshore locations closely.

1.5 Methods and Data

In order to answer the research question *how* latecomers can leverage R&D internationalization to become globally competitive, I am using a case study (Yin, 2014) built upon a mixed-methods design (Creswell & Plano Clark, 2011). My approach of studying latecomer catch-up through R&D internationalization is to use Huawei as an *unusual* case (Yin, 2014). The concrete conceptualization of the case study design changes according to the focus of the research question of the respective article. In article one, Huawei is used as an unusual case in terms of its rapid de-

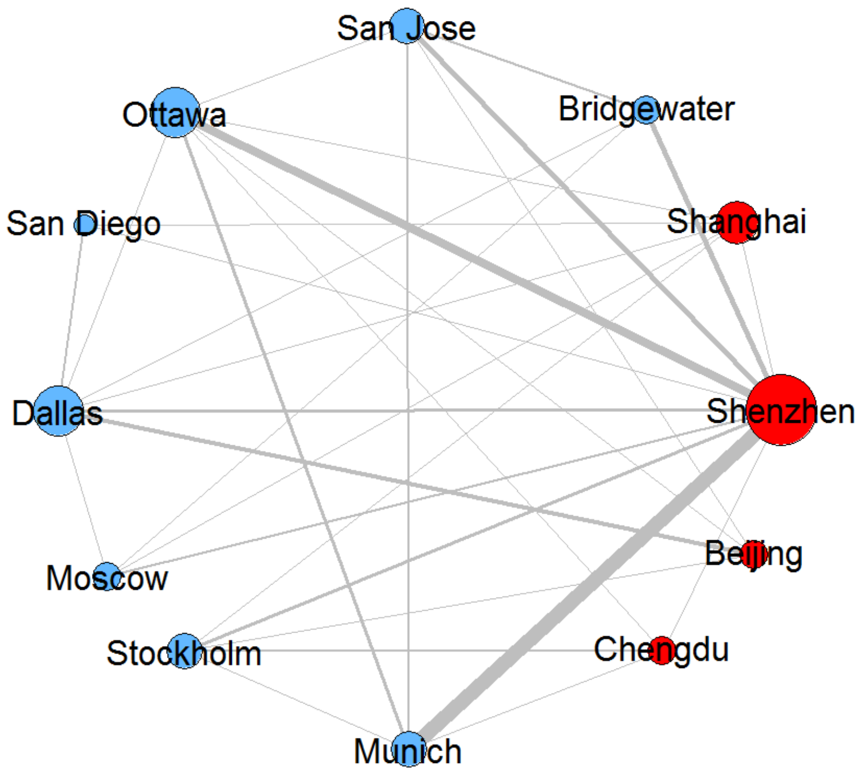

Fig. 1.1: Co-publications of Huawei's offshore locations

velopment and successful catching-up. The case focuses on the company's general R&D pattern whereas in article two Huawei is regarded in the light of an unusual case because of its particular mode of greenfield R&D and the role of the offshore experts hired in this unusual approach. For article three, the case of Huawei is representative for a latecomer that recently became a technological leader through focusing on internal innovation.

The research design of the dissertation follows an embedded multiphase mixed-methods design (Creswell & Plano Clark, 2011; Hurmerinta-Peltomäki & Nummela, 2006). Figure 1.2 shows the sequence of the research phases and the kind of data used for each. It starts with a quantitative approach in article one that is followed by a qualitative study for article two and a mixed-methods design for article three. The connection of how the studies build upon each other is indicated by the dotted arrows on the right-hand side of the figure. Moreover, the embedded element of the design relates to the data. The interview data is embedded in the patent data [1] as the interviewees

[1] Only one interviewee was identified by the bibliometric data alone. Nevertheless, the bibliometric information was used to triangulate information from patent data and get a better overview of which offshore locations were not uncovered by using patent data, for instance Moscow and Paris.

are a sub-sample of the inventors on the patent documents. This ensures that the findings from both can be integrated more smoothly from a conceptual point of view because both data sources provide access to the same object of study and allows for more solid findings.

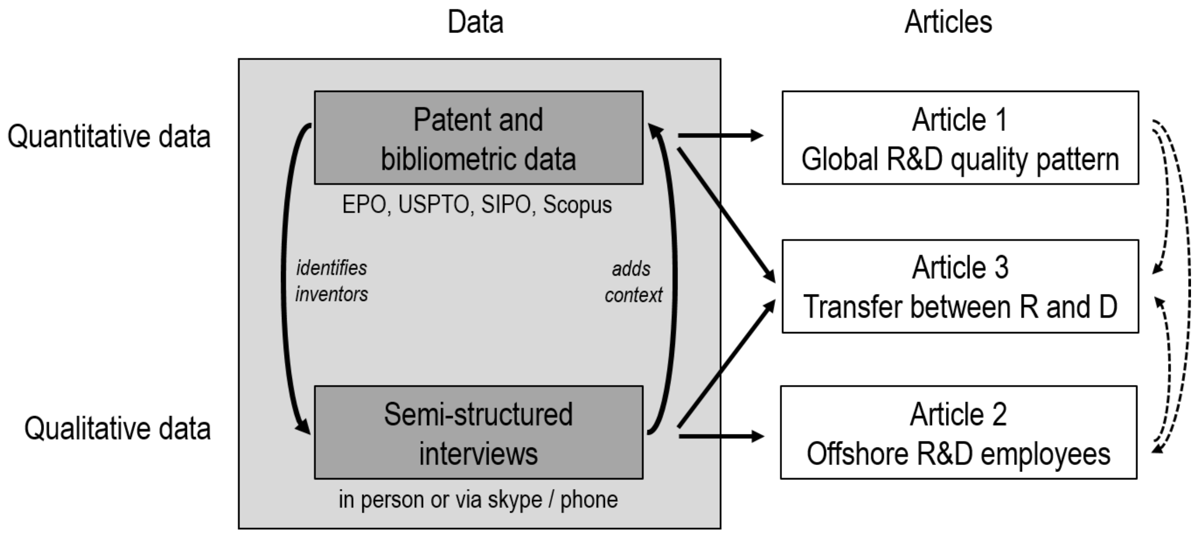

Fig. I.2: Data integration

A particularly important part of designing a reliable mixed-methods study is to think about the integration of the methods. This needs to draw out how the study is not simply paralleling or triangulating different methods but arrives at its findings through integrating the methods which enables the researcher to answer questions that could not have been answered by using one method alone (Creswell & Plano Clark, 2011; Kuckartz, 2014). In this dissertation, there are two levels of mixed-methods integration: One is the overall dissertation and the other is article three in which the qualitative and quantitative analysis are integrated directly. This is also reflected in figure I.2 by the solid black arrows indicating which data source was used for which article. For the overall dissertation I use result-based integration of all findings in order to draw conclusions and answer the research questions posed earlier (Creswell & Plano Clark, 2011).

In the following, I am going to give a detailed report of the data collection process and a general overview of how the data was analyzed. A more detailed discussion of the data analysis can be found in the respective chapters. The data first collected for this dissertation was the patent data. Patents are the footprints of MNEs' worldwide R&D activities that can help us understand the global patterns of innovative activity. Even if this type of data cannot deliver the complete picture of a company's R&D, it is a good proxy and has been widely used in the literature for measuring R&D output (Hagedoorn & Cloodt, 2003; Frietsch et al., 2010; Trajtenberg, 1990). By analyzing this data carefully, it is possible to outline the contours of MNEs' global R&D activities. The patent data sets were obtained from the PATSTAT database at the Fraunhofer-Institute for Systems and Innovation Research (ISI) in Karlsruhe and the PatentsView website. PATSTAT is operated by the European Patent Office (EPO) but contains data from patent offices worldwide. PatentsView is maintained by the United States Patent and Trademark Office (USPTO) and provides US patent data only. The sources cover data from the former State Intellectual Property Office in China (SIPO) [2], the USPTO, the EPO and the World Intellectual Property Organization (WIPO). Looking at data from multiple patent offices enables a more differentiated picture of global patent applications than the common approach of looking at USPTO data alone. Nevertheless, this can be a valid approach if the researchers know the object under study well so they can identify what they might miss by omitting other perspectives. This needs to be done sometimes because the data from multiple offices cannot be compared directly and needs to be analyzed separately because of differing legal regulations and procedures. Moreover, bibliometric data from Elsevier's Scopus was added to create a more complete picture of Huawei's global research activities. Bibliometric data has the advantage that it can show a more comprehensive picture of global research activity because it can be compared across countries more easily than patent data. Nevertheless, it is often less comprehensive, does not necessarily indicate innovation and provides less information than patent data, for instance on technology.

The patent data provides the names and the addresses of the inventors as well as the date of application, the patent authority of the priority application, technology classes and citations. Because the applicant of a patent is not necessarily the employer of the inventors on the patent (Ge et al., 2016), I added employer information from LinkedIn, Researchgate and others social media platforms to the patent data in order to verify which inventors actually worked for Huawei at the time of the patent application and which worked for external firms or universities. The inventors' addresses are then used to locate Huawei's R&D activity, which is a commonly used proxy for loca-

[2] The Chinese State Intellectual Property Office (SIPO) changed its name in 2018 to National Intellectual Property Administration (CNIPA)

tion when analyzing patents of MNEs (Ter Wal & Boschma, 2009). Using this information, I am able to draw a nuanced picture of Huawei's worldwide R&D activities in terms of location, quality, kind of technology and timing. Nevertheless, using patent data has some shortcomings that need to be addressed. Patents do not cover all R&D activities of firms as some outcomes can not be patented. Patents only signal technology that is new and commercializable. Moreover, Grupp (1998) points out that the coverage of patent data depends on the sector under analysis. The field of telecommunications in which Huawei operates relies heavily on patenting which makes patents a good proxy for innovative activity there.

Overall, patent and publication data can only show us the broader patterns of Huawei's R&D activity over time but not the underlying mechanisms. Therefore, I attempt to fill the blind spots researchers usually have when working with patent data by using qualitative interviews. In order to complement the picture and account for the methodological shortcomings of the patent data, I conducted qualitative interviews with 40 experts Huawei hired at its eight largest offshore locations by patenting in San Jose, San Diego, Dallas, Chicago, Ottawa, Bridgewater, Stockholm and Munich. Over 200 potential interviewees were identified by using the patent and publication data. I conducted the interviews in person or via Skype and telephone either from Germany or the US. The interviews were not audio-recorded for reasons of confidentiality, but meticulous transcripts were made during the interviews that were then typed and analyzed through the qualitative analysis software MaxQDA. For ethical reasons, strict anonymity was ensured to the interview partners and therefore the interviews were anonymised and personal information about the participants is strongly restricted.

Moreover, a review of print media reports on Huawei was conducted to gain additional insights into Huawei's politically motivated hiring of former officials and lobbyists. Overall, 17 articles were identified via searching Google News for the combination of "Huawei" with the key words "lobby*", "board", "board member*", "hire/hiring", and "official*". The material was then analyzed through qualitative content analysis via MaxQDA. This data was only used in the qualitative analysis of article two.

For studying R&D internationalization, the literature so far has mostly focused on the management level of global firms in order to understand how they build capabilities and innovativeness.

This study does not focus on management but looks at the tasks the individual technical experts fulfill in order to get a bottom-up perspective on the catch-up processes within the company. Following Tokatli (2015), I avoid falling for the company narrative and talking points prepared by management by taking the perspective of the offshore experts. In particular at Huawei, the narrative that the company's success is mainly build upon the hardships and dedication of Chinese engineers and its founder is very pronounced (de Cremer & Tao, 2015; Luo et al., 2011). Moreover, interviews with individual technical experts provide access to research on the micro-mechanisms of catch-up and innovative activities more so than interviews with management. Further, the interview approach provides insights into internal and external perspectives on Huawei because the interviewees have been outsiders for most of their career and some are again at the time of the interview. Thus, they are informed about the outsider's perspective of the industry on the company or even have taken this perspective themselves.

I.6 Overview

This cumulative dissertation is made up of three articles which represent the following three chapters. Table I.1 gives an overview of the articles, their objectives and data sources [3] as well as their current status as of October 15th 2019. The table also shows an additional article that is not part of this dissertation, as work on it started in 2014 before the beginning of my dissertation. Nevertheless, the article originates from the same line of work on Huawei and is part of the prior knowledge that this dissertation is build upon. This article provides insights into Huawei's collaboration with external research facilities at offshore locations in Germany. It uses a patent data set I developed for my master's thesis to show Huawei's collaboration patterns in Germany and identify the interview partners for the main part of the paper. The article was published in Technovation in April 2019.

All three dissertation papers are authored and conceptualized by me. The co-authors contributed to selected passages and provided input through discussions. Their contributions are listed in the

[3] Parts of the theory, case study description and methodological sections of the framework and the articles naturally overlap in content.

following. The first article is co-authored with Ingo Liefner who contributed in writing to the case study description, to the conclusion and in discussing the choice of method. The article was published in Scientometrics in September 2017. The second article is a single-authored paper that is accepted as a research note in Journal of International Business Studies. The third article is co-authored with Stefan Hennemann and Ingo Liefner. Stefan Hennemann contributed in writing to the theory section, the description of the quantitative findings, the conclusion and in discussing the quantitative model. Ingo Liefner contributed in writing to the theory section. The article has the status major revision at Journal of Economic Geography.

Table 1.1: Overview of articles

Title and Authors	**Objective**	**Data and Method**	**Journal**
Offshore versus domestic: Can EM MNCs[4] reach higher R&D quality abroad? *Schaefer, Liefner*	Global patterns of Huawei's R&D quality	Generalized linear models for patent data	Scientometrics (published)
Catching up by Hiring: The Case of Huawei *Schaefer*	The role of offshore R&D experts in the catch-up process	Qualitative content analysis of interview data	Journal of International Business Studies (accepted)
Give Us Ideas! - Splitting research and development to bridge lack of innovativeness *Schaefer, Hennemann, Liefner*	Locations for creation ideas and their internal transfer	Mixed-methods approach for patent- and interview data	Journal of Economic Geography (major revision)
Additional paper (not part of dissertation)			
A latecomer firm's R&D collaboration with advanced country universities and research institutes: The case of Huawei in Germany *Liefner, Si, Schaefer*	*Technology absorption from German URI*	*Qualitative analysis of patent and interview data*	*Technovation* (published)

In order to give an overview of the articles, figure 1.3 shows the level of analysis and methodology of the articles and the corresponding chapter number. Article one in chapter two gives an overview of Huawei's global R&D activities at the macro-level. It shows the global patterns and the importance of offshore activity. The findings of this article show how important offshore experts are for Huawei and therefore build the foundation for the research questions of article two in chapter three. Article two looks deeper into the role of the offshore experts at the individual level, covering Huawei's micro-level. While investigating the tasks of the offshore experts it becomes clear

[4] Inconsistencies in abbreviations, such as EMNEs for emerging-market multinational enterprises or EM MNCs for emerging-market multinational companies between the chapters result from differences in standard abbreviations used by the journals.

that Huawei splits its R&D between offshore and domestic locations. This leads to the research questions for article three in chapter four that are concerned with the interaction between the locations, therefore taking place at the meso-level of the firm. This article looks at how R&D tasks at offshore locations and at home are integrated within the company and what this tells us about the innovative process in the company.

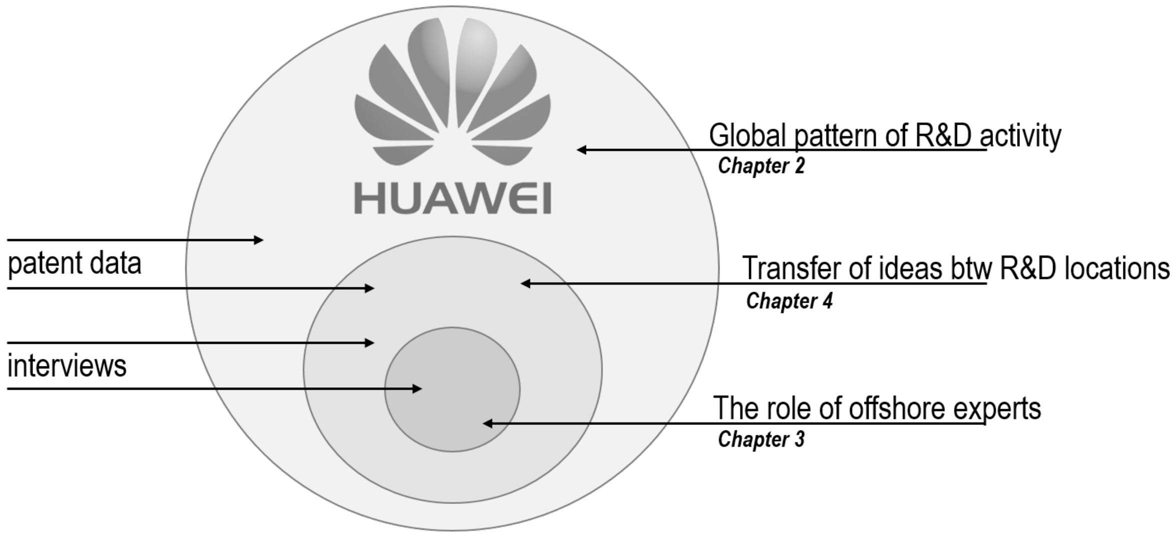

Fig. I.3: Levels of case study analysis

In the following paragraphs, the motivation and methodology of the articles are summarized. Article one lays the groundwork and establishes the spatial pattern of Huawei's global R&D quality. The study carefully examines the locations of Huawei's core R&D along multiple dimensions of R&D quality. The main question for the first article is whether Huawei is able to conduct high-quality R&D abroad despite facing high liabilities of foreignness and outsidership (Denk et al., 2012; Zaheer, 1995; Johanson & Vahlne, 2009), as the findings in the literature so far have been contradictory on the potential success or failure of offshore R&D (Hsu et al., 2015; Cantwell & Mudambi, 2005; Sofka, 2006). The aim is to examine whether taking the risks and costs of conducting R&D abroad results in higher output quality and provide a better understanding of Huawei's global R&D strategy. Only if the company is able to overcome liabilities, it can perform high quality R&D that produces high quality patents. This article also focuses on methodological questions about how to use patent data to identify the quality of patents at different locations of MNEs.

In order to rule out home office bias, patent data from three different patent offices is analyzed to unveil the difference between home-based and offshore patent quality. Moreover, this study considers three dimensions of R&D quality: forward citations for scientific impact, backward citations for breadth of technical background as well as family size for geographic scope and economic value (Carpenter et al., 1981; Harhoff et al., 2003; Trajtenberg, 1990; Albert et al., 1991; van Zeebroeck & van Pottelsberghe de la Potterie, Bruno, 2011; Lanjouw & Schankermann, 2004; Fischer & Leidinger, 2014). The data is analyzed using Poisson and negative binomial regression methods to explain the patent quality indicators through the location of the inventors. We find that several quality dimensions show a higher value if experts at offshore locations are involved.

As explained above, the research in chapter three and four builds upon those findings. Because the study shows that Huawei's core R&D is located abroad despite facing liabilities there, the next step is to unveil the role of Huawei's offshore R&D in the company's quest for competitiveness. As Huawei is known to be one of the very few Chinese companies that focuses on greenfield investments in R&D internationalization, the focus is on the individual employees the company hires abroad. Therefore, the role of employees hired at the company's most important locations in the US, Canada, Sweden and Germany is analyzed more in-depth through interviews with those offshore experts.

The second article looks at how hiring offshore experts helps Huawei build competitive advantage. It investigates greenfield R&D internationalization as an alternative to the better researched mechanisms of knowledge-seeking through acquisitions (Kumar et al., 2019; Luo & Tung, 2018; Anderson et al., 2015). Hiring experts at centers of state-of-the-art technology might be a particularly promising mechanism for latecomers to surpass global competitors and has so far been mainly discussed as a mechanism to increase their knowledge stock (Almeida & Kogut, 1999; Song et al., 2003; Luo & Zhang, 2016). Nevertheless, other mechanisms such as keeping a low profile through hiring instead of acquiring might play a role for catching up to incumbents and overcoming issues of liabilities and outsidership.

The article uses exploratory analysis of interviews with technical experts hired by Huawei abroad in order to avoid the company-narrative of the management level (Tokatli, 2015) and get insights into the micro-processes (Doz, 2011). The analysis is based on inductive category building to stay open to new categories and interpretations (Gibbs, 2018). The role of offshore experts is conceptualized through their skills, in particular experience, technical knowledge and language as well as embeddedness, encompassing their contacts and reputation.

One of the central findings in article two is that the offshore experts' main task is to create new ideas. These findings together with the findings from article one give cause for questioning Huawei's domestic innovation capability, even though the company today sells state-of-the-art technology. Therefore, the third article investigates more in depth the location of Huawei's innovative activities and the internal orchestration of its outputs.

To obtain a more detailed picture of the spatial pattern of Huawei's innovative activity, article three focuses on a comparison of R&D tasks abroad and at home to gain insights on how Huawei mastered its leap from a follower to a leader in the telecommunications industry (Mathews, 2002, 2006; Poon et al., 2006). The specific focus here is on innovative versus output capability, the latter enabling latecomers to produce state-of-the-art products before having caught up on innovation capability through external sourcing of ideas for new products (Awate et al., 2012).

In order to unfold Huawei's innovative activities, the article uses a mixed-methods approach by combining interview and patent data (Hurmerinta-Peltomäki & Nummela, 2006; Creswell & Plano Clark, 2011). The interview data is used to inductively study the tasks performed by the offshore experts in contrast to the tasks of their colleagues in China. Moreover the internal cooperation and information sharing within the company is another question of the qualitative analysis. The results of the first part of the analysis are then discussed in the context of the existing literature to develop deductive hypothesis for the quantitative analysis. Because we know that one of the main tasks for the offshore experts is to develop ideas and transfer them to China, ideas are used as unit of observation for the patent data analysis. The analysis uses the new-to-the-firm combination of technologies on patents as a proxy for new ideas (Fleming, 2001; Kim et al., 2016). The creation and transfer of the ideas are then analyzed in a time-to-event model that aims at explaining the time between the first observation of the idea and the date of the transfer between offshore and domestic locations. The results of both the qualitative and the quantitative analysis are then integrated to draw conclusions, which will be discussed further in the article as well as in the conclusion of this dissertation.

Chapter 2

Offshore versus domestic: Can EM MNCs reach higher R&D quality abroad?

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Abstract

In the current discourse about the technological development of emerging market multinational companies (EM MNCs), the internationalization of research and development (R&D) activities is increasingly discussed as a strategy for catching-up to established MNCs. EM MNCs attempt to use international R&D to tap into technologically superior resources abroad which are not available to them in their home market. This study compares the performance of domestic and offshore R&D activities to look into EM MNCs' ability to conduct high-quality R&D abroad. We use the Chinese telecommunication equipment manufacturer Huawei as a best practice case study. To map their worldwide patent quality pattern, we propose a multiple-patent-office-approach to ensure a balanced view on their activities with data from SIPO, USPTO and EPO. We also employ three different measures to capture different dimensions of patent quality. The results of the empirical model support the assumption of higher quality for patents with knowledge from advanced offshore locations.

2.1 Introduction

In the light of the increasing importance of knowledge as an asset for economic growth, the sourcing of knowledge created abroad has become an important strategy for companies. Emerging market multinational companies (EM MNCs) in particular depend on knowledge from abroad to upgrade their production as well as management, and facilitate catching up to established MNCs (Luo & Tung, 2007; Mathews, 2002). Besides absorbing knowledge-spillovers from foreign companies in their home market (Görg & Greenaway, 2004), EM MNCs have started to actively seek complementary knowledge abroad (Chen et al., 2012). Although it is risky for young and inexperienced MNCs to operate R&D activities abroad, the need to seek higher-level knowledge is rooted in the inability to acquire it in their home market. In contrast to the more common strategy of buying in R&D from established companies abroad in the form of M&As, only a small number of EM MNCs so far have started to set up their own R&D activities from scratch outside their home country (Awate et al., 2015; Di Minin et al., 2012; Hsu et al., 2015). In this study, we evaluate this upcoming and still under-researched phenomenon to analyze whether conducting R&D abroad can substitute for a lack of knowledge resources at the latecomer's home base and help the EM MNC to become competitively viable on a global scale.

We use the Chinese telecommunication equipment manufacturer Huawei Technologies Co. Ltd. (Huawei) as a case study. In just a few years, Huawei managed to become the largest applicant for patents at the world intellectual property organization (WIPO) and is the strongest applicant for patents among EM MNCs worldwide (WIPO, 2015). Moreover, Huawei's unique focus on greenfield R&D abroad instead of the more common M&As along with its huge internationalization success makes it a best practice example for other emerging companies. We are therefore interested in their ability to overcome the liabilities imposed on them in the context of R&D off-shoring (Zaheer, 1995; Johanson & Vahlne, 2009). Chinese MNCs in particular face strong liabilities when internationalizing caused by a large cultural and institutional distance to most advanced markets (He & Lyles, 2008; Child & Rodriguez, 2005). Therefore, despite Huawei's strong position within China, the question remains as to whether they are able to overcome those liabilities through their vigorous effort in R&D internationalization. If so, we argue that their offshore

R&D will outperform their domestic activities because it provides them with access to state-of-the-art knowledge not available to them in their home market. This can compensate Huawei for their home country disadvantage and enables them to produce advanced knowledge themselves.

A very widely-used form of measuring R&D output performance is patent statistics (Frietsch et al., 2010; Penner-Hahn & Shaver, 2005; Singh, 2008; Trajtenberg, 1990). We use patent data to assess different quality dimensions of patents evolving from an international background and compare it to the quality of domestic patents. In contrast to other studies, we explicitly use data from multiple patent offices to respond adequately to the fact that looking at data from various offices each time provides a different point of view and helps to rule out home bias (Criscuolo, 2006; Messinis, 2011). For EM MNCs in particular, we expect the pictures of patents applied for at their home base to differ in comparison to those applied for abroad. We use the inventors' addresses provided by the patent documents as a proxy for the EM MNC's worldwide R&D locations. This is a common proxy for location when looking at patents by MNCs, as many tend to apply for patents only through the domestic headquarters (Ter Wal & Boschma, 2009). We find that this is also true for Huawei.

Our contribution to the existing literature on EM MNCs' knowledge sourcing is a thorough analysis of Huawei's ability to reach better R&D performance through greenfield R&D abroad than at their home base. The research hypotheses state that innovative performance is better for patents which involve inventors living and working abroad, and in advanced markets in particular, than for patents only involving inventors living in the EM MNC's home country. This would imply that strategic investments can compensate for a deficient home base and enable EM MNCs to conduct cutting edge research. We also, for the first time, explicitly employ a methodology that includes data from three different patent offices to ensure a more differentiated perspective on R&D performance, therefore assuring the robustness of our findings.

2.2 EM MNCs' research and development internationalization

2.2.1 Perspectives and shortcoming in this emerging field of literature

Within the research on internationalization, R&D internationalization is a more recent focus. We find that the existing literature so far focuses mostly on R&D internationalization of AM MNCs or on EM MNCs' internationalization in general. R&D internationalization of EM MNC to access advanced knowledge abroad is a more recent field of attention, as it is a more recent phenomenon. As of today, only a small number of studies have conducted research on different aspects of this topic. Chen et al. (2012) find that those EM MNCs internationalizing in markets with strong technological resources show better technological capabilities at home. Awate et al. (2015) focus on the differences in R&D internationalization between EM MNCs and AM MNCs, and study their knowledge flows between the headquarters and the subsidiaries. Jindra et al. (2014) look at the European Union as a destination for EM MNCs' R&D internationalization and sub-national location choice. Hsu et al. (2015) investigate the effects of intensity and diversity of R&D internationalization on innovative performance in general and find that internationalization experience has a positive moderating effect on performance for the whole company. Studies on R&D internationalization from China in particular conclude that established theories about AM MNCs' R&D off-shoring do not suffice to explain EM MNCs' internationalization, as their initial condition and the drivers for internationalization differ (Child & Rodriguez, 2005; Di Minin et al., 2012).

Reviewing the literature shows that a more detailed picture of EM MNCs' international R&D strategies remains to be drawn. It has not been shown whether EM MNCs are really able to conduct higher-quality R&D abroad. We contribute to the literature through analyzing the output quality of offshore R&D in comparison to domestic R&D to see whether the EM MNC is able to increase their R&D performance when abroad. We also use data from multiple patent offices, including the EM MNC's home-office as well as the data from the US and European offices, to obtain a more comprehensive picture of the EM MNC's patent quality pattern. This provides us with a clear view of the underlying strategy in R&D and the worldwide pattern of the output quality.

2.2.2 Risks and liabilities for EM MNCs' R&D off-shoring

R&D internationalization is risky, especially for EM MNCs with a lack of experience in managing worldwide R&D networks. The physical distance between the headquarters and the offshore units induces difficulties in communication frequency and quality. Moreover, synergy and scale potentials in R&D cannot be exploited, which can lead to lower efficiency (von Zedtwitz & Gassmann, 2002). Further problems concerning R&D internationalization include immobility of personnel, less control over research results and the risk of parallel development (Gassmann & von Zedtwitz, 1998). The risk of knowledge spillover abroad in particular raises the question of whether it might be safer to keep high-level R&D in the home market. Also, concentrated technological development at home is easier to manage compared to the risky coordination of global R&D.

Another difficulty for EM MNCs is the knowledge gap which they have to overcome in order to conduct successful R&D abroad. Cohen & Levinthal (1990) state that the company's prior knowledge in a given field is crucial for being able to acquire state-of-the-art knowledge. Singh (2008) also finds the ability to integrate knowledge into the firm's knowledge base to be more crucial to a MNC's innovative performance than the sole venture of worldwide knowledge sourcing. He warns that coordination costs of international R&D can be higher than the gains if the MNC does not possess the absorptive capacity needed. The knowledge gap between EM MNCs' knowledge stock and the knowledge that they wish to access abroad is mostly higher than for AM MNCs. Therefore, it is even more difficult for them to incorporate the new knowledge. Furthermore, they lack international experience, management know-how and reputation, which also increases their costs as well as their risks (Hsu et al., 2015).

Besides this, EM MNCs also have to face liabilities of foreignness in their target markets. These are costs only faced by non-domestic firms for entering a foreign market (Zaheer, 1995). The costs are determined by the constellation of home and host market. In particular, the distance in culture, institutions, language as well as spatial distance between the two determine the costs (Denk et al., 2012). Moreover, the particular characteristics of the MNC determine whether these liabilities can be overcome. There is evidence that liabilities can make offshore R&D less successful than domestic R&D (Sofka, 2006). Johanson & Vahlne (2009) emphasize the role of networks for internationalization with the term liabilities of outsidership. They claim the MNC needs to build up connections at each location to overcome liabilities of outsidership from the business network. Those ties are based on trust and commitment and help the MNC to gain crucial knowledge on the market and the business environment (Johanson & Vahlne, 2009).

In comparison to AM MNCs, EM MNCs have to overcome even more of those liabilities when internationalizing their R&D into advanced markets because of greater cultural and institutional distance. With an increase in liabilities, the MNC's offshore unit's performance is likely to decrease (Miller & Parkhe, 2002; Miller & Eden, 2006). Therefore, internationalization of EM MNCs in advanced markets can make it harder to achieve high offshore R&D performance.

2.2.3 Drivers of R&D internationalization

MNC's R&D internationalizations are driven by various motivations. Kuemmerle (1997) differentiated between home-base-exploiting and home-base-augmenting strategies in establishing R&D sites abroad. EM MNCs are thought to aim frequently at accessing knowledge not available to them in their home market, which falls under augmenting motives. These motives include seeking highly qualified human capital abroad that is not available in their home market, as well as desirable research partners such as universities or public R&D institutes. Reasons other than home-base-augmenting that particularly apply for EM MNCs include institutional restraints and weak intellectual property rights in their home market (Hsu et al., 2015). In general, monetary advantages, proximity to markets and improving the company's image abroad can also be reasons to go abroad (Gassmann & von Zedtwitz, 1998). Most ventures are driven by more than one objective.

From a latecomer perspective, R&D internationalization for EM MNCs is especially useful because it can help to compensate for latecomer disadvantages such as lack of knowledge and experience (Hsu et al., 2015; Mathews, 2002). Mathews (2002) states that companies can use their latecomer status to quickly acquire state-of-the-art technology that had to be developed by advanced companies over time. This can promote leapfrogging and hence rapid upgrading of international market positions (Mathews, 2002). Leapfrogging can even create competitive advantages over established MNCs because the EM MNC can bypass earlier technological stages that AM MNCs had to go through (Chen, 2004; Mathews, 2002). This creates opportunities for EM MNCs to compete not only in low-tech industries, but also in new and evolving industries. EM MNCs from Asia are particularly known for sourcing sophisticated technology in advanced economies to upgrade their knowledge base (Poon et al., 2006).

A distinctive feature of home-base-augmenting strategies is the relation between the MNC's headquarters and its R&D subsidiaries. Augmenting is motivated by absorbing knowledge at the offshore location using knowledge from competitors or research institutions. The knowledge is then transferred back to the MNC's headquarters to incorporate it into the company's knowledge stock (Awate et al., 2015; Kuemmerle, 1997). If the offshore R&D unit is successful, it achieves a higher knowledge level than the headquarters in certain fields.

To summarize the theory from chapter 2.2.3, we notice that a main motive for EM MNC's R&D internationalization is the absorption of knowledge that is not available to them in their domestic market. Therefore, we would expect their offshore R&D to display higher quality than at home. The problem here, as described in chapter 2.2.2, is that they face high risks and liabilities abroad that might decrease the success of their offshore R&D. Therefore, the question remains as to whether EM MNCs are able to overcome those risks and liabilities and accomplish high quality R&D abroad. We believe that some strong innovation-based EM MNCs are able to overcome liabilities and reach their goal. Based on these considerations, we establish our first research hypothesis: EM MNCs can achieve higher R&D quality at their offshore locations than at their domestic labs.

2.2.4 Locations for international R&D

Chen et al. (2012) state that the need to go abroad is based on the notion that knowledge can be spatially bound. State-of-the-art technology can be tied to research laboratories, local research networks, universities and R&D institutes, suppliers and competitors, and finally the researchers

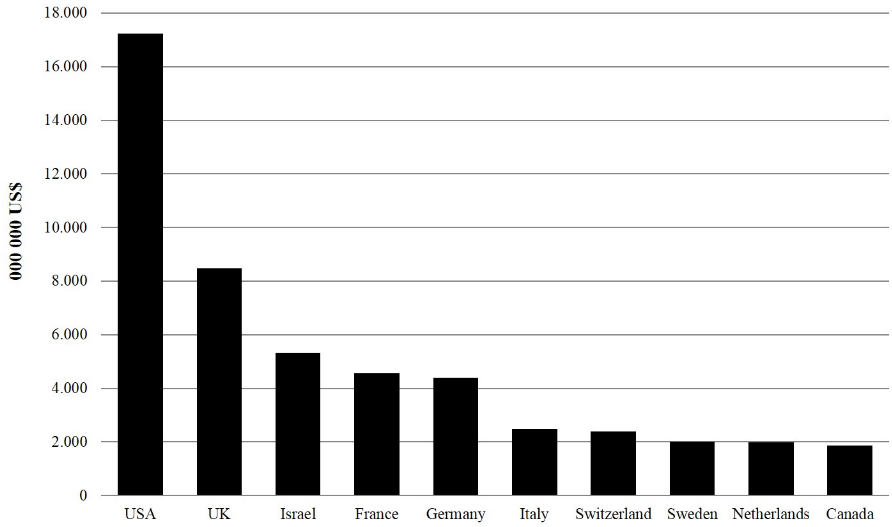

Fig. 2.1: Gross domestic expenditure on R&D financed from abroad in 2012, Own calculation with data from OECD

themselves. Tacit knowledge in particular forces EM MNCs to go abroad to acquire it. To tap into those knowledge sources, the companies need not only to be physically present with their R&D, but also to enter the local research networks (Chen et al., 2012). In order to find the best location for international R&D, EM MNCs need to identify their knowledge gaps and seek locations to complement their prior knowledge (Serapio & Dalton, 1999). The choice of location is also driven by the quality of knowledge that the MNC expects at a certain location (Kuemmerle, 1997). Therefore, R&D units from EM MNCs are mostly found in countries with advanced technological knowledge (Chen et al., 2012). Consequently, certain countries are more attractive for global R&D than others. Figure 2.1 shows the amount of gross domestic expenditure on R&D (GERD) that is financed from abroad for each location. The chart displays the top ten locations of incoming foreign direct investment in R&D. As we can see, the USA is still by far the most attractive location for R&D investment. Their GERD from abroad is about double the amount of the second highest number, which is for the UK. Also, the top ten locations are mostly European countries, along with Israel and Canada. Within Europe, the UK is followed by France and Germany, which are close to each other. The chart supports the notion that advanced market economies are most attractive for international R&D. Based on these notions, we augment our research with a second hypothesis: advanced markets are more important as offshore locations for R&D by EM MNCs than other emerging markets.

2.3 Case study description

2.3.1 Obstacles for Chinese MNCs' internationalization

The special case of Chinese internationalization and the particular liabilities they face has recently received some attention in the literature. Cultural and institutional distance are described as particularly high for Chinese MNCs. He & Lyles (2008) emphasize their lack of experience in doing business with western companies as a drawback for Chinese MNCs. China has been a centrally planned economy for decades, which caused more informal ways of doing business to be established (He & Lyles, 2008). Child & Rodriguez (2005) add that the high institutional dependence for companies in China and therefore the higher institutional distance to foreign markets poses an obstacle to internationalization. Another obstacle that is particularly impeding Chinese internationalization is the negative image that Chinese companies have abroad. Many advanced markets have expressed concerns about Chinese MNCs locating offshore activities there (Si & Liefner, 2014). In particular, those concerns are related to their reputation for only producing low-quality output, non-transparency of business activities and the strong influence of the Chinese state as well as the theft of intellectual property and copying. This negative image is a huge hurdle for entering local business as well as research networks and makes it harder to find qualified personnel (Si & Liefner, 2014). These are particularly crucial for the internationalization of R&D activity, as sharing knowledge relies heavily on interpersonal trust. Chinese companies are extremely interesting objects of study in this context because they rapidly entered the world market with their good-enough technology and now strive to be competitive in more sophisticated technologies (Chen & Wen, 2016; Liefner & Zeng, 2016; Nahm & Steinfeld, 2014; Fu & Gong, 2011). This is also true for our case study company.

2.3.2 The Case Study MNC: Huawei

We chose Huawei as a case study because of its innovation-centered development strategy and the rapid expansion of its international R&D activities. According to its Annual Report, more than

70,000 of a total workforce of about 150,000 are R&D employees (Low, 2007). Looking at the R&D output, Huawei is the worldwide leading firm when it comes to patent applications under the patent cooperation treaty system (PCT) (WIPO, 2015). This enormous international surge of patent applications raises the question of the underlying innovative strategy. Knowing Huawei from previous research, such as Liefner et al. (2019), we assume that this is the outcome of an expansive international knowledge-acquiring strategy. This strategy includes being one of the few EM MNCs that use greenfield investment to set up R&D facilities abroad, which makes it a very unique object to study. This study therefore provides a potential strategic alternative to the better researched knowledge-acquisition through M&As.

The core technologies that the case study company Huawei provides are telecommunications network equipment, IT products and solutions, and smart devices. Founded in the late 1980s in Shenzhen, Guangdong province, China, the company started as a low-cost producer that served the otherwise neglected domestic rural markets and benefited from Chinaś growing and increasingly demanding home market (Fan, 2011; Low, 2007; Mu & Lee, 2005). From 2001 onwards, Huawei has continuously served advanced markets with their products as well (Fu & Sun, 2015). Today, Huawei is the worldś largest telecommunications equipment company (Wan et al., 2015). It is also one of the few privately owned companies among the state-owned-dominated national champions in China.

Even if most of Huaweiś R&D is carried out at the headquarters in Shenzhen, Huawei's R&D activities have shown a remarkable internationalization dynamic. Huawei has set up R&D centers in many regions, including advanced markets such as the US (e.g. Silicon Valley in 1993, Dallas in 1999, Plano, TX, 2001) and the EU (e.g. Stockholm in 2001, Munich in 2008) (Fan, 2011). Huawei's foreign R&D centers are often located in places where Huawei's competitors carry out their R&D as well. While the extent and scale of Huawei's overseas R&D presence is absolutely remarkable (Fan, 2011), it is the Shenzhen capabilities center that assesses the compan's capabilities, collects knowledge from its subsidiaries and diffuses knowledge to those subsidiaries that need it (Fu & Sun, 2015). Through setting up R&D as greenfield investment, the company ensures close ties to its headquarters.

2.4 Data and methods

2.4.1 Patent data

Patent data as indicator for innovation

As it signals new and commercializable technology, patent data is a frequently-used measurement for innovation-related activity in innovation literature. Patent citations in particular have gained attention as a measurement for the technological importance of patents (Hall et al., 2005; Trajtenberg, 1990). Nevertheless, the literature also discusses various shortcomings when using patent data. Patents do not account for all of the innovative activities within a company and not all objects of innovation can be patented. The informative value of patent data also depends on the sector that is analyzed (Grupp, 1998). In innovation-driven and technology-intensive industries, patents play a more important role in protecting intellectual property. In those industries, patents can be used as proxies for most of the innovative activities. Other industries also use utility models, industrial design, copyrights, trademarks, corporate secrets or rapid commercializing to protect intellectual property (Neuhäusler, 2012; WIPO, 2015). Furthermore, there can be strategic reasons for patenting other than protecting a company's innovations. These include blocking competitors from using a certain technology, improving the company's reputation or using patents as exchange material in negotiations with cooperation partners (Blind et al., 2006). This means that we have to be careful when interpreting patents as innovative indicators (Neuhäusler, 2012). Therefore, we have to keep in mind that we can only analyze that part of the innovative activity of Huawei that can be accessed through patent data. However, as patenting plays an important role in the technology field of digital communication in which Huawei operates, it is still a solid proxy to study their offshore R&D quality. As we focus on the differences between patent quality within one company we do not need to adjust for industry specific patenting behavior. Overall, Patent data is one of the most frequently used and available proxies we have for innovative activity, if it is interpreted attentively.

Multiple patent office analysis

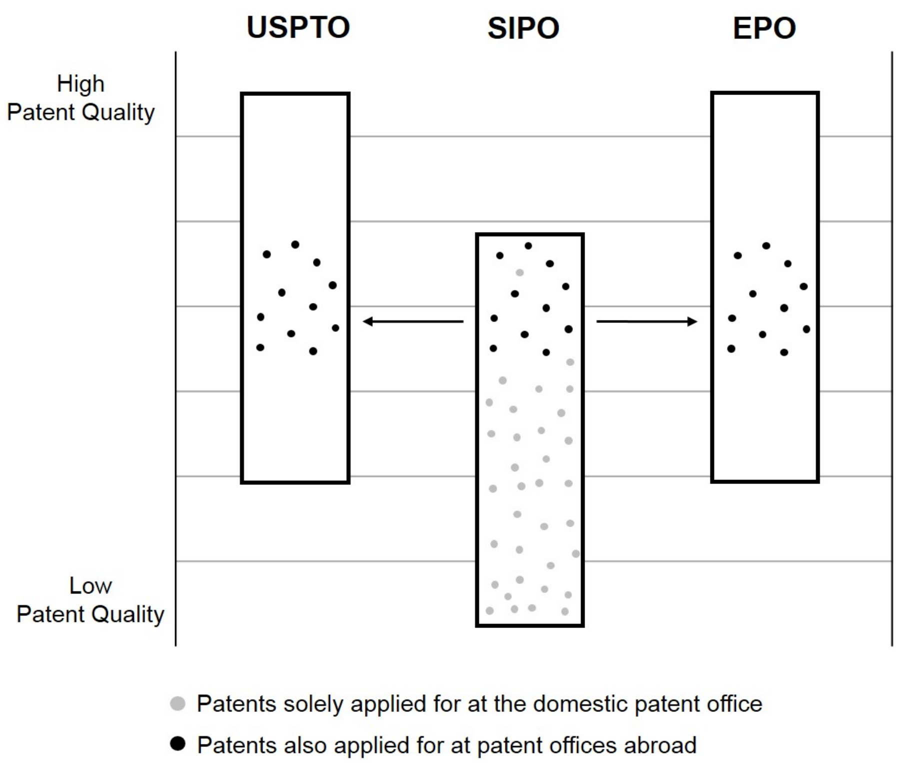

Fig. 2.2: Model of domestic patents and their relative quality ranking at different patent offices

Concerning our methodology, we find that studies applying patent analysis to investigate R&D internationalization of AM MNCs, such as Penner-Hahn & Shaver (2005), Lahiri (2010) and Singh (2008), rely solely on data from the USPTO. This might be adequate for looking at AM MNCs' R&D internationalization, but does not provide enough information in the case of early stages of R&D internationalization. EM MNCs' R&D activity will in most cases be unequally represented at their domestic and international patent offices.

There is strong evidence that place of invention and place of application heavily correlate (Frietsch & Schmoch, 2010). Most inventions that originate from China are taken to the Chinese State Intellectual Property Office (SIPO) first, but inventions originating from the US and Europe are likely to be taken first to USPTO or the European Patent Office (EPO) respectively. Only a smaller number of patents are also filed at other offices. This is also true for the data we use in this study. We find that we can clearly see patents originating from the US being more often applied at USPTO. We see this effect for European patents at EPO as well, but it is less distinct than for the US patents.

Overall, most of Huawei's patents are applied for in their domestic market. One reason for this, despite a certain home base bias, is the relatively low quality of domestic patents. For example until 2009, SIPO patents did not even have to be "new to the world" but only "new to the market" to be granted. We also know from previous research that the Chinese government is influencing the patenting behavior of Chinese firms in various ways, such as patent subsidy programs (Dang & Motohashi, 2015; Li et al., 2012; Liefner et al., 2016). These provide distorting incentives for patenting other than innovative activity and can lead to a certain mismatch of patents and innovation (Li et al., 2012). Dang & Motohashi (2015) find that the Chinese policy increases the number of patents, while causing the quality of patents to decrease. Only the strongest patents can also be applied for at USPTO or EPO, where their relative ranking in quality compare to the other patents at the respective office changes as shown in fiure 2.

On another note, the database of EM MNCs' home patent offices is mostly the least reliable. We find that the data from SIPO is less complete than that of USPTO and EPO, especially when it comes to citations. This weakens the reliability of SIPO patents as indicators of innovation, but as SIPO is Huawei's home patent office, analysis of patent data from SIPO is vital for understanding the EM MNCs' patenting picture. This additionally emphasizes the advantage of analyzing data from more than one patent office separately.

2.4.2 The Datasets

Patent value and indicators

Patent value has different dimensions depending on the stakeholders that assess it. Frietsch et al. (2010) concentrate on five dimensions of patent value: technological value of the patent, radical vs incremental innovations, economic value, social value and strategic value. In our case study, we focus on the dimensions of technological and economic value, according to their relevance for our research question. Those dimensions are the ones most important to latecomer MNCs. We exclude strategic value because it does not foremost aim at contributing to the MNC's knowledge stock and therefore is not subject to our analysis. To measure patent quality concerning technological and economic value the literature suggests a variety of indicators that can be obtained from patent data. After several tests with possible indicators we decided to chose forward citations and backward citations as indicators for technological value and patent family size for economic value. Trajtenberg (1990) emphasized the use of patent citations as a patent value indicator. The number of forward citations shows the amount of subsequent research that builds upon the patent, which is discussed to reflect newness and technological importance (Albert et al., 1991; Carpenter et al., 1981). It has been the most frequently used and validated indicator in the literature (Hall et al., 2005; Frietsch et al., 2010). Fast recognition of patents shortly after publication indicates strong activity in the research area (Lanjouw & Schankermann, 2004). The literature proposes using a certain time frame to measure forward citations accounting for the time lag between application, publication and citation of the patent (Squicciarini et al., 2013; van Zeebroeck & van Pottelsberghe de la Potterie, Bruno, 2011). Therefore, we apply a four-year time frame. Since the most current data available includes patent data up to 2014, we only use patents from 2010 and before when looking at forward citations. For this indicator, we only use patents that were cited at least once to fit the model. Furthermore, as citation rules differ between patent offices, it is very difficult to compare patents applied for at different offices directly. This is another - but more technical - reason why we decided to analyze the data from each office separately.

Another indicator that we use is the number of backward citations, which can be an indicator for the underlying knowledge breadth of the patent (Harhoff et al., 2003; Rosenkopf & Nerkar, 2001; van Zeebroeck & van Pottelsberghe de la Potterie, Bruno, 2011). In the patent document, backward citations are used to outline the state-of-the-art technology upon which the invention builds. The broader the technical scope of the patent, the more backward citations the document is expected to have. The indicator "number of backward citations" has the advantage of being available much more promptly than forward citations.

The indicator "family size" is used to measure the geographic scope of a patent (van Zeebroeck & van Pottelsberghe de la Potterie, Bruno, 2011). It displays the number of patent offices worldwide at which the invention has been applied for. This is a more direct measure of expected monetary value, as companies have to pay for each application in each country separately. It therefore represents economic or market value as well as the international relevance of the invention (Lanjouw et al., 1998; Fischer & Leidinger, 2014).

We also tested several other patent quality indicators discussed in the literature, such as claims, legal status and number of technology classes (Lanjouw & Schankermann, 2004; Squicciarini et al., 2013; van Zeebroeck & van Pottelsberghe de la Potterie, Bruno, 2011), but as they did not prove to be solid indicators, we omitted them. Additionally, we used the number of inventors as a variable for comparison during analysis, but did not include it in the results section because it is a quality input indicator rather than an output indicator.

Datasets

The data for our research was compiled using the EPO Worldwide Patent Statistical Database (PATSTAT) version accessible at the Fraunhofer Institute for Systems and Innovation Research in Karlsruhe. The database is provided by the European patent office to assist patent research. It contains patent data of more than 50 patent offices worldwide. Despite the high reliability of data, at PATSTAT we can also obtain data that is not accessible on the website of some of the national patent offices. Most importantly, we can access the address of each inventor for SIPO patents instead of being limited to the first inventor's address.

To identify all patents belonging to Huawei, we searched the database for "Huawei", "Futurewei" and related spellings. As a next step, we cleaned the 151 results so that only subsidiaries of the Huawei group were taken into account. Our dataset includes all major subsidiaries of the Huawei group except for HiSilicon and Proven Honour Capital, which either account for only a very small fraction of patents or operate in financing (Huawei, 2014). To draw the most comprehensive picture possible of patents that include inventors living or working overseas, we obtained patent data from three different patent offices. The first one is Huawei's home patent office SIPO in China. As we know, there is a certain advantage for domestic applicants, and we find that Huawei accordingly applies for most of its patents at SIPO. Frietsch et al. (2010) mention that this effect is driven by the specific interest that companies have in their home market as well as lower costs when applying inventions in their home market and in their domestic language. Chapter 2.4.1 discusses

Table 2.1: Dataset Descriptives: Huawei's patents at the three patent offices

	SIPO	**USPTO**	**EPO**
Number of patents	40,408	7,363	6,128
Time frame	1995 - 2013	1998 - 2014	1999 - 2013
China-only inventor patents	96.0 %	74.1 %	92.7 %
Patents granted	n/s	40.8 %	30.5%
Patents also applied for under PCT	36.08 %	85.68 %	93.52 %
Average number of inventors	2.19	2.55	2.55

patent quality and international application in more detail. As Table 2.1 shows, the number of patents applied for at SIPO is about six times the number of patents applied for at each of the other two offices: USPTO and EPO. We chose USPTO and EPO for our analysis, as they cover the regions most attractive for R&D investment (see Figure 2.1), and we know that Huawei has been conducting R&D there (see chapter 2.3.2). We also looked at patents filed under the PCT to get a better understanding of Huawei's patent pattern. However, we do not include these in our analysis, as PCT applications are processed differently from applications at national patent offices that actually grant patents. We still use the PCT data to verify our findings from the national offices' data.

Table 2.1 shows that Huawei first patented intellectual property in 1995 in China. Three years later, the MNC started to apply for patents at USPTO and one year later at EPO. Patents applied for at USPTO are the most likely to have non-Chinese residents among their inventors, whereas only four percent of SIPO patents included at least one offshore inventor. We can also see that SIPO patents are less likely to be further applied for under the PCT and have a slightly lower number of inventors than patents filed at the other two offices. The datasets are not disjoint and overlap concerning patents applied for at more than one of the three patent offices.

The location of inventors is obtained from the inventor's address on the patent as suggested by Ter Wal & Boschma (2009), because the applicant of almost all patents is the Huawei headquarters in Shenzhen rather than the local subsidiaries. The address is intended to display the residence of the inventor, but can also be found to refer to the address of the local workplace. Both addresses are very good proxies for the location of the patent's knowledge. Besides the quality indicators and addresses, we collected data on the priority year, the number of inventors, the technology class as WIPO 35 following Schmoch (2008) and the patent offices at which it was applied for. The statistical unit that we use is patents rather than patent families, as we look at each dataset separately.

2.5 Descriptive findings

2.5.1 Worldwide distribution of offshore inventors

Fig. 2.3: Overview of worldwide residency of offshore inventors at Huawei

Figure 2.3 shows the six most important residencies of inventors and distinguishes between the three patent offices. The most eye-catching is the number of patents with inventors from the US. It is the largest number of patents by offshore inventors for each of the three patent offices. As we use absolute numbers, we can also see that most of the offshore inventor patents are applied for at USPTO, except for the two East Asian countries. This is interesting, as we know from Table 2.1 that the absolute number of SIPO patents is six times higher than the number of patents applied for at USPTO. Nevertheless, USPTO has a much bigger share, 25 percent compared to 4 percent, of offshore inventor patents, and this is why their absolute number of offshore inventor patents is almost 300 patents more. We see that inventors from South Korea and Japan play a larger role in patents at the SIPO than at the other two patent offices, which was expected due to their proximity to China. The number of absolute applications at EPO is the lowest.

Table 2.2: Inventor Residency at the three patent offices

	SIPO	USPTO	EPO
Offshore Inventor Teams			
Only Offshore	22.5 %	65.5 %	77.1 %
China and Offshore	77.5 %	34.5 %	22.9 %
Offshore Inventor Residency*			
North America	64.6 %	81.7 %	65.7 %
Europe	20.2 %	18.9 %	35.2 %
East and Southeast Asia	15.3 %	2.2 %	2.9 %
Rest of EM	1.2 %	2.0 %	2.5 %

North America: USA, Canada
Europe: Austria, Belgium, Switzerland, Spain, Finland, France, UK, Greece, Italy, Netherlands, Norway, Poland, Czech, Ireland, Germany, Sweden
East and Southeast Asia: Japan, South Korea, Hong Kong, Singapore, Taiwan, Philippines, Vietnam, Guam, Malaysia
Rest of EM: South Africa, Russia, India, Brazil, Mexico, Turkey, Algeria, Egypt, Saudi Arabia, Sudan, Nigeria, Cameroon, United Arab Emirates, Grenada, Virgin Islands, Samoa

Note: Patents can be assigned to multiple inventor countries
* Percentage of offshore-inventor-patents with at least one inventor living or working in this region

A look at Table 2.2 provides a more comprehensive picture of patent applications concerning the residency of inventors. The first half of the table shows the structure of the inventor teams among the offshore inventor patents. We can see that at the foreign patent offices, the inventor teams mostly consist of offshore inventors only. In contrast, the fraction of the mixed inventor teams at SIPO is more than three-quarters. The second half of the table shows the worldwide distribution of inventors. As we already know that the bulk of patents have only China-based inventors (see Table 2.1), we only look at patents that have at least one offshore inventor. We can see that for each database, the percentage of patents that have at least have one inventor from North America is by far the highest. We also see a bias favoring inventors from the region that the patent offices cover: for USPTO, the percentage for North American inventors is higher than at the other offices, and the percentage of European inventors at EPO is also around 15 percent higher than at the other offices. Furthermore, East and Southeast Asia play a much bigger role among the offshore locations for patents applied for at SIPO, Huawei's home patent office. All other locations that we find in the patent datasets are found to be either emerging or developing nations that make up only a small fraction of offshore patents.

To sum up, we find with regard to hypothesis two that the most important locations are advanced markets: the US, Sweden, Germany and Canada. Emerging markets play a minor role as R&D locations for Huawei. We also find that advanced markets in proximity to the company's headquarters, such as South Korea and Japan, play a smaller role than we expected.

2.5.2 Technology fields

Table 2.3: Patents assigned to major technology fields

Technology Class		**SIPO**	**USPTO**	**EPO**
Sector	**Field**			
Electrical Engineering	6: Computer technology	15.6 %	30.6 %	12.7 %
Electrical Engineering	8: Semiconductors	83.4 %	69.3 %	87.1 %
Instruments	10: Measurement	1.1 %	2.6 %	0.6 %
Mechanical Engineering	30: Thermal processes & apparatus	6.8 %	7.9 %	8.4 %

Note: Only valid cases, one patent can be assigned to multiple technology fields

We also look at the technology fields to which the patents are assigned to see whether they differ between locations. Around 90 percent of patents are assigned to only one technology field, while about 9 percent are assigned to two. Only a few patents are assigned to three or more technology fields. This is similar for all three offices. The most common field for Huawei's inventions is "Semiconductors", with around 85 percent of patents assigned to it at SIPO and EPO, and almost 70 percent at USPTO, as shown in Table 2.3. The second largest field, "Computer technology", also shows a discrepancy between SIPO and EPO on the one hand and USPTO on the other. At USPTO, over 15 percent more patents are assigned to this field compared to the other two offices. This is because software is generally patentable at USPTO, which is not possible without restrictions at EPO and SIPO (Hall & MacGarvie, 2010). EPO contains a slightly higher fraction of patents applied for in the third biggest field "Thermal processes and apparatus" than the other two offices. Finally, the field of measurement shows a stronger use at USPTO than at the other offices, but has an overall low percentage of patents applied for at each office.

2.6 Empirical models

2.6.1 Model description

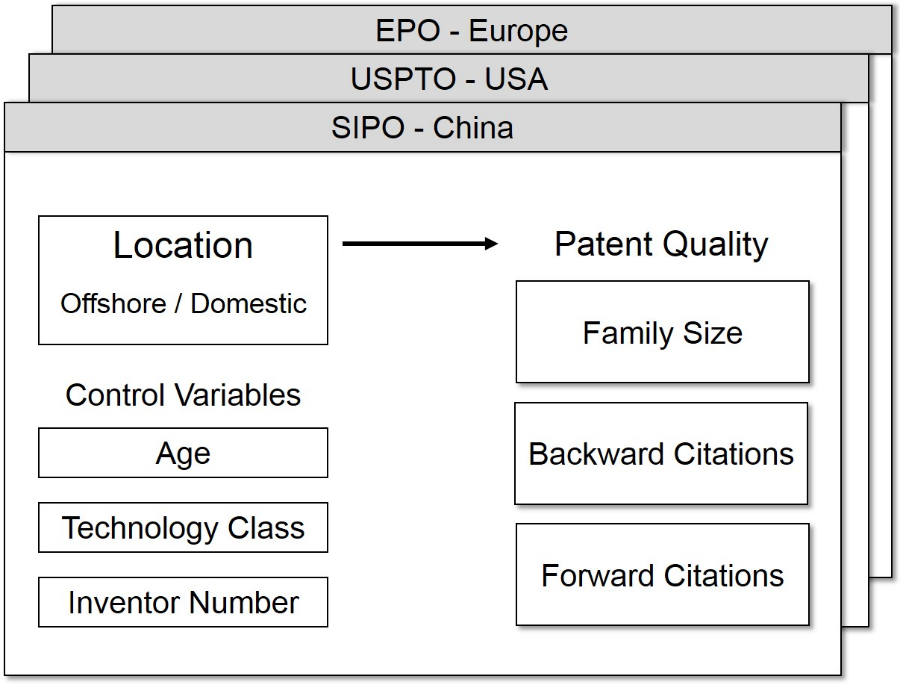

Fig. 2.4: Empirical Model

Figure 2.4 summarizes the variables and the structure of the empirical models. The figure shows that we use four input measurements in each model. The predictor variable for each model is the dichotomous variable "Offshore Inventors", used as a categorical variable. As control variables, we also use the age of the patent, the number of inventors and dummy variables for technology classes. For each of the three patent offices, we calculate three different models, one for each of the following quality measurements: family size, backward citations and forward citations. Since the response variables include only count variables, we use generalized linear models (GLM) instead of standard OLS regression as a multivariate model (Zuur et al., 2009). This approach is typical for the analysis of patent data (Neuhäusler, 2012; Singh, 2008). These models fit best if the mean is less than ten and the variance is similar to the mean (Zuur et al., 2009). In Table 2.4, we can see that this is true for most of the indicators except for backward citations at USPTO and EPO. Therefore, we need to be more careful when interpreting the outcome of those two models.

We apply a *Poisson log model* for the dependent variable family size. For the dependent variables backward and forward citations, we have to use a *Negative binomial regression model*, as we find them to be over-dispersed. This means the variance of the response variable is greater than the model expects, which distorts the outcome (Zuur et al., 2009). In Table 2.4, we can see that for those variables, the variance is much bigger than the mean. Also, a value greater than 1 for the Goodness of fit indicator Chi-Square Value / d.f. for the variables indicates the over-dispersion (see Tables 2.5 - 2.7). As the samples are each quite large, we can use the Negative binomial model as an alternative.

Table 2.4: Quality indicator descriptives

	Family size			**Backward Citations**			**Forward Citations**		
	SIPO	USPTO	EPO	SIPO	USPTO	EPO	SIPO	USPTO	EPO
Mean	1.8	3.98	4.56	7.16	17.07	13.34	2.09	4.67	3.94
SD	1.39	1.75	1.48	7.67	15.14	10.97	2.08	5.07	4.65
Variance	1.93	3.07	2.18	58.83	229.22	120.36	4.31	25.74	21.58
Range	1 - 17	1 - 14	1 - 14	1 - 99	1 - 216	1 - 216	1 - 50	1 - 50	1 - 50

2.6.2 Goodness of fit measurements and data coverage

Tables 2.5 - 2.7 show the results of the Poisson and negative binomial Regression for each dataset. The Goodness of fit measurement "Pearson Chi-Square / d.f." shown in the table indicates the quality of the models. Ideally, the Pearson Chi-Square / d.f. measurement is between 1 and 1.5, which is true for most of the models, as we already use Negative binomial models for the over-dispersed indicators. Only family size in the USPTO and EPO datasets has a value lower than 1, which indicates under-dispersion. This means that contrary to over-dispersion, the variance of the response variable is lower than the mean, which we can also see in Table 2.4. However, as we do not have too many explanatory variables or outliers, there is no need to correct for it (Zuur et al., 2009). Another goodness of fit measure is the omnibus test that shows the overall significance of the model over an intercept-only model. For our models, all values indicate significance.

Another measurement we need to have a look at before interpreting the data is the percentage of cases included. We can see that we have information on family size for almost all patents in our datasets. Backward citation also represents most of the data for USPTO and EPO, but only covers 9 percent of SIPO patents. This is due to the quality of data for this variable at SIPO. Before 2009 in particular, only a small percentage of patents contains information on backward citations. This means that we need to be careful when interpreting this model, as it only represents a small fraction of the dataset, mostly patents with a larger family size. Nevertheless, the total number of patents included in the model is still more than 3,700 due to the size of the SIPO dataset. For Forward Citation, we can see that the coverage is lower than for most of the other response variable models, but as we only include patents with at least one citation for statistical reasons, this explains the numbers. They still, however, represent a large enough part of the datasets to interpret. Overall, the EPO dataset is the most complete one but forward citation is the best available for the USPTO dataset.

Table 2.5: Poisson and negative binomial regression models with data from SIPO - China

	(1) Family size	(2) Backward Citations	(3) Forward Citations
Intercept	0.622	1.032	0.358
Offshore Inventors (B)	0.215*** (0.017)	0.109*** (0.035)	0.188*** (0.417)
Offshore Inventors EXP(B)	1.240	1.115	1.207
Age	Included	Included	Included
Inventor Number	Included	Included	Included
Technology dummies	Included	Included	Included
Pearson Chi-square / d.f.	1.063	1.635	1.410
Probability distribution	Poisson	Negative binomial	Negative binomial
Included cases	39,723 (98.5 %)	3,701 (9.2 %)	12,510 (40.0 %)

*: sign. at 0.1
**: sign. at 0.05
***: sign. at 0.01

2.6.3 Findings

In Tables 2.5 - 2.7, we provide the coefficients (B) as well as the exponentiated values of the coefficients Exp(B), which can be interpreted as incident rate ratios. The values can be interpreted in percentage terms.

For the response variable *family size* in the SIPO dataset, the offshore inventor variable shows a positive and significant value (0.215***), which means that the size of patent families is larger for patents that include at least one offshore inventor. In more detail, this means that if we have

Table 2.6: Poisson and negative binomial regression models with data from USPTO - USA

	(1) Family size	(2) Backward Citations	(3) Forward Citations
Intercept	1.080	1.973	0.083
Offshore Inventors (B)	-0.282*** (0.016)	0.098*** (0.022)	0.373*** (0.036)
Offshore Inventors EXP(B)	0.754	1.098	1.453
Age	Included	Included	Included
Inventor Number	Included	Included	Included
Technology dummies	Included	Included	Included
Pearson Chi-square / d.f.	0.616	1.427	1.288
Probability distribution	Poisson	Negative binomial	Negative binomial
Included cases	7,207 (97.9 %)	6,505 (88.3 %)	3,590 (70.9 %)

*: sign. at 0.1
**: sign. at 0.05
***: sign. at 0.01

Table 2.7: Poisson and negative binomial regression models with data from EPO - Europe

	(1) Family size	(2) Backward Citations	(3) Forward Citations
Intercept	1.192	1.952	-0.091
Offshore Inventors (B)	0.057** (0.023)	-0.223*** (0.035)	0.139* (0.078)
Offshore Inventors EXP(B)	1.059	0.08	1.149
Age	Included	Included	Included
Inventor Number	Included	Included	Included
Technology dummies	Included	Included	Included
Pearson Chi-square / d.f.	0.398	1.343	1.358
Probability distribution	Poisson	Negative binomial	Negative binomial
Included cases	6,068 (99.0 %)	6,074 (99.1 %)	2,524 (53.4 %)

*: sign. at 0.1
**: sign. at 0.05
***: sign. at 0.01

offshore inventors in the inventor team, we have a 24 percent (EXP(B)=1.240) higher incident rate for family size than for the reference group of China-only invented patents. We also see this positive relation in the EPO dataset, but the incident rate and the significance are lower. These two coefficients show that patents with patent teams that have at least one inventor from outside the companies' home base have a broader geographical scope. For the USPTO dataset, we see a reverse relation. A coefficient of -0.282 indicates a smaller family size when offshore inventors are included. This is likely to be due to the patentability of software in the US as well as their large market size. When Huawei develops high-quality patents with foreign inventors in the US (with 82 percent of them living in the US, see Table 2.2), this might be because some kinds of software

are patentable at USPTO, but not at the EPO or SIPO. Therefore, they can not be applied for at other offices. In Table 2.3, we can also see that the percentage of patents in the field of computer technology at USPTO is much higher than at the other offices, which supports this theory. Another reason for a smaller family size at USPTO might be that the patents developed in the US are developed for the US market, which is a very big market itself, and there might be no need to apply for them at further patent offices. These points might also be the reason why the family size models show under-dispersion at USPTO: the variance is lower than usual because many patents are only applied for at USPTO.

The response variable *backward citations* was included to measure the underlying knowledge breadth of the patent. In chapter 2.6.2, we note that we need to be careful with our interpretation, as the variable does not fully fit the model and we have a low number of cases included for SIPO. Overall, we see a positive relation in the SIPO and USPTO dataset. The coefficients are small but significant in both cases. For the EPO dataset, we see a negative and significant relation, meaning that patents that have at least one offshore inventor have fewer backward citations. The differing incident rates between the offices can partly be attributed to the different citation regulations between the patent offices. At USPTO, most citations are made by the inventors rather than the patent examiner. Therefore, we find that the interpretation of the variable makes most sense at this office, as the relation between the knowledge used by the inventors and the citations they make is more direct than at EPO. Besides those technical considerations, we also find that backward citations are subject to discussion in the literature concerning their informative value regarding patent quality. Some scholars argue that many backward citations signal a more incremental innovation because the patent is said to be built upon a lot of existing knowledge (Squicciarini et al., 2013). They argue that break through innovations cannot cite many other patents because the technological gap between them and the former state of technology is too wide. To summarize our thoughts on backward citation, we find it to be the least informative indicator for patent quality in our data set.

For *forward citations*, we find the clearest picture of the influence of offshore inventors on patent quality. The incident rate for the offshore inventors at all three datasets indicates a positive relation. For the Chinese patent office, we find a 20.7 percent incident rate, which is slightly lower than the one for the model with family size as a dependent variable. The USPTO dataset displays the highest exponentiated coefficient with 45.3 percent. At EPO, the incident rate is lower (14.9 percent) and significant at the 10 percent level. This could again be an indication that differing citation rules between the offices influence the outcome of the analysis when comparing USPTO and EPO. Overall, this variable clearly shows that the presence of offshore inventors increases the number of citations of the patent, and therefore indicates a higher technological value.

We additionally looked at the quality differences between the most important locations: USA, Sweden, Germany and Canada. We find that the numbers of inventors are too low to produce significant results when broken down to a single location and therefore refrain from interpreting the results here. Nevertheless, we can see that patents from Sweden show the highest quality compared to all other offshore locations.

With regard to our first research hypothesis, we learn that overall patents with offshore inventors do have a higher quality, which is true for all three patent offices. Also, we obtain a more differentiated picture of patent quality and are able to learn more about our indicators through using three different patent offices than we could learn from one.

2.7 Conclusion

Our major empirical findings support our hypotheses that overall, despite facing liabilities abroad, the inclusion of offshore inventors in R&D (hypothesis 1) as well as choosing advanced markets as R&D locations (hypothesis 2) increases the quality of innovation.

Our paper's main theoretical contribution is threefold: firstly, our findings contribute to the literature on EM MNCs, providing empirical evidence for the fact that R&D internationalization using greenfield investment can be a successful approach towards incorporating new knowledge into an EM MNC's R&D and innovation. Secondly, enriching the discussion about R&D internationalization, our results highlight important particularities of EM MNCs, which are a quantitative bias on patent applications at the less demanding home country office, and the achievement of higher-quality R&D results at foreign locations and based on the contributions of foreign inventors. Thirdly, our findings indicate that EM MNCs' R&D internationalization will reinforce existing locational specializations and knowledge bases of the worldwide leading R&D locations. Our paper's major methodological contribution relates to the treatment of patent data from different offices. The findings prove that using data from only one patent office might provide a clearer but possibly wrong picture. Particularly for EM MNCs in the initial phase of R&D internationalization, multiple patent office analysis is strongly recommended in order to reveal the entire picture. Overall, we find that the analysis of the patent indicators family size and forward citation provides suitable means for analyzing R&D quality despite the shortcomings discussed in the literature.

The following limitations need to be addressed: we were not able to depict the most current picture of forward citations at Huawei, as we have to apply a four-year time frame. In the case of Huawei, we still obtain a good insight because the company has a long record of patenting overseas, but it might be an obstacle for analyzing other emerging companies. Another limitation is of course the case study approach. As a Chinese MNC, Huawei is in some respects a special case among EM MNCs. Despite the high liabilities they experience abroad, they have a government that provides strong support for internationalization such as subsidies and access to cheap credit. This makes Chinese MNCs willing to take greater risks in their internationalization and results in a fast pace of internationalization. Although we find Huawei to be an insightful best practice case, further research should shift the focus of analysis to either more industries or a broader geographical area. We also feel that the literature at this point could profit from a more detailed qualitative analysis of inventor biographies and networks concerning offshore R&D. Moreover, a closer look at the invention itself could help to gain more knowledge on offshore patent quality.

An important managerial implication of this paper is that EM MNCs do not have to build up sophisticated R&D capacity in their home market before they can achieve high R&D quality, instead being able to use offshore R&D in the form of greenfield investment. This strategy is able to overcome LOF and LOO abroad and provides a successful alternative to M&As. It requires EM MNCs to set up R&D laboratories in major R&D locations of AM MNCs, to employ highly qualified local personnel at these laboratories, and to set up organizational processes to handle patent applications and internal knowledge distribution. From a national policy perspective, we find that

R&D locations in the US and Europe are still technologically ahead. Chinese MNCs, and Huawei in particular, however, are also capable of creating meaningful inventions that are strong enough to be submitted to international patent offices. Hence, for EM MNCs, it makes sense to access knowledge abroad through R&D off-shoring, as it seems to be a path for successfully upgrading R&D performance. AM have to face the fact that their local knowledge is increasingly attracting EM MNCs that aim to incorporate it into their own knowledge stock.

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Chapter 3

Catching up by Hiring: The Case of Huawei

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Abstract

Hiring experts in centers of state-of-the-art technology is an important way in which a multinational enterprise (MNE) can gain competitive advantage, and yet use of this mechanism remains under-researched. This study uses the case of a Chinese MNE that recently achieved a leading position in the telecommunications market: Huawei Technologies. Taking the perspective of Huawei's offshore hires, I find that greenfield investments contributed to overcoming liabilities of origin and outsidership in the global telecommunications industry. Nevertheless, even now that Huawei has caught up with industry incumbents, its output capabilities remain dependent on the innovation capability of its offshore experts.

3.1 Introduction

Latecomer companies, especially those in knowledge-intensive and innovative industries, have become more visible in the last decade through their global R&D activities (Awate et al., 2015; Di Minin et al., 2012; Gammeltoft, 2008; Papanastassiou et al., 2019). To reduce the gap between themselves and incumbents (Mathews, 2002; Mudambi, 2008), latecomers are increasingly investing in international centers of innovation as springboards to global competitiveness (Luo & Tung, 2007). Although some latecomers have been able to build the capabilities needed to catch up with (and even surpass) more established competitors (Luo & Zhang, 2016), we still do not fully understand the mechanisms that allow them to gain a place among global players. A particularly promising, but as of yet under-researched mechanism, is the hiring of experts at offshore locations (Almeida & Kogut, 1999; Song et al., 2003). I investigate how the establishment of foreign greenfield R&D subsidiaries can be a low-profile alternative to the better-researched catch-up mechanism of acquiring foreign high-tech firms and also how the experts at those subsidiaries can contribute to global competitiveness beyond providing access to knowledge. I carry out an in-depth case study of the Chinese telecommunications equipment manufacturer Huawei Technologies Co. Ltd. (Huawei), which is known for strategically hiring R&D experts outside its home country, earning it a reputation for intense knowledge sourcing. Huawei stands out because of the rapidity with which it caught up with the industry leaders in telecommunications, surpassing them in terms of annual revenue and patent applications at the World Intellectual Property Organization (WIPO) (Lee et al., 2016). In fact, Huawei was a technological leader in China but had little left to learn in its home country so it turned abroad to access state-of-the-art knowledge (Boutellier et al., 2008; Fan, 2011). In order to hire senior experts, it set up R&D units close to competitors, a strategy used previously by Korean MNEs (Lee & Lim, 2001). Huawei's reliance on offshore hiring to catch up makes it an ideal subject for a case study exploring how hiring offshore experts can provide competitive advantages. [1] To identify the micro mechanisms of its catch-up process,

[1]The concept of offshore experts has been discussed in the literature as "host country nationals" (HCN) meaning persons working in their home country for a foreign company in contrast to expatriates who work abroad for a company from their home country (Gong, 2003; Vance & Paik, 2005). I do not use the term because it does not account for the diverse cultural backgrounds of experts working for MNEs and Huawei in particular (Caprar, 2011).

I explicitly take the perspective of the offshore experts in over 40 qualitative interviews at eight different R&D locations. I identified potential interviewees using an original Huawei patent and scientific publication dataset, which I also used to analyze the timeline of Huawei's global R&D activities. I concentrated on the period leading up to Huawei's global breakthrough to show how the company achieved competitive advantage from a latecomer position. I contribute to the literature on R&D internationalization and entry modes by investigating mechanisms of a latecomer's greenfield investments. Catching up by hiring goes beyond learning-by-hiring. To catch up, firms must overcome liabilities of origin and of industry outsidership, and they can do that with offshore hires embedded both in the firm and in industry networks. I also uncover the strong connection between Huawei's output capabilities and the innovation capability of its offshore experts.

3.2 Theoretical Background

3.2.1 Literature

I build on the Luo & Tung (2007, 2018) notion that outward foreign direct investment (FDI) serves as a springboard for latecomer companies attempting to build competitive advantage and overcome latecomer disadvantages. Jumping off the springboard allows latecomers to leverage home-country competences and to make use of new opportunities abroad at the same time, which is in line with the dynamic capability argument (Grøgaard et al., 2019; Luo & Tung, 2007; Teece et al., 1997). Competitive advantage can be built by combining already-existing advantages, such as Huawei's low labor costs and reputation for outstanding customer service, with new capabilities like technical and innovative skills. Latecomer companies are under pressure to compete globally while simultaneously defending their home market against established rivals (Hsu et al., 2015; Luo & Tung, 2007). A common strategy for latecomers is to try to move from lower to higher value-added activities in global value chains by acquiring state-of-the-art technology from incumbents (Mathews, 2002; Mudambi, 2008), saving themselves the time it took others to develop those technologies (Chen, 2004). Asian companies especially are known for strategically gaining expertise from abroad (Child & Rodriguez, 2005; Poon et al., 2006). Earlier studies have looked at Korean and Taiwanese latecomers who caught up in the 1970s, Samsung and LG Electronics for example (Cho et al., 1998; Lee & Lim, 2001; Miao et al., 2018). I analyze a company from China as a more recently emerging economy, and specifically focus on its "emerging phase" in an effort to detect capabilities that latecomers need in order to create competitive advantage (Hernandez & Guillén, 2018). Global incumbents benefit from international networks that have historically evolved (Meyer et al., 2011), latecomers on the other hand need to find ways to enter these despite their lack of connections and global industry embeddedness (Cantwell & Mudambi, 2011; Johanson & Vahlne, 2009). I propose that one strategy that can help overcome such restrictions is to leverage the inherent embeddedness of locations where employees, companies and stakeholders are already integrated in global industry networks. Here, the offshore expert dual embeddedness can provide the firm that hires them with not only an entrée into the local context, but more importantly a way into the global industry network. Latecomers may also suffer from liabilities of origin. Emerging market firms in particular often have to contend with stereotypes that stem from the behavior of other home-country actors, including other firms and governments (Asmussen, 2009; Fiaschi et al., 2017). Being an industry outsider from China added to Huawei's struggle to enter the global telecommunications industry. Not only industry incumbents attempted to block it, but some Western governments such as the US did as well. Given the additional obstacles it faced, the question is how Huawei managed to become a global technology leader. According to the springboard perspective, the acquisition of foreign firms is the main means of accessing state-of-the-art knowledge (Luo & Tung, 2007), but there has been recent calls in the literature to shift the focus on other investment modes such as greenfield investments (Kumar et al., 2019; Luo & Tung, 2018). Many scholars have assumed that acquisitions are made to obtain strategic assets such as technology and brands and that they can offer fast access to the business network of an acquired firm, while greenfield investments, which entail building facilities from scratch, have thus far been mainly ascribed to market-seeking motives (Anderson & Sutherland, 2015; Rui & Yip, 2008; Klossek et al., 2012). In this regard, Huawei is an atypical case as it pursues knowledge-seeking strategies through the establishment of greenfield R&D subsidiaries, thus the analysis contributes to closing a gap in our understanding of mechanisms of greenfield investments in knowledge-seeking R&D internationalization (Anderson & Sutherland, 2015). Instead of acquiring firms for their knowledge, Huawei hires offshore experts, who are experienced technical experts from technologically advanced competitors or research institutions at Huawei's offshore locations, in order to tap their experience and technical know-how. The extant literature recognizes the hiring of offshore experts as a way to obtain state-of-the-art knowledge; ergo, learning-by-hiring (Almeida & Kogut, 1999; Song et al., 2003).Those experts have tacit and complex knowledge that is not easily codifiable, which can be used to build up the company's knowledge stock (Argote & Ingram, 2000). Incumbents on the other hand are eager to preserve their competitiveness and attempt to reduce the inter-firm mobility of highly qualified employees through non-compete contracts and the threat of patent litigations (Campbell et al., 2012; Ganco et al., 2015). In order to better understand the value of offshore experts for Huawei, in this study I do not, as some have, focus solely on learning mechanisms, but adopt a broader perspective, analyzing the eclectic role of experts in creating competitive advantage. I achieved this by conducting interviews using an exploratory approach leveraging the experts' point of view in order to allow for new insights into catching up by hiring. I was able thus to go beyond learning-by-hiring and show how offshore experts improve Huawei's embeddedness in global telecommunications industry networks.

3.2.2 Context and development

When Huawei was founded in the late 1980s, global players from Western countries such as Ericsson, Siemens, Nokia, Motorola, Alcatel, Nortel and Lucent dominated the telecommunications industry. In the early 2000s the bursting of the IT bubble started a wave of consolidations that created Alcatel-Lucent and Nokia-Siemens-Networks, and eventually led to Nortel's bankruptcy in 2009 (Lee et al., 2016). This was an important factor in the development of Huawei, China's own telecommunications market was another. When the Deng Xiaoping Open Door Policy began in 1984, Chinese telecommunications technology lagged behind that of the West by some 20 years. By the time Huawei was founded, there was huge pent up demand especially in rural areas (Mu & Lee, 2005). It first sold cheaper low-end telecommunications infrastructure equipment in the countryside which allowed it to avoid head-to-head competition with more technologically advanced foreign competitors which were concentrating instead on large urban areas (Lee et al., 2016; Li & Cheong, 2016). Once its domestic market reached a certain degree of saturation, Huawei expanded sales to other emerging markets, India and Russia, and a number of countries in Africa and Latin America (Lee et al., 2016; Micheli & Carrillo, 2016). Leveraging its low prices, familiarity with rapidly changing political conditions, and the political ties between its home country and host countries, Huawei's strategy was to become big by first winning emerging markets (Cooke, 2012; Li & Cheong, 2016; Micheli & Carrillo, 2016). Again Huawei avoided direct competition with global players while it built expertise and grew. The next step was to tackle the low quality of its products. In the mid-2000s it started to expand its R&D activities to global innovation centers outside China. Today, Huawei does its most impactful R&D offshore, as shown by the fact that its higher quality patents are created by its offshore in contrast to domestic employees (Schaefer & Liefner, 2017). Geographic, cultural and institutional distance had little impact on the sequence of Huawei's R&D investments, as the company entered Western technology centers such as Silicon Valley early on (Fan, 2011). Huawei's disregard for cultural and institutional distance was a result of the company following the location choice of global industry leaders, but proved a major hurdle for the company for gaining legitimacy. Still now, Huawei's strategy prioritizes internal innovations over acquired ones thus it locates close to competitors in order to hire technological experts (Chang et al., 2017). Cooke (2012) observes that Huawei's offshore subsidiaries usually start out with a small team of Chinese expatriates who then hire local employees. Huawei also upgraded its technological capability through strategic foreign R&D cooperation, for example it formed alliances with Texas Instruments, Sun and Intel (Lee et al., 2016), and in the early phase of internationalization pursued fast and unidirectional knowledge absorption from university collaborations (Liefner et al., 2019). As a privately owned firm, Huawei did not receive financial incentives from the China Development Bank as did its state-owned competitors. This did not change until the mid-2000s when the Chinese government helped it in its efforts to internationalize as part of the Going Global Policy. That support enabled the company to expand its sales to established markets, which it again did by initially selling products at very low prices in order to build a customer base (Cooke, 2012; Micheli & Carrillo, 2016; Nolan, 2014). Unlike its experience in emerging markets, in the West Huawei came up against a hostile political climate, the US even accusing Huawei of espionage, an accusation some see as directed at the Chinese government (Cooke, 2012; Chung & Mascitelli, 2015). Just as it had stymied state-owned Chinese companies previously, the US government stood in the way of Huawei making acquisitions and barred it from bidding for national network projects, causing Huawei to focus on European, Canadian and Australian markets (Anderson & Sutherland, 2015; Chung & Mascitelli, 2015; Nolan, 2014). Despite these roadblocks, by 2008 Huawei became the number one patent applicant at WIPO and in 2012 surpassed industry leader Ericsson in annual revenue (Lee et al., 2016). Huawei was a late entrant in the standardization process for the fourth generation of wireless systems (4G), but it became a main contributor to the fifth (5G). When making generalizations from case studies, one needs to take into account its specificities (Brinkmann & Kvale, 2018; Yin, 2014). In Huawei's case this includes government-provided advantages (Gaur et al., 2018) such as access to cheap capital which allows the company to take greater risks, a bad reputation in the West, even in comparison to other Chinese companies, and geopolitical risk, as the latest developments in the trade dispute between the US and China demonstrate.

3.3 Methods

3.3.1 Research Design

To answer "how" using the among Chinese MNEs uncommon strategy of hiring offshore experts instead of acquisitions helps Huawei to create competitive advantage on a global scale, a case study design was deemed most appropriate because of the high complexity of the phenomenon (Birkinshaw et al., 2011; Ghauri, 2004; Marschan-Piekkari & Welch, 2004; Yin, 2014). This research design makes it possible to unfold interrelated and consecutive processes, for instance experts at offshore locations using their contacts to approach further potential employees, which starts a self-reinforcing spiral that helps the business unit and its network to grow. Previous research has identified a lack of qualitative studies when it comes to knowledge-seeking subsidiaries, leading to a lack of in-depth understanding of the phenomen (Michailova & Mustaffa, 2012). (Doz, 2011, p. 587) argues that a qualitative study can make a crucial contribution as it "allows a conceptualization from the standpoint of the actors at work". The research design I adopted for this case study allows me to tap into the perspective of offshore experts, in order to uncover their role in the company's catch up. In order to capture variations between locations, I interviewed experts at Huawei's major patent-or scientific publication-producing offshore R&D labs (Birkinshaw et al., 2011), hence the R&D subsidiaries form the meso-level of analysis. The aggregated level of analysis is the company itself, and the goal is the big picture, Huawei's R&D internationalization. The case is embedded in the context of the global telecommunications industry, as the interviewees all have profound knowledge of the industry and are able to situate their experience within the context of the industry, providing both an insider's and an outsider's perspective on the company. This means that the study has features of an embedded case study method as well as a multiple case study design (Yin, 2014). Some interviewees were current Huawei employee, others former ones. Another feature of the study design intended to ensure critical distance from the company is that I did not ask managers about their aims, but instead asked engineers about their practical tasks. This provided a check on the kind of one-sided company-created narratives Tokatli (2015) warns are the 'dark side' of firm-centric case studies. In line with this, I adopted an exploratory approach with mainly inductive category building to stay open to new interpretations of the offshore expert role in generating competitive advantages (Doz, 2011; Flick, 2018).

3.3.2 Data and Analysis

The main findings of my qualitative analysis are drawn from semi-structured interviews. I identified potential interviewees and obtain a broader picture of the company's R&D activity using three databases, PatentsView for data from the United States Patent and Trademark Office (USPTO), PATSTAT for the European Patent Office (EPO), and Elsevier's Scopus for publication data. The experts I selected to ask for an interview were either at the time or previously employed at an offshore location of Huawei Technologies or at Huawei Device, Futurewei or HiSilicon, Huawei subsidiaries. As the inventors listed on patent applications filed by Huawei are not necessarily employed by Huawei (Ge et al., 2016), I used online social media platforms such as LinkedIn and ResearchGate to investigate which experts were, or had been, employed by the company. There is a clear break point in the number of patents and scientific publications per location, eight of them being far and away the most active: Munich, Stockholm, Dallas, San Jose, San Diego, Bridgewater, Chicago and Ottawa. Together they account for more than 90% of Huawei's offshore patents filed with the USPTO and 88% with the EPO, as well as 73% of all offshore scientific publication activity. I contacted 233 inventors using LinkedIn and e-mail and was able to do 42 interviews. I carried out interviews between February and September 2017, some in person, others via Skype or telephone, in one case I conducted a follow up interview. I decided against inclusion in the analysis of one interview simply for lack of usable information. Twenty-four of the remaining 40 interviewees were located in the US and Canada, 14 others in Europe. Two interviewees did not have a fixed location. The majority of interviewees were offshore experts, that is, they were experienced technical experts whom Huawei hired from technologically advanced competitors or research institutions outside of China and two interviewees were Chinese expats, educated in China and previously employed by Huawei China. In addition to their professional experience, all of the offshore experts had a tertiary education at one of the universities located in Western hotspots of the global telecommunications industry. Four of the interviewees had a Chinese university undergraduate education before getting a higher degree or taking an academic position abroad. These interviewees were able to provide a cultural insider's perspective. Many of those interviewed in the US and in Canada were from India or a country in South America, the Middle East, North Africa or East Europe, but all of them had had some education in North America or had worked there before Huawei hired them. Those interviewed in Europe were mostly from within Europe. The interviewees without exception were males. This is reflective of the industry as I was able to identify less than 0.1% females among the offshore inventors and none agreed to an interview. Finally, across the board, former employees were more open to sharing insights than current ones, the latter were also reluctant to share negative experiences. The main questions posed in the semi-structured interviews are provided in the appendix. There are three blocks of questions, the first about previous employment, coming to work at Huawei, and the particular lab joined, the second about external contacts and influence, and the third about their tasks and role within Huawei. The professional background responses provide information about the kind of knowledge and contacts Huawei is able to access abroad. Responses to the second set of questions provide information about the extent of external contacts and how they might be used, as well as the possibility of external barriers to Huawei's operations. Finally, responses to questions about tasks and work partners within the company throw light on the internal role of experts. I employed qualitative analysis software using MaxQDA. Coding the text helped me to identify general patterns as well as complex interrelationships. The main codes follow the guidelines of the semi-structured interviews and therefore are based on theoretical considerations. All of the sublevel categories evolve from open coding, using an exploratory research approach to generate findings from the micro-level (Gibbs, 2018). I compared the interviewees' responses using cross tables that split the material along variables used to process background information on the interviewees. Table 3.1 shows the interviewee variables by theme and the number of interviewees per category. This is not intended to quantify the qualitative data or imply that the interviews can be weighed in anyway against one another, but to give a more transparent overview of the material.

Table 3.1: Interviewee variables

Name of thematic set	**Variables**	**Number of interviewees**
Location: city-level	Dallas / San Jose / San Diego / Bridgewater / Chicago / Ottawa	24
	Munich / Stockholm	14
	Undefined	2
Location: regional-level	USA / Canada	26
	Europe	14
Employment status	Current	16
	Former	24
Employment length	<4 Years	16
	4 – 7 Years	15
	>7 Years	9
Former employer	Academia	12
	Competitor	26
	Huawei China	2
Cultural background	Chinese	6
	Non-Chinese	34
Position	R&D	35
	Management	2
	Sales	3
Huawei's R&D internationalization phase during employment (not disjoint)	Early activities (<2009)	15
	Rapid expansion (2009 – 2013)	34
	Take-over (>2013)	22

To preserve confidentiality, I coded the material alone in two iterations at different points in time in order to bolster coding reliability and to ensure analysis quality. I shared my findings with one of the interviewees who I found had provided exceptionally broad insights and used his feedback to critically review the results (Brinkmann & Kvale, 2018). A limitation of the data is that it only shows the parts of Huawei's R&D that resulted in patents and scientific publications. Nevertheless, Huawei is known to encourage patenting and strongly incentivizes employees to do so. This is why the data is a good proxy for the company's R&D activity in Western markets. Another limitation is that the perspective of offshore experts does not reflect the intentions of the company's management. This means that it is difficult to know if management decisions were made deliberately or in response to circumstances. Further, a review of print media on the topics of Huawei appointing foreign retired officials and politicians to local boards and hiring lobbyists shows its efforts to obtain political expertise. I searched Google News under "Huawei" with key words "lobby*", "board", "board member*", "hire/hiring", and "official*". Table 3.2 in the appendix gives an overview of 17 articles appearing between 2010 and 2015 in Australia, the UK and the US.

3.4 Results and Discussion

3.4.1 Huawei's offshore R&D in the global context

The publicly available data on Huawei's offshore R&D is neither detailed nor consistent, therefore I use patent and scientific publication data to track the company's activity. Figure 3.1 provides an overview of activity at Huawei's main offshore locations. Differences in patent regulations between the USPTO and the EPO make it impossible to compare directly the number of patents filed between them, although I am able to illustrate in the figure Huawei's intense R&D output, especially in the US, which is remarkable given that the company has very few sales in that market.

The interviews make clear that Huawei's R&D location choices abroad often followed the location of competitors. The downsizing of a rival could mean an opportunity for Huawei to hire experts without running into non-compete agreement problems. The company targeted Ericsson experts and set up its own facilities in Stockholm and San Diego when the Swedish firm down-

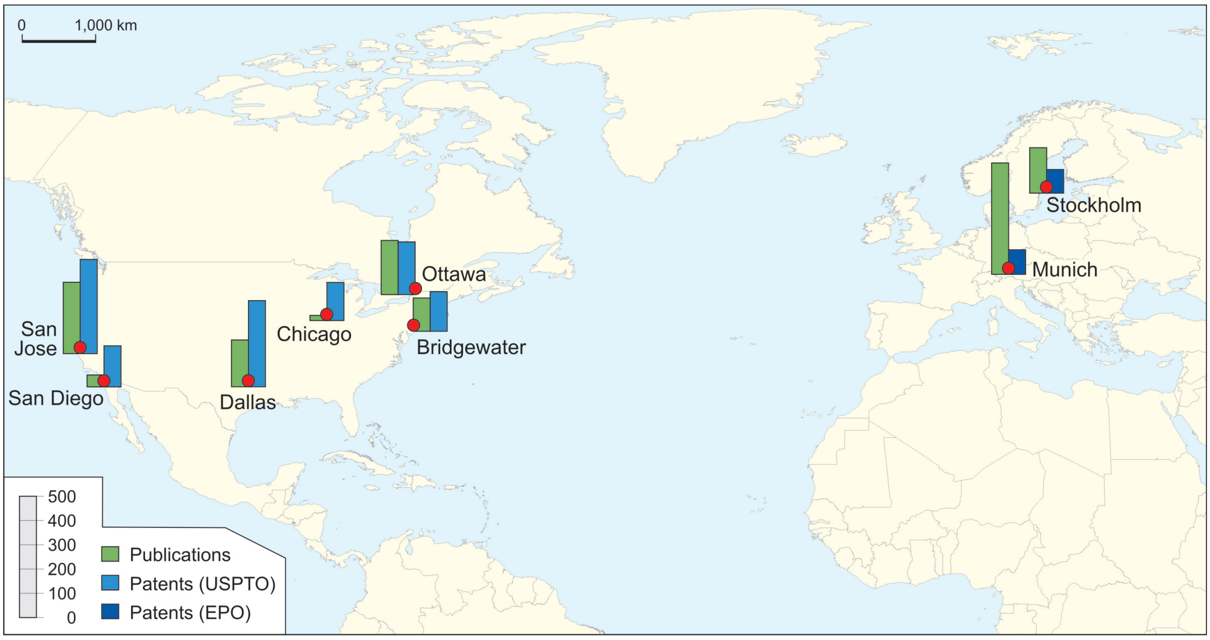

Fig. 3.1: R&D output of Huawei's offshore locations

sized in those cities. Huawei also appears to have been motivated by the bankruptcy of Nortel to open a facility in Ottawa where it was able to hire entire teams that lost their jobs. Moreover, following the location of competitors provides access to established infrastructure for a particular technology at a given location, such as university departments focusing on technology in which Huawei was interested in the case of Ottawa and Munich. In San Diego and Dallas Huawei was able to tap into supplier and customer networks. Hiring from competitors is not uncommon in the industry, but interviewees emphasized the extent to which Huawei used them was unusual. In some cases Huawei located offices only meters from competitors. That was seen by some in the industry as being aggressive, but many employees welcomed the job option at Huawei after losing their previous job. Depending on the shortage of local alternatives, such as in Ottawa compared to the many opportunities in San Jose, many of them did not have to relocate because of the job at Huawei. This is not to say that all experts were "pushed" to work for Huawei. Huawei was offering higher salaries and a range of perks including more professional freedom. Each of Huawei's offshore labs specializes in a different portfolio of technologies. As it follows the competition, those portfolios are driven by the focus of competitors and by extension by the key personnel Huawei might be able to hire. In other words, Huawei's offshore experts influence the company's local specialization. For example, in Dallas the primary focus is on telecommunications, whereas in Silicon Valley it is on internet products. Likewise, in some locations there is more cooperation with universities than in others that tend, for instance, to concentrate on work in standardization. Figure 3.2 distinguishes between three different phases in Huawei offshore R&D output, starting with the first from the Stockholm lab in 2004 followed by smaller labs in Dallas, San Jose and San Diego in 2006. Interviewees from Stockholm explained that Huawei started there under the name Atelier Telecom to avoid attracting attention; it was renamed Huawei in 2004. The oldest locations in the US are Dallas, San Diego and some minor activities in Silicon Valley. Between 2009 and 2013, Huawei started to expand its offshore R&D more rapidly and, early in this phase, major locations in Munich, Chicago, Bridgewater and Ottawa started generating output. In addition, Huawei's labs in Silicon Valley became more active around 2011. After Huawei overtook its competitors in terms of revenue in 2014 (the take-over phase in Figure 3.2), there was another surge in output, but fewer new locations. This coincides with heavy recruiting by Huawei to take advantage of some industry incumbents cutting back as the fourth generation of wireless systems (4G) was at the end of its technological life cycle and the fifth (5G) not yet ready for the market.

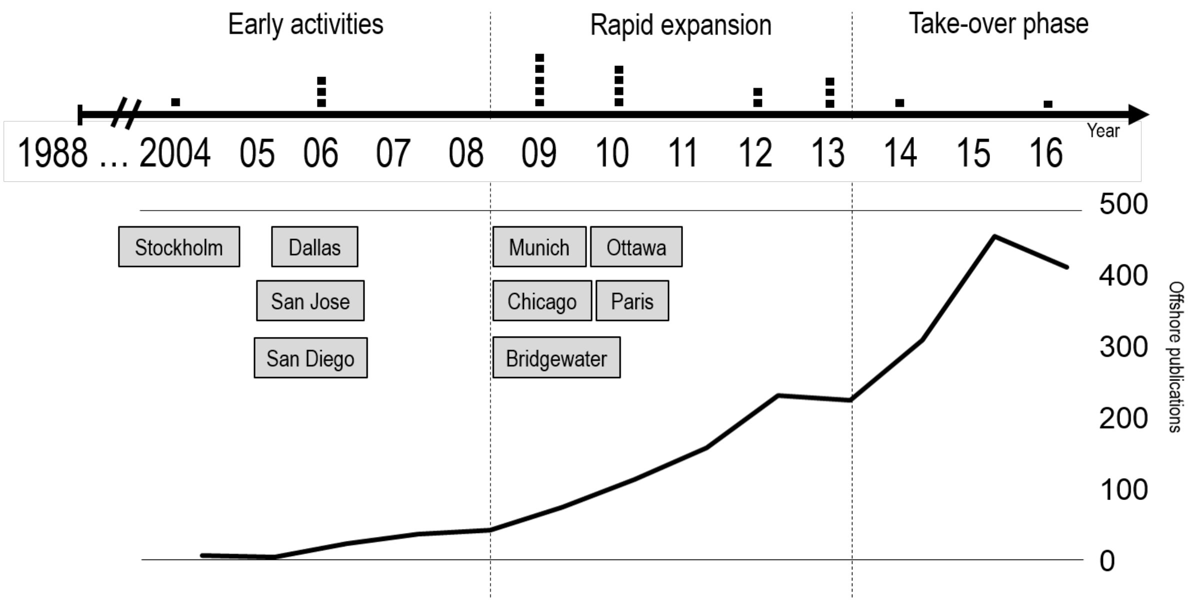

Fig. 3.2: Development of Huawei's offshore R&D

Very early in its R&D internationalization process, Huawei emphasized patenting to increase its portfolio and improve its position in negotiations for license fees. The company filed a tremendous number of them, primarily to signal technological competence. Recently Huawei has changed course, not concentrating on their quantity, but filing patents for high-quality ones.

3.4.2 The role of offshore experts

The role of the offshore experts during Huawei's entrée in the global industry fall into five categories: contacts, perceptions of reliability&reputation, experience, technical knowledge and language. The first two of the five are related to embeddedness while the latter three correspond to skills. Table 3.3 in the appendix provides a detailed overview, while Figure 3.3 gives an overall picture.

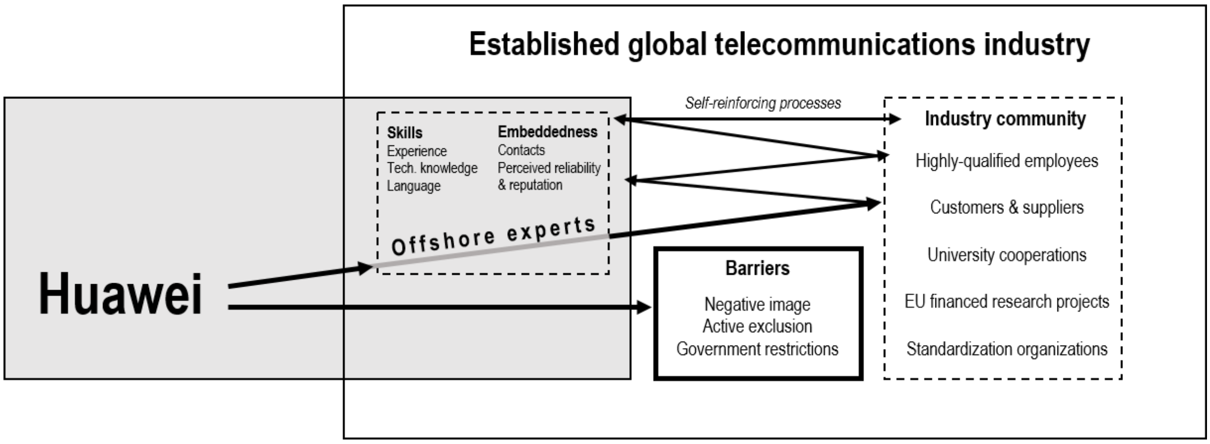

Fig. 3.3: The role of offshore experts in Huawei's catch up

Hiring embedded offshore experts contributed to overcome the vicious circle of barriers, such as lack of skills, reputation and contacts, that blocked it from competing in the industry and contributed to reverse this process. [2] Figure 3.3 shows how hiring those experts started a recurrent process, similar to the upward spiral of the springboard perspective (Luo & Tung, 2018), that gradually helped Huawei to improve its position in the global telecommunications industry. The figure displays the dual embeddedness of the offshore hires by visually embedding them into the context of Huawei at the same time as in the context of the established global telecommunications industry. The two arrows represent Huawei's access to qualified employees, customers, universities, research projects and standardization organizations: One is interrupted by barriers, such as

[2] Hiring technical offshore experts is a powerful means Huawei used to enter the global industry, but not the only one. It also used technical and managerial consultancy, political lobbying, and participation in prestigious R&D cooperation projects.

a negative image, exclusion and government restrictions, symbolizing the difficulties of gaining access; the other arrow shows how offshore experts helped to overcome these barriers with their skills and embeddedness. The dynamic of the model is shown by the arrows that build upon each other and bounce back and forth between Huawei and its offshore experts and the industry, in a recurrent process of greater that facilitates more and more access with every iteration. For example hiring highly skilled employees provides state-of-the-art knowledge used to create new technology, which can be patented and become part of standards, and thus improve Huawei's reputation and attractiveness for potential new highly skilled employees. Therefore, the need to bridge disadvantages through offshore experts decreases over time as the company builds its own network and reputation abroad, catches up on technical skills, and gains more global experience. Overall, Huawei seeks technology as well as legitimacy by hiring skilled and embedded experts abroad. Even if most offshore experts fulfill both roles, it makes sense to distinguish between these two hiring motivations.

3.4.3 The role of skills

Huawei hires senior experts with experience in the industry or with doctoral degrees from foreign universities. The company is unusual in that it does not provide skills development opportunities for experts outside of China, which is unusual, compared to other employers. In contrast, Huawei hires at home mostly young university graduates, who are described as very smart but still inexperienced by some of the interviewees. Offshore experts are implicitly tasked to share their experience with young hires as they work on joint projects, for instance attending together standardization meetings during which those with more experience might tutor those with little on how to negotiate successfully. However, offshore experts, from Canada and the US in particular, emphasized that they are not allowed to share restricted technologies, for instance those with military relevance, with their Chinese colleagues. I list in Table 3.2 print media about foreign retired officials and politicians working for or with Huawei. The company seeks political expertise about host markets, in particular for its market-seeking offshore activities in Australia and the UK, mostly from individuals who have a background in the areas of trade and investment, IT technology, foreign or domestic policy, and defense or cyber-security. They have helped Huawei with strategic issues and with bidding for government contracts. In a similar way, technical offshore experts have used the skills they have honed through longstanding experience in the industry to help Huawei's catch up by facilitating the company's participation in standardization committees and in EU-financed research projects. In short, Huawei has been able to make use of its experts' knowledge about informal industry policies and customers technological requirements. Offshore experts have also helped make up for a lack of English fluency, which is an industry requirement that many Chinese engineers cannot meet in spite of English being the official language of the company. Offshore experts have also brought to bear their technical knowledge, by which I mean the kind of knowledge gained through university education, to generate patents, and state-of-the-art technical solutions for customers, represent the company at conferences, and contribute to industry standard-setting committees. Each of these was important in bridging the knowledge gap between Huawei's domestic R&D and that of global industry competitors. Nonetheless, interviewees report that while that gap is rapidly closing, Huawei remains behind when it comes to innovative skills. Thus, one of the main tasks for offshore employees is to create novel product ideas—ones that can be developed and produced by a larger and less costly workforce in China. Locating the more work-intensive task of development in China not only saves costs but allows for better alignment of development and production. Such division of tasks enables Huawei to make better use of its competitive advantage, but on the negative side, it exposes the company to knowledge spillovers, loss of information in the transfer process, and political risk in host countries. Putting these findings in the context of the literature, the interviews confirm that leveraging the experience and the product knowledge that offshore experts gained while working for top competitors enables Huawei to produce state-of-the-art products without having to first learn how to create them itself. The extant literature holds that while companies can gain output capabilities by acquiring technologies directly related to a specific product, experience and knowledge of the overall technology is needed for innovation capabilities (Awate et al., 2012).Singh & Agrawal (2011) also challenge the idea of learning-by-hiring, as they find that companies use their newly hired employees' knowledge directly instead of integrating it. At the same time, it may be more attractive for firms to invest in output capabilities in the early stages of internationalization because that is likely to provide quicker returns than the longer term process of acquiring innovation capabilities by integrating the knowledge of experts. Huawei relies on the innovative ideas of its foreign experts and uses them to bridge its own lack of innovation capabilities.

Proposition 1: Hiring experienced and knowledgeable offshore experts can be a means of directly accessing the innovative input needed for developing state-of-the-art products—even before the rest of the company has caught up on innovation capability.

3.4.4 The role of embeddedness

Being an industry outsider initially made it difficult for Huawei to hire the best people, but became easier over time as the company became better known and increasingly embedded. One strategy used to overcome the difficulty of hiring key people was to offer them greater professional freedom, including allowing them to build their own teams, which they often did by recruiting former colleagues. In that way Huawei gained accessed to experts and other experts known to them. Huawei offered other strong incentives as well like lucrative bonuses and exceptionally high salaries—in some cases doubling what had been earned before. Interviewees reported that such benefits had to be weighed against long-term job market prospects being harmed by working for Huawei as its reputation in the global industry was one of technological backwardness and lacking reliability. There were also push factors, for instance the earlier mentioned experts who had worked for Nortel in Ottawa or Ericsson in Stockholm had few good alternative employment options if they wanted to stay where they were. Huawei benefited not only from the contacts of former colleagues of their offshore experts, but from their strategic contacts within the industry at large as they served as door openers to customers and to suppliers, such as AT&T and Qualcomm, and to research collaboration with prestigious universities. Some interviewees reported that this was only partially successful as some of their contacts became unusable when they joined Huawei, as former colleagues tended to see the company as unreliable. Huawei tried to improve its image by bringing on board highly-respected figures in the industry in order to signal that the company was technologically competent to customers and in standardization (see Table 3.3). Moreover, the offshore experts' higher cultural proximity in comparison to their Chinese colleagues improved

Huawei's reliability in the eyes of Western business and research partners. Huawei appointed ex-military officers, former heads of industry, and retired UK and Australian government officials to be non-executive directors of the local boards of its foreign subsidiaries (See Appendix Table 3.2). The articles reveal that Huawei wanted the appointees both to advise Huawei's management and to improve the way in which the company was seen. Huawei also hired lobbyists in Washington in an attempt to change the image of the company among US politicians, an effort that appears not to have been successful. The analysis of the interviews uncovers that the offshore experts believe that a main barrier for Huawei is its lack of legitimacy among global industry stakeholders. Prior research has shown that negative impressions can in part be due to cultural and institutional distance such as that between China and the West. In the case of Chinese companies this seems to stem from allegations of excessive government influence on companies (Child & Rodriguez, 2005; He & Lyles, 2008; Si & Liefner, 2014). Western host countries often depend on producing sophisticated technology for the world market and are concerned about losing critical technologies, in some cases even of military relevance, to foreign competitors (Meyer et al., 2014). The Chinese military career of founder Ren Zhengfei compounds the problem as the principal Huawei product is telecommunication infrastructure which is particularly vulnerable to foreign intelligence. For these reasons, Chinese attempts to make investments in the West are often received with skepticism if not with outright hostility (Buckley et al., 2018). The US government has from early on blocked Huawei's acquisition of US companies, claiming national security reasons. In addition to placing former politicians and other nationally-known figures on subsidiary boards, Huawei has tried to overcome liabilities of origin by making greenfield investments rather than acquisitions. [3] Host countries tend to see greenfields as less invasive than acquisitions and more legitimate, and because the investor public profile is also lower they are less likely to attract media attention (Buckley et al., 2018; Meyer et al., 2014). Greenfields not only help Huawei avoid a number of issues, but they even boost its image through the positive reputation and connections of its offshore experts.

Proposition 2: Greenfield R&D investments where offshore experts are given a predominant role

[3] There are particular factors and conditions that made a greenfield approach attractive for Huawei. and this may limit generalizability to other latecomers, the sensitivity of the telecommunications industry, Huawei's access to cheap credit, and an economic downturn to name a few.

can help latecomers in sensitive industries gain legitimacy abroad. Moreover, they can signal technological competence and improve firm reputation.

3.4.5 The scope of offshore experts

Huawei went abroad to gain knowledge of the global telecommunications industry because the most powerful players are currently located in the West. Experts in gateway locations are well embedded in a worldwide industry community by participation in cross-border networking and through international standardization and research projects, but they are not very mobile on a global scale. Huawei is not able to hire them in China so it set up R&D labs abroad to leverage their dual embeddedness that provides access to the local context and the global industry network at the same time. In some cases, Huawei hires key experts with extensive international connections even though they are based in areas remote from its existing offshore R&D labs. Huawei also hires experts recently arrived in locations where it has a lab even though they are originally from far away. Another example for the expert's scope is Huawei's European R&D center in Munich where many employees come from outside Germany and make regular use of their industry contacts back in their home countries. All in all this shows that Huawei hires experts not only for their local connections and reputation as discussed in the literature (Johanson & Vahlne, 2009), but also for their global impact.

Proposition 3: Offshore experts may not be hired solely for their embeddedness in local industry networks, but also for their embeddedness in global industry networks that would otherwise be inaccessible to latecomers.

3.5 Conclusion

Conditions were favorable for entering the global telecommunications industry using a catching-up-by-hiring strategy at the time Huawei was setting up R&D facilities abroad. Lee & Malerba (2017) explain that the catch-up cycles of industries have a repetitive temporal pattern of emerging windows of opportunity that allow latecomers to achieve industry leadership. Huawei benefited from a cooling down phase in the technological life cycle that led to competitors downsizing, hence more industry experts were on the job market. Some of them coming to work for Huawei helped it enter the industry. Rather than attempting to make acquisitions that would provide fast access to markets through existing brands, Huawei used greenfield investments to gain influence with its own brand (Anderson & Sutherland, 2015). Moreover, the company was able to generate dynamic capabilities by combining its already existing advantages of access to cheap capital, low labor costs at home, and a reputation for providing customer-centric service, with newly-acquired technical and innovation capabilities provided by offshore hires. The perspective of the offshore experts provides a more disaggregated picture than found in the many studies that rely mainly on management accounts. Indeed, aggregating the perspectives of experts and locations allows unvarnished insights from behind the curtain of the corporate image, such as that working for Huawei was initially considered harmful for the careers of some experts and caused partial loss of their networks. In addition to showcasing a different perspective, I consider a less-investigated means of internationalizing. Future research should not only look at formal acquisitions when studying catch-up strategies, but look deeper into hiring practices of greenfield investments as this study shows that they are not only undertaken to serve foreign markets. One contribution of this study is that it shows that latecomers in highly globalized industries may also be able to profit from hiring non-locals who are culturally and professionally embedded in the international industry networks, thus providing entry points to latecomer firms seeking to become internationally embedded in an industry. There are some limits to the generalizability of this study as Huawei is a rather special latecomer in terms of the particular timing of its internationalization, its access to cheap domestic capital, its negative image abroad, and the politically sensitive nature of its telecommunication infrastructure business. Nonetheless, this case provides valuable insights into the mechanism of hiring as part of a catch-up process. The management implication is that hiring experts at locations of strategic global importance can be a way to accelerate efforts to catch up with industry leaders under certain circumstances. This approach, in contrast to acquisitions, might help latecomers gain legitimization in host countries. The policy implications of the findings for Western decision makers are that latecomer companies can absorb displaced experts during market downturns, although more research is needed on the sustainability of such jobs. Finally, one long-term implication for Huawei is that it might want to concentrate its most innovative R&D activities in China to reduce political risk and spillovers as well as the information losses inherent in transferring research output over long distances. The current political situation in the US in particular shows how vulnerable Huawei's current approach leaves it. The question remains of whether Huawei will manage to catch up in terms of innovation capability at its main Chinese R&D locations and become independent from its offshore experts' inventive capabilities. In such a scenario, it might then suffice to have just a few overseas locations as listening posts for cooperation and technology monitoring, in particular in host countries where it faces political risk.

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Appendix for Chapter 3

Table 3.2: Print media on Huawei hiring officials abroad

Title	Date of publication	Author	Newspaper / publisher
Former US official joins Huawei consultancy	21.10.2010	Stephanie Kirchgaessner	Financial Times
Huawei names John Brumby, Alexander Downer board members	06.06.2011	Michael Sainsbury	The Australian
Downer joins the board of Chinese telco	06.06.2011	Lucy Battersby	The Sydney Morning Herald
Downer, Brumby join Huawei Australia board	06.06.2011	James Hutchinson	iTnews
Government's former IT boss in MI6 grilling after taking job with Chinese mobile giant	07.08.2011	Abul Taher	Daily Mail
Row over Chinese role for British trade chief three months after £1.2m pay off	13.11.2011	Valerie Elliot	Daily Mail
Huawei's Downer warns on Chinese paranoia	18.04.2012	James Hutchinson	CRN
Huawei hires former U.S. defense contractor official	10.07.2012	Ellen Nakashima	The Washington Post
Huawei expands lobbying amid national security probe by Congress	26.08.2012	Eric Engleman / Jonathan D. Salant	The Washington Post
Huawei's Australian directors get two more years in job	24.08.2013	Peter Cai	The Sydney Morning Herald
Admiral goes in to bat for Huawei	27.10.2012	Peter Cai / Lucy Battersby	The Sydney Morning Herald
Conservatives and Lib Dems take donations from Chinese company accused of US security threat	20.11.2012	Rowena Mason	The Telegraph
Chinese firm Huawei spends tens of thousands lobbying British politicians	30.11.2012	Christopher Hope	The Telegraph
Questions grow on U.S. lobbyists with strong ties to Chinese firm linked to espionage worries	26.04.2013	Richard Pollock	The Washington Examiner
It's the biggest company that no one has heard of	27.04.2013	Adele Ferguson / Peter Cai	The Sydney Morning Herald
Lord Browne to head Huawei's UK board	16.02.2015	Daniel Thomas	Financial Times
Huawei appoints three non-executive directors to UK board	16.02.2015	Paul Withers	Mobile News

Table 3.3: Cross table on relationship between skills and experience

	Industry standards Particularly important in telecommunications, high license fees are demanded to use standards, increases influence and signals technological competence	**EU-financed projects** Helps to capture technology, boosts reputation, provides contacts in the industry, early attempts to participate fail for lack of embeddedness	**University cooperation** Cooperating with prestigious ones signals competence and improves global image, technology transfer is not necessarily the main goal	**Customers & suppliers** Needed to operate in the global industry, improving perceptions of reliability is easier through existing contacts	**Qualified employees** Initially difficult to hire because Huawei is unknown / has a negative reputation in the industry
Contacts	Important for negotiations and keeping up-to-date on industry politics	Contacts in the projects help getting accepted	Contacts from academia used to set up cooperations	Contacts to customers of former employer	Recruiting former colleagues to work in the team
Perceptions of reliability & reputation	Helps in negotiations and for getting influential positions in standards	Hiring European engineers and cooperating with European universities generates perceived reliability	Hiring experts from academia improves perceptions of reliability	Western experts are sent to client meetings to signal technological competence	
Experience	Helps to negotiate and interpret politics between stakeholders	Project experience helps to apply for and succeed in projects	Knowledge of the field helps to choose the right cooperation partners	Understanding of western customer's wishes	
Technological knowledge	Understanding of state-of-the-art technology enables contribution			How to make the products fit the customers' needs and how to create state-of-the-art solutions	
Language	Bridging English language barrier for Chinese engineers to facilitate active participation		Local R&D takes over projects from headquarters to bridge language barriers		

Chapter 4

Give us ideas! - Splitting research and development to bridge lack of innovativeness

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Abstract

Recently, established centers of state-of-the-art technology notably experience increasing knowledge-intensive activities by Emerging-market multinational enterprises (EMNEs). This reflects EMNEs' quest to upgrade technological capability in order to compete with global players. We study those upgrading mechanisms employing a mixed methods design that combines qualitative interviews and quantitative patent data based on a case study of Huawei Technologies. The results show that the company divides research and development between established Western and domestic Chinese locations, transferring offshore employees' innovative ideas to develop them into products in China. We find that this bridges Huawei's current lack of domestic innovation capability.

4.1 Introduction

Emerging-market multinational enterprises (EMNEs) in particular from Asia have gained market shares by absorbing leading technologies in centers of state-of-the-art technology, often located in established Western countries, and profiting from low labor costs at home (Luo & Tung, 2007; Mathews, 2002, 2006; Poon et al., 2006). However, this is not a favorable position for them or their home-countries in the long run, because it creates dependency on technology absorption. Moreover, the companies' competitive advantage mainly depends on lower wages and production costs (Hansen et al., 2016), which is not a sustainable situation for them (Gereffi & Lee, 2012; Mudambi, 2008). In order to improve their position, EMNEs need to increase their share of higher value added activities and produce globally competitive technology. This requires EMNEs' R&D activities to change from adapting to innovating, which is a difficult step because innovative activities require a very different set of skills and capabilities. The question remains how EMNEs are able to master this leap from a technology follower to a technology leader.

In order to shed light onto this question we analyze the technological coming-of-age of a company that just recently became a leader in its industry: Huawei Technologies. Despite the most recent struggles with the US government, the Chinese company underwent an extremely rapid development between its first larger international R&D activities in Sweden around 2004 and overtaking Ericsson in annual sales in 2012. The case of Huawei is remarkable because it is among the few Chinese companies that have managed to become a world leader in the telecommunications industry in a very short time, despite very high liabilities of origin (Fiaschi et al., 2017).

Now that Huawei is no longer a follower, it cannot rely on adopting technology from industry leaders anymore but needs to create innovative products itself. An important distinction we make here based on Awate et al. (2012) is between innovation capability – the ability to create innovative technology in-house – and output capabilities – the ability to produce innovative products without necessarily being able to create the underlying technology. We know from previous studies on Huawei's offshore R&D that the company conducts its most impactful R&D, as measurable by patent data, at its offshore locations in the US, Canada and Europe instead of its domestic locations in China (Schaefer & Liefner, 2017). As we generally observe an increasingly global split

of tasks by MNEs following the value chain stage of their activities (Crescenzi et al., 2014, 2016), the question remains if Huawei achieves innovation capability at its domestic locations or if it relies on innovative input from abroad. Moreover, we are asking how the company integrates offshore and domestic R&D and how the company is compensated for the higher risks of managing transnational R&D projects, including knowledge spillovers, loss of information in the transfer process and political risks in the host countries (von Zedtwitz & Gassmann, 2002). Answering these questions contributes to our knowledge about the changes in the geography of international R&D fragmentation, which is one of the key areas for current research on R&D internationalization and innovation identified by Papanastassiou et al. (2019). Pointing towards the importance of these issues, Bathelt et al. (2018) note that the fields of Economic Geography and International Business are increasingly paying attention to the global dispersion of value creation. They state that combining perspectives from both disciplines might help to explain the rationales behind MNEs' behaviors, which shape the global landscape of innovative activity. This study aims to contribute to our understanding of the spatial arrangement of value creation and the resulting dependencies between locations by analyzing the micro-level processes of innovation and knowledge creation such as firms, teams or individuals. Thus we contribute to a literature that has so far mostly focused on the macro-level analysis of countries and industries (Andersson et al., 2002).
In order to explore how Huawei creates innovative technology, the study combines interview and patent data to illuminate the mechanisms of upgrading and to understand the spatial pattern of Huawei's innovative activities. Following this mixed-methods approach, we start with the qualitative part that inductively generates findings from the interviews, which are then discussed in the light of the existing literature. From this discussion, we deduce hypotheses that are tested in the following quantitative part. We then integrate the findings from both parts to draw broader conclusions. The study contributes to the literature by showing how splitting R&D helps Huawei produce state-of-the-art products and become a technological leader. The results show that the company's domestic activities have not yet caught up on innovation capability, creating a dependency on the inflow of innovative ideas from abroad.

4.2 Case context: Huawei's global ascent

Because of its political brisance today, few recent high quality studies on Huawei neither condemn nor hype the company. While only a few researchers have had systematic insights into the micro level of Huawei's activities, as the company is known to be reluctant to open up to independent journalists and researchers, most studies have been conducted based on secondary evidence such as public company reports and patent data. In the literature Huawei has been used as an outstandingly successful case of a Chinese company that performed upgrading through an R&D intensive strategy (Boutellier et al., 2008). The company was founded in the late 1980s in Shenzhen in southeast China and after becoming successful on the Chinese market by focusing on low-cost technology for rural areas, employed a similar growth strategy to emerging markets such as India, South Africa or Latin America (Lee et al., 2016; Micheli & Carrillo, 2016). In the early 2000s, the company started focusing more on state-of-the-art technology in order to expand its sales to more established markets. In order to absorb knowledge and signal competence, Huawei started to use technological consulting, set up R&D alliances with companies such as Texas Instruments or Intel and started collaborating with established universities (Chang et al., 2017; Fan, 2011; Lee et al., 2016; Liefner et al., 2019). The company also expanded its own R&D to global innovation centers such as Silicon Valley and Silicon Prairie (Fan, 2011). For its offshore R&D activities, Huawei focused on hiring technological experts rather than using acquisitions (Chang et al., 2017) because for example in the US several attempts to acquire smaller technologically leading firms were blocked by the US government for alleged security concerns (Chung & Mascitelli, 2015; Nolan, 2014). This catching-up by hiring enabled Huawei to keep a low profile and navigate liabilities of origin. In terms of technology, Huawei was able to sell its products below competitors' prices by profiting from its follower position and exploiting the cheaper labor costs at its domestic location. However, in order to be competitive on a global scale, Huawei had to improve its technological capabilities considerably (Chang et al., 2017). In 2012, Huawei surpassed former market leader Ericsson for the first time in annual revenue (Lee et al., 2016). Nevertheless, Schaefer & Liefner (2017) find that Huawei does its highest impact R&D abroad instead of at its headquarters. Therefore, the question remains as to how much of its core innovative activities are based in Huawei's home market.

4.3 Mixed-Methods case study design

We chose Huawei as a case because it represents a very current example of an EMNE reaching global player status, which enables us to study its recent upgrading process (Hernandez & Guillén, 2018). Moreover, Huawei is a special case as the company does not mainly rely on acquiring technologically advanced companies but directly hires the technological experts it needs to gain specific expertise. We mix sources from in- and outside the firm in order to avoid what Tokatli (2015) calls the 'dark side' of firm-centric case studies: falling for the corporate narrative. Huawei's narrative is that the company reached its global status because of the dedication and hardships endured by the Chinese R&D employees in order to create high-tech products, often attested for by the story of new employees receiving a mattress for sleeping in the office. Moreover, many sources describe how the devotion and self-sacrifice of founder Ren Zhengfei motivated employees to surpass expectations. These narratives repeatedly come up in press articles as well as interview-based research on the company (de Cremer & Tao, 2015; Luo et al., 2011).

The case study follows a sequential embedded mixed-methods design in order to study the mechanisms and the role of different locations in Huawei's upgrading-process. The interviewees for the qualitative analysis represent a subgroup of the inventors on the patents used for the quantitative analysis. They were selected to represent the different offshore locations and the diverse professional and cultural backgrounds of the interviewees, thus providing multiple perspectives on the companies' offshore R&D activities (Yin, 2014). The data types are considered equal and the sequential nature of the chosen exploratory approach is maximizing the insights of the research topic (Creswell & Plano Clark, 2011; Hurmerinta-Peltomäki & Nummela, 2006; Kuckartz, 2014). We first collect patent data to identify locations and potential interviewees. We then conduct the interviews and analyze them. From the interview results, we develop hypotheses that we test by using the patent data. Finally, we integrate the findings from both analyses in order to draw our conclusions (see Figure 4.1). The qualitative part enables us to understand the mechanisms of how innovations are created and distributed within the company. The quantitative part is more suited to observe changes over time and analyze the broader patterns across locations. By unveiling the underlying mechanisms of transnational innovation through qualitative analysis, we bridge a blind spot that patent data based research typically has.

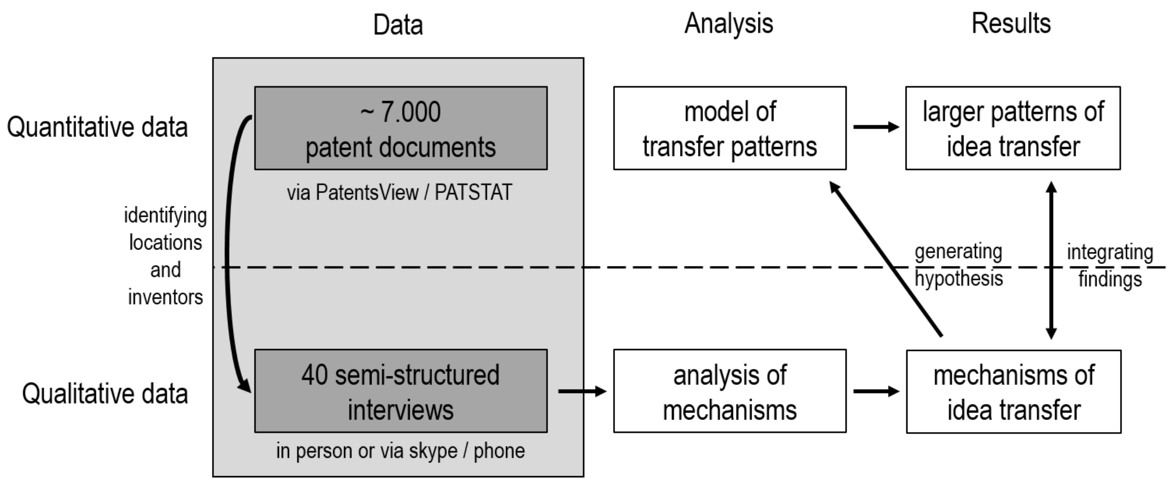

Fig. 4.1: Mixed-Methods Design

4.4 Qualitative Analysis

4.4.1 Interviews

The interviews were conducted between February and October of 2017 with former and current employees at Huawei's offshore R&D centers. In order to gain a more nuanced understanding of the internal mechanisms, we interviewed 40 experts from eight different offshore locations of the company, representing the biggest and most active ones in patent application: San Jose, Dallas, San Diego, Chicago, Bridgewater, Ottawa, Stockholm and Munich. Some experts were not assigned to a specific location. The experts were selected via their patenting activity for Huawei. The sample contains mostly industry experts with work experience from established competitors and academia but also from Huawei China. Including the perspective of inventors who have a cultural insider perspective on China or on Huawei in China is a very valuable addition to the sample. The main questions for the semi-structured interviews address the tasks of the offshore experts

and the offshore locations, as well as the communication within the company. An overview of typical questions for the interviews is provided in the appendix. Nevertheless, the questions changed throughout the interview period according to new insights from the interviews. For example, in order to learn about Huawei's upgrading process we initially started out asking about how the interviewees provide access to the local knowledge base and how that knowledge is then transferred. We found out early that the interviewees have only little professional exchange outside of the company once they work for Huawei. Therefore, the offshore experts are not so much connectors to knowledge from outside but the main source of knowledge themselves. Following this finding, we shifted our focus away from their outside connections towards the interviewees themselves.
The interviews were analyzed by using the qualitative analysis software MaxQDA. The coding process took place in three steps. First, the material was sorted into broader partly overlapping fields of interest to make it more accessible, such as personal education and career background, tasks at Huawei as well as external and internal connections. Through the knowledge obtained from the interviews and the first round of thematic coding, sub questions to the broader research question about the role of Huawei's offshore R&D in upgrading the company's technology were derived:

- How does the skill set of the offshore and the domestic employees differ? Why? Does it change over time?
- How is internal cooperation between the locations organized? Which aims are the locations pursuing?
- What are the channels for idea transfer? How successful are they? How do the channels change over time?

These questions were used for the second round of coding, this time using an inductive coding procedure in order to keep an open mind towards the perspectives of the interviewees. The third step was the consolidation of the inductive codes to see which statements refer to the same phenomenon. The text passages in the consolidated codes were then split along the interviewee variables shown in Figure 4.2, using the segment matrix of the program. This enabled us to see the different perspectives the interviewees have while analyzing the text according to our sub questions. We then used the tables and coding-memos to summarize our findings and answer the sub questions.

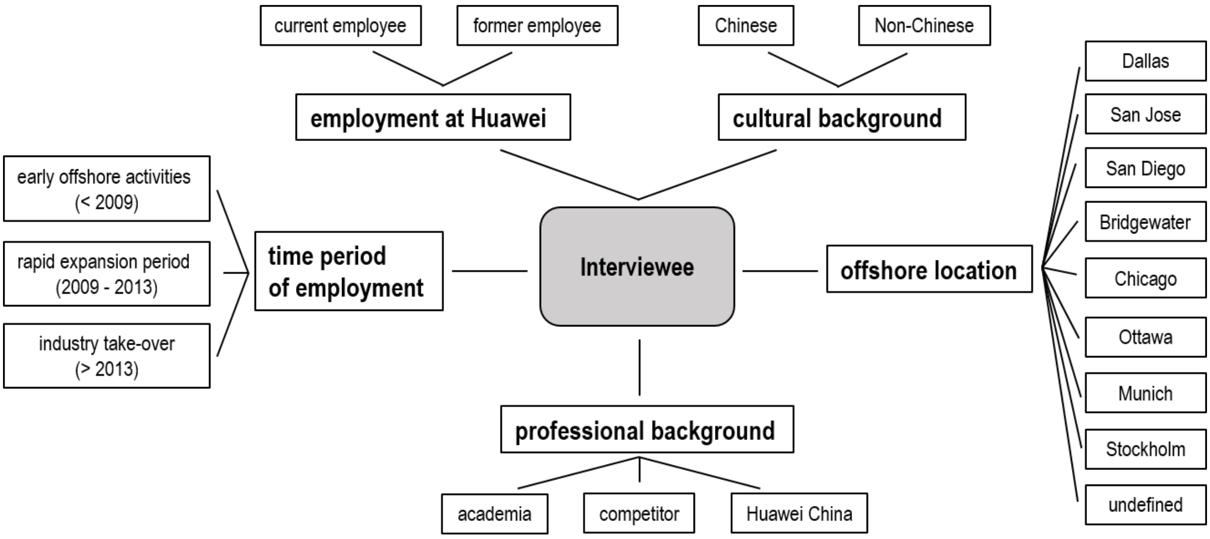

Fig. 4.2: Interviewee variables

4.4.2 Qualitative Findings

From the interviews, we learned that the experts see a gap between Huawei's offshore and domestic R&D capability, claiming that employees in China have caught up on technological and organizational knowledge while they are still struggling to create new "ideas". In the terms of the interviewees, knowledge refers to technological knowledge often obtained from university that is needed to understand state-of-the-art technology and develop such products. In contrast, ideas are outlines for new technologies or parts thereof beyond the state-of-the-art that require profound knowledge and understanding of the technology but also creativity and industry experience. We also distinguish a third category, which is organizational knowledge, to which the interviewees refer mostly indirectly, which describes for instance the ability to put together and manage innovative teams. The interviewees claim that the Chinese engineers know how to do things but they do not know what to do, a question often left to the offshore experts who state that their colleagues in China need to improve "how to be innovative" and "think outside the box". The R&D done in China mostly aims for more incremental improvements while research abroad creates more breakthrough novelties.

It becomes apparent from the interviews that the main reason for this capability gap is the pool of mainly young graduates from university, often the best of their cohorts, with only little work experience or exposure to the global industry, which Huawei is able to hire from in China. In contrast, Huawei's offshore employees are mostly experienced senior engineers that have been working for one of Huawei's big competitors or in academia for a minimum of five years. Another factor influencing the work done abroad and at home comes from different ways of approaching tasks. The engineers in China often employ a trial and error approach from which they learn. This is feasible because they are more numerous and their labor less costly for Huawei.

The interview material indicates the awareness for the need of high quality R&D developed in the later phase of Huawei's internationalization. Some offshore experts report that in the early days of internationalization, the engineers in China were even resistant towards new technical approaches and ideas at first. The first step was to catch-up on state-of-the-art knowledge, which was done in the earlier phase of internationalization through the transfer of technological as well as organizational knowledge. Interviewees with a long employment history at Huawei emphasize how fast their colleagues in China caught up on state-of-the-art technology. Nevertheless, the interviewees point out that the capability of the Chinese R&D varies between different fields as Huawei works on a very broad range of technologies from analogous to digital in-house.

In the early stages of Huawei's upgrading, the company used offshore experts to bridge the knowledge gap between them and the global industry. The offshore experts were sent to represent Huawei in standardization and EU financed research projects or talk to customers. Their role changed when Huawei caught up on state-of-the-art knowledge and aspired to become an industry leader. Now they provide the company with innovative ideas, for which they draw from their long-term experience. Therefore, the main ideas for innovative products come from abroad while the engineers in China do the fine-tuning. Transferring their ideas to China causes discontent for some offshore engineers, because they are not involved in bringing their own idea to the market, which many of them are used to from working for established competitors.

Following the endowment with capabilities discussed above, we find that the offshore and domestic R&D locations fulfill different tasks in Huawei's innovation process. Ideas from abroad have

to be taken to China where the larger and less costly workforce takes over the more work intensive tasks, aligning development with production. While the offshore locations are mostly doing research, the domestic locations are focusing on the development. The interviewees claim that today, the gap in experience between offshore and domestic engineers might be slowly closing.
Huawei's headquarters hierarchically control the flow of information, directing all communication between offshore R&D locations through China. All offshore locations work closely with Huawei's respective technology hubs in China, where Shenzhen, for example, would be more oriented towards telecom and Beijing more towards internet. The interviewees state that working with the respective locations in China is highly encouraged by Huawei, while competition within the company hinders the exchange of ideas between offshore locations. In a few cases, engineers from different offshore locations worked together, but the interviewees claim that this kind of exchange was not encouraged by the headquarters. The direction of exchange is very clear. The interviewees claim that the offshore side is expected to meticulously report their work to China while the domestic side remains silent. Some interviewees even used the term "teaching" for their interaction with the Chinese engineers.
Huawei uses various channels for the transnational transfer of knowledge and ideas. Many projects teams consist of offshore and domestic engineers to ensure that results are directly transferred to China. The interviewees state that the particular transfer channel depends on how complex the technology is. A lot of knowledge exchange happens via personal contact. Many of the interviewees travel regularly to the respective technology hub in China, which in some cases helped to establish personal relationships to Chinese co-workers and improve communication between domestic and offshore locations. Visitors usually give presentations, explain the newest technology in detail to their coworkers in China and distribute the slides containing the technical details. The exchange via documents and slides is feasible over distance and helps to overcome language barriers by using universally understood mathematical formulas and technical drawings. Other forms of communication over distance are video conferences, desktop sharing and electronic messaging. Another mechanism is engineer expatriates from China working for one to three years at the offshore location. Their task is to help with the communication with China by translating and to transfer the knowledge they acquire abroad back to China. However, this practice is used less

frequently now.

Some experts say that it was sometimes difficult to work with co-workers in China, because of the cultural and language barriers as well as spatial distance and the time difference that requires nightly phone conferences. Moreover, there are certain technologies, in particular those of military relevance, that fall under export control rules, which means those technologies cannot be transferred to China. In summary, the company's R&D in China has caught up on technological and organizational knowledge, but not on how to create innovative ideas because of lack of experience of the young Chinese employees. Therefore, the company transfers ideas from abroad via various channels to its domestic R&D where the development takes place.

4.4.3 Theoretical discussion

In the following, we connect our findings with the literature to look deeper into the characteristics of the idea transfer and prepare the hypotheses for the quantitative analysis. In the theoretical discussion we follow the definitions of Andersson et al. (2016) where technology refers to a machine or tool, innovation to the creation of new ideas for those technologies or the production thereof and knowledge is the underlying understanding of the above. Adding to this definition, experience is the result of accumulating knowledge. The lack of experience at Huawei's domestic locations is one of the reason for the innovation capability gap we observe in our case study. Experience is determined by the time and intensity spend on knowledge accumulation. Broader experience reinforces creativity because more previously unconnected knowledge can be connected to create ideas (Argote & Miron-Spektor, 2011; Nijstad et al., 2010). Zooming out, experience can also be seen as the cumulative accomplishment of a task, which can be spatially concentrated in locations with a long history of performing the task, making experience context specific and influenced by geography, time and organization (Argote & Miron-Spektor, 2011). Thus, we find that not only experience in general is required to create innovative ideas for the global telecommunications industry, but a specific kind obtained from operating in this global industry environment, which Huawei's domestic engineers have not been exposed to sufficiently in the past.

Moreover, what is needed for creating products that nobody has thought of before is the capability to combine previously unconnected parts of knowledge (Bharadwaj & Menon, 2000; MacLean et al., 2015; Mascitelli, 2000). One of the reasons why employees trained in culturally Western education systems have advantages for detecting novel directions for technology development is that the education is at least partly built on the concept of Socratic dialectics. It emphasizes questioning the status-quo much more than the Confucian education model found in China and other East Asian economies (Marginson, 2011, 2018; Tweed & Lehman, 2002), which focuses on repetitive and teacher-centered learning. This educates people to be very good at following predetermined ways laid out by others, but not to be creative in the sense of leaving these paths and exploring unknown territory (Abrami et al., 2014; Cao et al., 2009; Woronov, 2008). The result is that many Chinese engineers are not trained to break with the status-quo.

Rietzschel et al. (2007) argue that experience and the ability to make use of the individual pool of knowledge are crucial for developing new ideas. We find that the offshore expert's seniority and education is offering a greater pool of industry specific experience and a better training to search for new ideas compared to the domestic engineers. This is in line with our finding that the offshore locations are the primary locus of original idea generation at Huawei. Therefore, the company has to deal with the issue of transferring ideas caused by the immobility of the innovation capability needed to create ideas. First, it is commonplace that highly qualified people found in centers of state-of-the-art knowledge prefer not to move, so their knowledge appears to be sticky (Hippel, 1994) and attached to these places. Second, because tacit components make up a large portion of the capability of creating new products, the transfer of those capabilities is extremely complicated. Transferring all capabilities necessary for the creative process itself is a lot more difficult than transferring the results of it. This motivates Huawei to set up subsidiaries abroad and transfer ideas created there for immediate access to innovation capabilities. This bridging of lack of innovation capabilities is in line with Luo & Tung (2018), who propose that springboard MNEs might use knowledge resources abroad directly to compensate for what they are not good at. The ability to properly orchestrate the idea creation and transfer in such a transnational setting is an intangible asset for firms and an important part of value creation (Andersson et al., 2016). In order to look deeper into the orchestration of Huawei's global R&D, we are building upon these insights and derive our hypotheses for the quantitative analyses. The first hypothesis is concerned with the direction of idea transfer.

Hypothesis 1: Because of a better endowment with innovation capability, Huawei strategically aims at transferring ideas from offshore to domestic locations. Therefore, ideas from abroad are more likely to be transferred to domestic locations than vice versa and take shorter time to be transferred.

In the literature, the role of a firm's knowledge is conceptualized as a key resource in the resource based view of the firm (Wernerfelt, 1984) and as playing a central role in creating combinative and dynamic capabilities (Kogut & Zander, 1992; Teece et al., 1997; Zahra & George, 2002). These competences can be further developed through cycles of knowledge absorption and learning (Nonaka, 1991). Luo & Tung (2018) explain that springboard MNEs use an upward spiral of self-improvement, where companies first need to build a knowledge base before tapping into critical technologies and talents. We learn from the interviews that Huawei had to acquire technological and organizational knowledge over time, which forms the base of transferring ideas today. To learn more about the effect of experience on idea transfer, we are testing the following hypothesis:

Hypothesis 2a: Over time, Huawei becomes increasingly capable of smoothly transferring ideas through building technological and organization knowledge. Thus, the time it takes to transfer ideas within the company is expected to decrease with increasing company experience.

We learn from the interviews that the Chinese employees seem to be catching-up on experience and innovation capability. We therefore ask if the transfer of ideas from the domestic to the offshore locations becomes more systematic and therefore faster over time.

Hypothesis 2b: Over time, Huawei's locations in China start to gain experience and build innovation capability, so that offshore locations increasingly pick up ideas from domestic locations to build upon. Therefore, the time to transfer ideas from domestic to offshore locations decreases with increasing company experience.

Further, we are looking deeper into the preconditions for a successful transfer of ideas. The literature describes that a successful transfer depends heavily on the absorptive capacity of the receiving unit in the form of familiarity with the technological background of the idea (Cohen & Levinthal, 1990). In Huawei's case, the impact of absorptive capacity on transfer is supposed to be higher for the transfer of ideas from offshore to domestic locations as there is generally less experience at domestic locations. We also argue that more intense experience with the idea at the sending location makes the transfer easier. Therefore, we arrive at the following hypothesis:

Hypothesis 3a: Huawei uses its internationalization effort systematically to organize transfer of ideas by developing sending capacity in offshore locations as well as receiving capacity in China. Thus, high sending capacity and high receiving capacity are significant positive drivers of idea transfer process, in particular from offshore to domestic locations.
Moreover, ideas based on more intricate and complicated knowledge are more difficult to transfer between locations. The transfer of those ideas needs more intense exchange between people such as face-to-face contact instead of electronic exchange channels, which prolongs the transfer.

Hypothesis 3b: The successful transfer of ideas also depends on the intricacy of the underlying knowledge. Therefore, the knowledge intricacy of ideas is significantly hindering and slowing down the transfer process.

From a strategic perspective, the global novelty of the idea is also an important factor for its transfer. Ideas that are close to or even pushing the global state-of-the-art need to be distributed fast within the company in order to reap the benefits of novelty. This is particularly important in the direction of product development so the idea can be translated into a product quickly.

Hypothesis 3c: The transfer of ideas also depends on the global novelty of it. Thus, the closer the idea is to the global frontier, the faster it will be transferred. This effect is stronger for global novelties that are created at offshore locations.

4.5 Quantitative Analysis

4.5.1 Data

For the quantitative analysis, we use patent data from the United States Patent and Trademark Office (USPTO) retrieved in March 2019 by using the PatentsView application-programming interface [1]. Using patents from USPTO provides only new-to-the-world patents and patents that fulfill international quality standards. Because patent applications are often submitted to multiple patent offices, the USPTO data set covers not only patents created in the US but from all over the world giving insights into ideas originating from China and Europe. The USPTO coverage of R&D activities in Europe is higher or very similar compared to the European Patent Office (EPO), also for most European countries (Table 4.1).

Table 4.1: Data coverage USPTO and EPO for applications until 2014

Inventor Location	USPTO	EPO
Canada	330	136
Germany	133	142
Sweden	204	129
US	1623	557
China	7098	9018
Rest EU	151	49
Asia	65	34
Rest of World	63	27

In order to operationalize new ideas, we are using the first-time combination of technological components as a proxy for new-to-the-firm ideas. Every pair of components appearing on the same patent is counted as a combination. This approach has been used in the literature before, where the novelty of ideas is measured as unusual or new combinations of technology (sub)classes on patents (Fleming, 2001; Kim et al., 2016). Even if not every single new combination necessarily represents a break-through innovation, this approach enables us to look at the bigger picture of the distribution of new ideas within the company.

The classification we use is the Cooperative Patent Classification (CPC)[2] developed by the EPO and USPTO in order to harmonize patent classifications. The components are the technology groups on the patents. Groups are more fine-grained than Subclasses but still represent technological components, compared to the even more detailed Subgroups, which also include application mechanisms of components. Table 4.2 gives an example of a typical technology on which Huawei's inventors work. The Subclass classification "Telephone Communication" is still relatively broad, whereas the group "Substation equipment" describes a more specific technological component.

[1] patentsview.org/api

[2] cooperativepatentclassification.org/cpcSchemeAndDefinitions.html

The Subgroup describes a mechanism for the component.

Table 4.2: CPC classification hierarchy with example

H	Section	Electricity
H04	Class	Electric communication technique
H04M	Subclass	Telephone Communication
H04M 1/00	Group	Substation equipment, e.g. for use by subscribers; Analogous equipment at exchanges
H04M 1/73	Subgroup	Battery saving arrangements by switching on/off the receiving circuit [...]

We use the inventor addresses to determine whether the idea was created in China or at one of Huawei's offshore locations. Following our research design, we are only distinguishing between the categories domestic or offshore location. Using the priority date of the patent, we then calculate how long it takes until the idea is transferred across location categories. The priority date is the first time a patent is submitted to a patent office worldwide, which means even if we find the patent via the USPTO, we use the date of its first application in China or Europe to trace its origin. We consider an idea as transferred once an inventor team at the opposite location is able to apply the idea without help from inventors working at the original location. Therefore, we exclude patents with mixed offshore and domestic inventor teams, as they do not provide further insights regarding our question. We also exclude the two most recent years 2017 and 2018 because of a possible time lag in patent applications with Chinese inventor teams filed first at the China National Intellectual Property Administration (CNIPA). These could bias our data in favor of patents originating from US teams, which would appear in the data set earlier. We also filter "born-global" ideas that appear for the first time simultaneously at a domestic and offshore location, because they do not represent a transfer. We categorize patents created in Hong Kong as domestic only because of its extreme spatial proximity to Huawei's headquarters in Shenzhen.

4.5.2 Time-to-event analysis

We are using a survival or time-to-event analysis to analyze the time new ideas take to be transferred within the company. This method is commonly used in medical studies to model the influence of covariates on patient survival time as the dependent variable. This type of analysis has been applied in Economic Geography before, for example when studying firm or project survival (Cole et al., 2019; Falck et al., 2013; Neffke et al., 2012). The advantage of using time-to-event analysis over an ordinary least square (OLS) approach is that the Cox or Weibull distributions are a better fit to model time as a dependent variable, as time is non-negative and residuals are usually not normally distributed. Moreover, it enables us to take into account observations that did not experience the event, in our case the ideas that do not get transferred, to correctly estimate the time to event. The event in our model is the first time an idea appears at a location category opposite to the one from which it originates. The observation period starts when the idea appears for the first time and ends at the transfer or the last time it appears in the data, which is called "right-censoring". Figure 4.3 gives an overview of the trajectories of ideas and how we measure our dependent variable, the time until transfer.

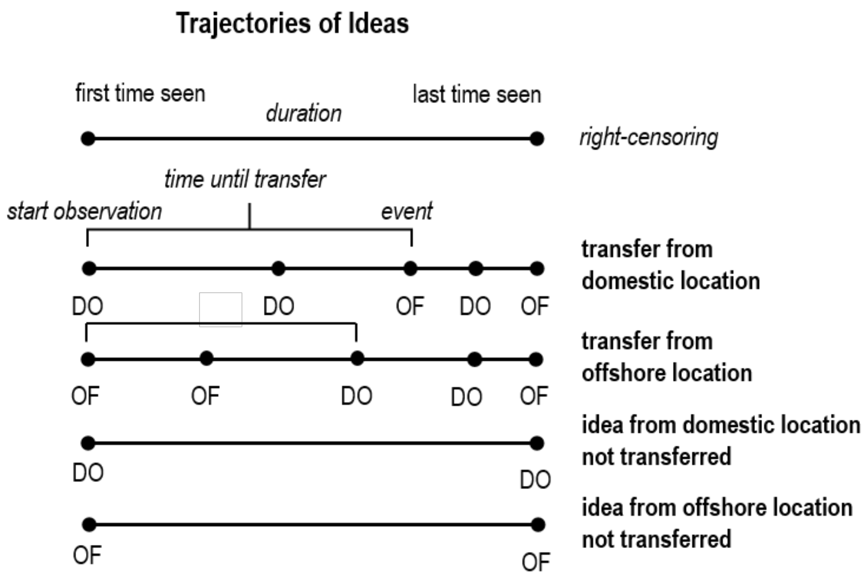

Fig. 4.3: Categories for measuring transfer of ideas in the time-to-event analysis

The baseline hazard function for the Weibull model, which is the instantaneous failure rate with all covariates being zero, if the observation has not yet experience the event (Moore, 2016), is given by

$$h_0(t) = \lambda \gamma t^{\gamma-1}$$

with the scale and shape parameters $\lambda > 0$ and $\gamma > 0$ as well as $0 \geq t > \infty$. The proportional hazards model, which in our case describes the hazard of transfer at time t for the ith idea, is

$$h_i(t) = \exp(\beta_1 x_{1i} + \beta_2 x_{2i} + ... + \beta_p x_{pi}) h_0(t)$$

with i = 1, 2, ..., n. The unit of observation in our model are ideas, measured as combinations of technology groups.

The dependent variable for the model is the time until transfer of the idea, as described above. In order to test the hypotheses, we define a set of independent variables. The detailed description of the metric variables is attached in Table 4.6 and Figure 4.5 in the appendix. The variables origin of the idea, is dichotomous, taking a value of 1 for offshore locations and 0 for domestic locations in China. The variable labeled experience of the company measures the company's age in years at the creation of the idea. The sending capacity of the idea is the intensity of application at the sending location, measured as the number of occurrences normalized by the time between the first occurrence and the transfer. For the receiving location, we include the absorptive capacity, which is the familiarity with each component of the idea, before the idea is transferred. This is calculated analogues to the sending capacity taking the mean number and mean presence of both components of the idea. Further, we include the knowledge intricacy of the idea as the average number of technological components on the patents associated with the idea. This gives us a proxy of the intricacy of the knowledge underlying the technologies that include the idea. In addition, we include the global novelty of the idea measured as the time between the first appearance of the idea among all USPTO patents and the first appearance in the Huawei data set. This gives an indication of how new the idea is overall. Finally, we include a dummy for the international expansion of Huawei's R&D activities, which took off after 2006, to control for the lower number of offshore activity before.

Table 4.7 and 4.8 in the appendix give an overview of the descriptive statistics of the variables and the correlation matrix of the independent variables, showing low correlations between the independent variables. Table 4.3 shows the average values for the dependent variable for the origin of ideas and the state of the transfer. Looking at the average time until transfer already gives us an idea of the differences between the locations. While ideas from domestic locations take 4.37

years on average to become transferred to offshore locations, transferring ideas from offshore to domestic locations only takes 2.3 years.

Table 4.3: Average time until transfer

	Origin: Domestic	Origin: Offshore	Sum
Transferred	4.37	2.30	3.96
	(1,420)	(353)	(1,773)
Not-Transferred	4.31	2.60	3.95
	(1,512)	(391)	(1,901)
Sum	4.34	2.45	3.96
	(2,932)	(744)	(3,676)

4.5.3 Quantitative findings

Figure 4.4 illustrates the Kaplan-Meier Curve of the survival probability over time, comparing the origin categories of ideas. The two distinct curves show that the transfer from offshore is faster at any point in time and that the two lines are mostly parallel, confirming the proportional hazards assumption underlying the model. Table 4.4 displays the main results of the binomial model in odds ratios and the results from the Weibull model as hazard ratios with upper and lower boundaries, following a recent call by Wasserstein et al. (2019). The Coefficients and asterisks corresponding to Table 4.4 and the results of the robustness checks are reported in the appendix.

The binary event of whether the transfer happens or not gives a first glimpse of Huawei's R&D strategy. We are reporting odds ratios for model (1) in Table 7 that show the change of odds towards transfer versus no transfer for a one-unit change in the independent variable. Models (2) – (4) report hazard ratios that show the percentage change in hazard rate for every additional unit of the independent variable. These models allows us to investigate the temporal properties of the transfer of ideas.

Turning to hypothesis one, model (1) shows that there is a much higher chance for an idea transfer from offshore locations to China (36 percent). Model (2) shows that ideas from offshore locations increase the hazard of transfer at a point estimate of 39 percent at any point in time compared to the ideas from China. This confirms the hypothesis that the transfer of ideas from abroad to domestic locations is faster and more successful.

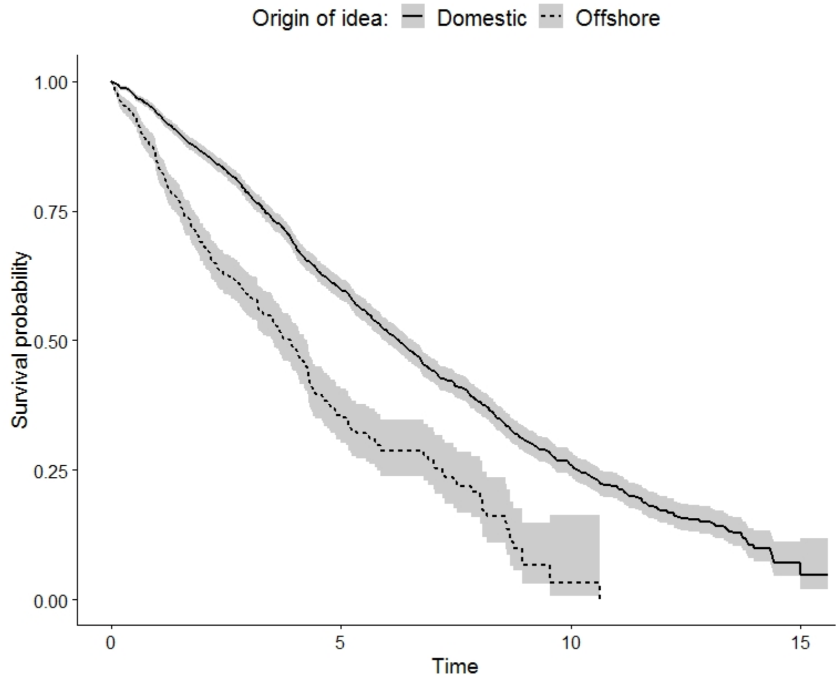

Fig. 4.4: Kaplan-Meier Curve for the covariate "Origin of idea"

Table 4.4: Main results for GLM and time-to-event analysis

Dependent variable:	transfer: yes / no	time until transfer		
Model (distribution):	GLM (binomial)	PH (Weibull)		
Location:	all	all	offshore to domestic	domestic to offshore
	(1)	(2)	(3)	(4)
origin of idea	1.359	1.386		
	(1.129-1.636)	(1.219-1.575)		
company experience	0.782	1.119	1.008	1.155
	(0.757-0.807)	(1.094-1.145)	(0.961-1.059)	(1.125-1.185)
sending capacity	1.00	1.066	1.070	1.137
	(0.985-1.018)	(1.059-1.072)	(1.068-1.072)	(1.124-1.151)
absorptive capacity	1.775	1.240	1.178	1.261
	(1.580-1.998)	(1.152-1.335)	(1.024-1.355)	(1.154-1.377)
knowledge intricacy	0.938	0.955	0.851	0.989
	(0.902-0.974)	(0.928-0.983)	(0.799-0.907)	(0.957-1.021)
global novelty	1.033	1.019	1.011	1.021
	(1.025-1.041)	(1.013-1.024)	(1.000-1.023)	(1.015-1.027)
international expansion	1.546	0.902	1.254	0.804
	(1.189-2.013)	(0.767-1.060)	(0.725-2.168)	(0.675-0.958)
scale parameter λ	-	0.004	0.186	0.001
shape parameter γ	-	1.502	1.131	1.654
Observations	3,676	3,676	744	2,932
Log Likelihood	-2,279.706	-5,203.786	-898.561	-4,244.483

Note:
GLM: Odds ratios are reported with upper and lower boundaries in parentheses
PH: Hazard ratios reported with upper and lower boundaries in parentheses

Turning towards the second hypotheses on experience, model (2) shows that while the company gains experience, the hazard of transfer increases, meaning a shorter time the transfer takes. This confirms hypothesis 2a about the transfer process becoming faster over time. In addition, an interesting insight comes from model (1): With the company maturing, the likelihood of an idea transfer decreases by 12 percent for each additional year of experience. Together with our finding about hypothesis 2a, this shows that there is less but faster transfer as the company gains experience. The reason for this might be that the company focused earlier at absorbing ideas, turning to fewer but more promising ideas over time while gaining the capability to transfer those selected ideas faster.

For hypothesis 2b, we find in model (3) and (4) that experience decreasing transfer time is only clear for domestic locations that transfer ideas to offshore. From the independent nature of experience for offshore locations, we can interpret that the offshore locations possess the transfer abilities from the beginning of their operations. Moreover, it shows that the transfer of ideas from domestic locations becomes faster with increasing experience, indicating that over time they might start to create valuable ideas that are taken to offshore locations to build upon. These findings confirm hypothesis 2b.

Next, we assess hypotheses three on sending and receiving capacities. Model (1) shows that while the sending capacity is not affecting the transfer, absorptive capacity is a very important driver of the transfer process. Model (3) shows that the sending capacity of the offshore locations is significantly decreasing the time of transfer by 7 percent. Likewise, the absorptive capacity for the domestic location significantly increases the hazard of transfer by 18 percent, showing that experience with the components on the receiving side decreases the time of transfer. Nevertheless, the coefficients in model (4) for transfer from domestic to offshore locations are even higher, only partly confirming hypothesis 3a. We interpret the higher coefficients in model (4) as higher demand for experience on both the sending and receiving location. Nevertheless, the findings confirm that idea transfer depends on prior experience, in particular on the receiving side.

Concerning hypothesis 3b, model (1) shows that a higher knowledge intricacy decreases the chance of an idea transfer between 10 and 3 percent for each additional technology component. Model (2) shows that in terms of speed, knowledge intricacy is decreasing the hazard of transfer by 4.5

percent for each additional mean component in the technology that uses the idea. Comparing model (3) and (4) shows that the direction of the effect is only clear for offshore locations transferring ideas to China. Complex ideas from domestic locations sent out to offshore locations do not suffer under higher intricacy, because experts at offshore locations understand complicated technologies more quickly due to a priori experience. These finding confirm hypothesis 3b.
Concerning the global novelty of the idea, we find in model (1) that each additional year the idea is on the market increases the transfer chance by 3 percent. In addition, the hazard rate is increasing the older and therefore further from the state-of-the-art the idea is. However, this effect is only significant for ideas that are transferred from domestic locations to offshore locations. Based on this observation, we need to reject hypothesis 3c. Nevertheless, this finding seems not surprising considering that newer ideas might also be more difficult and time consuming to transfer, in particular regarding the findings about the intricacy of knowledge slowing down the transfer process.

4.6 Discussion and Conclusion

The last decades have seen a rich literature that is concerned with the strategies of technological upgrading in MNEs from emerging economies such as China. The central developmental bottlenecks discussed include a lack of knowledge and innovation capabilities. We find that the core competence of a latecomer firm must undergo several radical shifts during the firm's development, inducing changing roles of the firm's locations within its global innovation network.
In order to jump ahead of competitors, Huawei needed to create innovative state-of-the-art technology itself. Nevertheless, creating innovative products is not necessarily a sign that the company managed to obtain so-called innovation capability, but can be achieved through relying on external innovative input through which the company gains output capabilities (Awate et al., 2012).
The qualitative analysis shows the lack of experience for idea creation at domestic locations in Huawei's global R&D network. In order to bridge this lack of innovativeness, Huawei splits its R&D activities between established industry locations abroad and domestic locations in China.
The company harnesses the creativity of offshore experts and channels the flow of ideas to its

domestic locations, where the ideas are developed to products, creating output capability for the company. The key mechanism enabling this development is the strategic division of labor within the R&D process. This mechanism required Huawei's domestic locations to catch up on organizational and technical knowledge, which they did through knowledge absorption in the initial phase. Gaining absorptive capacity enables the domestic locations to use the offshore experts' novel ideas to develop state-of-the-art technology. In accordance to our observation that the more straight-forward developmental tasks within new product creation are taken to China, the literature observes that innovative processes are becoming increasingly fine-sliced today, in order to standardize repetitive parts (Andersson et al., 2016). Moreover, concentrating development activities at home provides scale and synergy effects, proximity to the headquarters, lower communication costs and protection of commercial results (von Zedtwitz & Gassmann, 2002). For Huawei, our analysis adds low labor costs and the positive side effect of stirring the internal flow of ideas and knowledge towards China.

The results of the survival analysis show that offshore locations transfer ideas systematically to China and that experience is a critical ingredient for a fast transfer. The expertise of the offshore locations is the result of an effective search for talent at the right locations, which is reflected in the results from the qualitative and quantitative analysis. Another evident finding is the gradual and systematic accumulation of experience at Huawei's domestic locations and therefore possibly changing roles in the spatial split of tasks.

Nevertheless, even if the current market position of the firm as of 2019 marks the successful transformation from a follower to a technology leader; we find that the spatial split of R&D produces a dependency on the inflow of ideas from abroad. The company has not yet managed to conduct its highest value added R&D at its domestic locations, due to the lack of innovation capability available in China. Nevertheless, the data shows that the flow of ideas from China increases speed over time, indicating that Huawei might be improving its innovation capability at home. What still needs further investigation is the quality and function of ideas coming from this direction. As part of the further development, it can be expected that as the quality of ideas from China increases over time, the function of offshore locations might become less relevant within Huawei's global R&D network.

Methodologically, this study is the first to use novel combinations of technological components on patents within a firm as a proxy to study the internal flow of ideas. Nevertheless, we can only interpret ideas on patents as a proxy for transfer because we know from the interviews that every offshore locations works closely with a domestic location and that there are mechanisms in place that facilitate the exchange of ideas between them. It would be too imprecise to use this method for companies without those strong ties or even whole industries.

This study contributes to the theory of latecomer firms by showing how R&D internationalization can bridge a lack of innovation capabilities and support a quick build-up of market competitiveness. One apparent hallmark of Huawei's transformation to a technological front-runner is strategically locating in the search for creative personnel and matching this offshore activity with deliberate transfer to domestic R&D centers seems. This process of "search-match-transfer" may mark a new feature of upgrading strategies for EMNEs. In the case of Huawei, this feature responds to shorter technology cycles and ensures quicker idea generation and transfer. Nevertheless, this approach also leads to a dependency on offshore activities, which can be risky for latecomers as the current conflict between Huawei and the US government shows.

Moreover, the study shows that the phenomenon the literature usually discusses as knowledge transfer needs a more nuanced conceptualization, because the role of technological and organizational knowledge as well as ideas changes during the various stages of latecomer catch-up. From a policy perspective, the study shows how the support of emerging market governments for their firm's R&D internationalization can enable a quicker path to selling globally competitive products if hiring abroad strategically aims at experienced and creative experts. Nevertheless, even if those EMNEs are then able to position themselves in the global market, there still need to be mechanisms in place that pull the higher value added activities towards the home country in order to reap the benefits of value creation and become more independent from potentially risky offshore activities.

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Appendix for Chapter 4

Table 4.5: Overview of anonymized semi-structured interviews

Interviewee ID	Month of interview	Employment Region	Currently working for Huawei?
EU01	02.2017	Europe	no
EU02	02.2017	Europe	no
EU03	02.2017	Europe	no
EU04	03.2017	Europe	no
US01	03.2017	USA	no
US02	05.2017	USA	no
US03	05.2017	USA	yes
US04	05.2017	USA	no
US05	05.2017	USA	no
US06	05.2017	USA	no
US07	05.2017	USA	no
US08	05.2017	USA	no
US09	05.2017	USA	no
US10	06.2017	USA	no
US11	06.2017	USA	no
US12	06.2017	USA	no
US13	06.2017	USA	yes
US14	06.2017	USA	yes
US15	06.2017	USA	yes
US16	06.2017	USA	yes
US17	06.2017	USA	yes
EU05	06.2017	Europe	no
US18	06.2017	USA	no
US19	06.2017	USA	yes
EU06	07.2017	Europe	no
US20	07.2017	USA	no
EU07	07.2017	Europe	no
EU08	08.2017	Europe	yes
US21	08.2017	USA	no
CA01	08.2017	Canada	yes
EU09	08.2017	Europe	no
CA02	08.2017	Canada	no
CA03	08.2017	Canada	yes
EU10	08.2017	Europe	yes
EU11	08.2017	Europe	no
CA04	08.2017	Canada	yes
EU12	08.2017	Europe	yes
CA05	09.2017	Canada	yes
EU13	09.2017	Europe	yes
EU14	09.2017	Europe	yes

Additional data material

Table 4.6: Description of metric variables

idea	i
component 1	c_1
component 2	c_2
technical component	$c \in \{c_1, c_2\}$
day	d
receiving location	r
origin location	o
technology subunit	$x \in \{i, c_1, c_2\}$
location	$l \in \{r, o\}$
number of patents at location l containing x at day d	$n_{l,x,d}$
number of components on patent p containing idea i	$c_{i,p}$
date of start of world-wide observation of x	w_x
date of start of company-wide observation of x at location l	$s_{x,l}$
date of event (transfer of i)	e_i
founding date of company (approximation)	f = 1987.01.01
global novelty	$t_{w,i} = (s_i, l - w_i)/365,25$
company age (at start of observation in years)	$t_{x,l} = \frac{s_{x,l} - f}{365,25}$
company age at event in years	$t_{f,i} = \frac{ei - f}{365,25}$
time-to-event	$t_{se,x,l} = \frac{e_i - s_{x,l}}{365,25}$
mean presence of components	$t_{m,i,l} = \frac{(t_{se,c_1,l} + t_{se,c_2,l})}{2}$
mean appearance of components at receiving location	$n_{m,i,r} = \frac{\sum_{d=s_{c_1}}^{e_{c_1}} n_{r,c_1,d} + \sum_{d=s_{c_2}}^{e_{c_2}} n_{r,c_2,d}}{2}$
absorptive capacity for the idea at the receiving location	$AC_i = \log\left(\frac{n_{m,i,r}}{\frac{t_{m,i,r}}{t_{f,i}} * 100}\right)$
sending capacity for the idea at the origin location	$SC_i = \frac{\sum_{d=s_i}^{e_i} n_{o,i,d}}{\frac{t_{se,i,l}}{t_{f,i}} * 100}$
knowledge intricacy	$kc_i = \frac{\sum c_{i,p}}{n_i}$

Table 4.7: Descriptive statistics of covariates

Metric dependent variable PH	**mean**	**standard deviation**	**min**	**max**
time until transfer	3.96	3.09	0.01	15.58
Metric covariates				
company experience	22.74	3.70	12.60	29.00
sending capacity (sending location)	0.71	4.41	0.02	191.00
absorptive capacity (receiving location)	0.18	0.67	-2.06	4.54
knowledge intricacy	5.85	2.00	2.00	14.00
global novelty	23.82	10.54	0.00	63.97
Dummy dependent variable GLM	**1**	**0**	**Frequency of 1**	**Frequency of 0**
transfer of idea	yes	no	1903	1773
Dummy covariates				
origin of idea	offshore location	domestic location	744	2932
international expansion	after expansion	before expansion	2939	737

Table 4.8: Correlation matrix of covariates

	origin of idea	**company experi-ence**	**sending capacity (sending location)**	**absorptive capacity (receiv-ing location)**	**knowledge intricacy**	**global novelty**
company experience	0.283					
sending capacity (sending location)	0.048	0.057				
absorptive capacity (receiving location)	0.169	-0.032	0.033			
knowledge intricacy	0.130	0.220	0.006	-0.018		
global novelty	0.073	0.331	0.001	-0.190	-0.096	
international expansion	0.217	0.757	0.033	-0.018	0.143	0.265

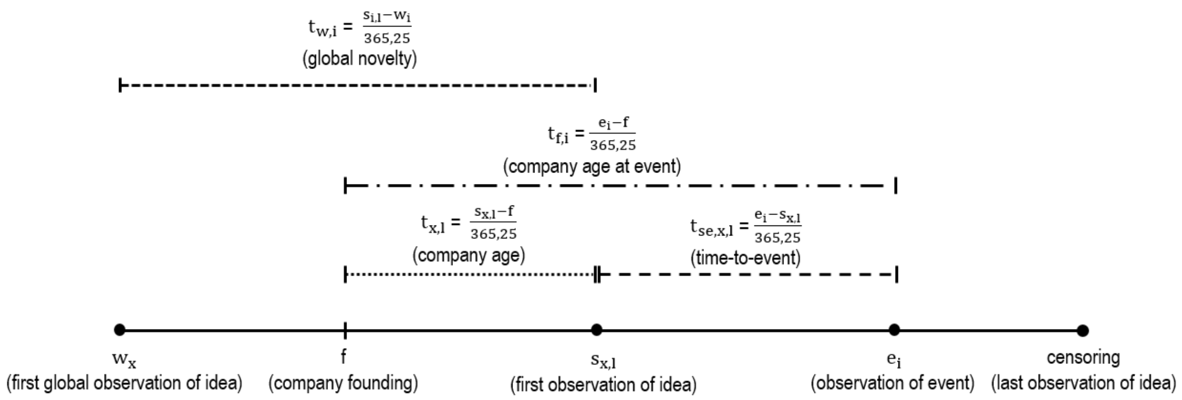

Fig. 4.5: Calculation of durations

Table 4.9: Coefficients and significance values corresponding to Table 4.4

Dependent Variable:	time until transfer		
Model:	proportional hazards (Weibull distribution)		
Location:	all	offshore to domestic	domestic to offshore
	(2)	(3)	(4)
origin of idea	0.326***		
	(0.065)		
company experience	0.112***	0.009	0.144***
	(0.012)	(0.026)	(0.013)
sending capacity	0.064***	0.046***	0.129***
	(0.003)	(0.005)	(0.006)
absorptive capacity	0.215***	0.164**	0.232***
	(0.038)	(0.071)	(0.045)
knowledge intricacy	-0.046***	-0.161***	-0.011
	(0.015)	(0.033)	(0.017)
global novelty	0.018***	0.011*	0.020***
	(0.003)	(0.006)	(0.003)
international expansion	-0.104	0.225	-0.218**
	(0.083)	(0.280)	(0.089)
scale parameter λ	3.687***	1.488***	4.021***
shape parameter γ	0.407***	0.121***	0.503***
Observations	3,676	744	2,932
Log Likelihood	-5,203.786	-898.561	-4,244.483

*: sign. at 0.1
**: sign. at 0.05
***: sign. at 0.01

Robustness checks

The shape parameter is similar for the two samples, confirming a similar distribution of both. The diagnostics plots in Figure 4.6 and 4.7 show generally parallel and non-crossing lines for the two groups of idea origin, suggesting that a proportional hazards Weibull model is adequate for analyzing the data. Moreover, comparing estimated values and observed values shows that the data overall fits the model, with only few observations out of line at the lower and upper end of the distribution. We also compare our results to the results of other survival models as well as an OLS model. Table 4.10 shows the results. Comparing our Weibull model from model 1 to the exponential model in model 4, another fully parametric model, the results shows mostly slightly smaller effects sizes but the same direction of effects on the dependent variable. Applying a semi parametric Cox regression in model 5, we find a very similar magnitude for the effect and direction on the dependent variable. Comparing the Log Likelihood and AIC measures of the models, we find that the Weibull model has a better fit with the data.

Moreover, we test if our results hold for modeling the time until transfer for ideas with a multivariate OLS regression, containing only the transferred combinations in model 6. Because we now interpret regression coefficients instead of hazard ratios, a negative coefficient means the time until transfer is shorter, and therefore corresponds to a positive hazard ratio that indicates a higher hazard for the transfer. The estimated coefficients for origin of ideas, company experience, sending capacity and knowledge intricacy reflect the same behavior as in Weibull models, while estimated coefficients for absorptive capacity, global novelty and international expansion are not significant, most likely due to the loss of information from the non-transferred ideas that cannot be incorporated into a standard OLS-model.

In order to test potential biases caused by unsuited time period restrictions in the data set, we adjust the dependent variable by limiting the period for transfer after the first appearance of the combination to five years. This effectively exclude cases where the combination appears again after many years, not necessarily being the product of a direct transfer. Moreover, high values for the dependent variable might bias the model, which we control for with this adjustment. Table 4.11 shows that the magnitude and direction of the results of the main model remain robust. Summing up, the results can be considered robust and the choice for the Weibull model over other hazard models such as the Cox or Exponential model is justified.

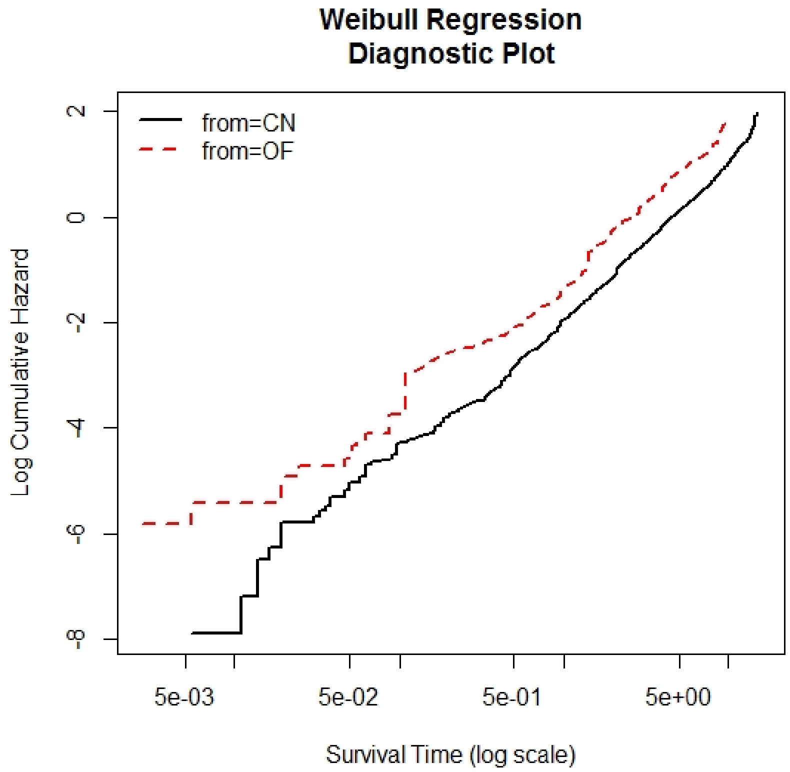

Fig. 4.6: Weibull diagnostics plot for groups

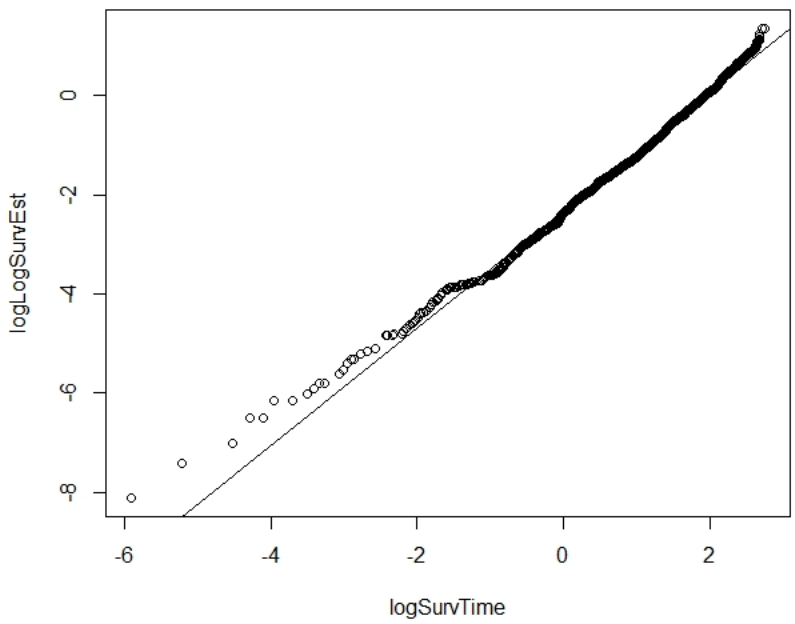

Fig. 4.7: General model fit for Weibull distribution

Table 4.10: Sensitivity analysis for transfer of ideas

Dependent Variable:	time until transfer				transfer: yes / no
Model:	proportional hazards model			OLS	GLM
	Weibull (parametric)	Exponential (parametric)	Cox (semi parametric)	Normal	Binomial
	(2)	(5)	(6)	(7)	(1)
origin of idea	0.326***	0.294***	0.342***	-0.631***	0.306***
	(0.065)	(0.065)	(0.066)	(0.142)	(0.095)
company experience	0.112***	0.038***	0.133***	-0.519***	-0.246***
	(0.012)	(0.011)	(0.012)	(0.024)	(0.016)
sending capacity	0.064***	0.045***	0.292***	-0.080***	0.001
	(0.003)	(0.003)	(0.029)	(0.016)	(0.008)
absorptive capacity	0.215***	0.225***	0.212***	0.109	0.574***
	(0.038)	(0.037)	(0.038)	(0.076)	(0.060)
knowledge intricacy	-0.046***	-0.045***	-0.048***	0.201***	-0.064***
	(0.015)	(0.015)	(0.015)	(0.035)	(0.020)
global novelty	0.018***	0.017***	0.019***	-0.002	0.033***
	(0.003)	(0.003)	(0.003)	(0.006)	(0.004)
international expansion	-0.104	0.013	-0.042	0.039	0.436***
	(0.083)	(0.083)	(0.085)	(0.186)	(0.134)
Observations	3,676	3,676	3,676	1,784	3,676
R^2	-	-	0.154	0.455	-
Log Likelihood	-5,203.786	-5,373.341	-12,492.300	-	-2,279.706
AIC	10,421.57	10,760.68	-	2,877.709	4,575.4

*: sign. at 0.1
**: sign. at 0.05
***: sign. at 0.01

Table 4.11: Robustness check for 5-year time frame for transfer of ideas

Dependent Variable:	time until transfer		
Model:	proportional hazards (Weibull distribution)		
Location:	all	offshore to domestic	domestic to offshore
	(8)	(9)	(10)
origin of idea	0.359***		
	(0.070)		
company experience	0.134***	0.009	0.177***
	(0.014)	(0.027)	(0.016)
sending capacity	0.058***	0.045***	0.119***
	(0.003)	(0.005)	(0.007)
absorptive capacity	0.243***	0.148**	0.276***
	(0.043)	(0.075)	(0.054)
knowledge intricacy	-0.079***	-0.163***	-0.044**
	(0.017)	(0.034)	(0.020)
global novelty	0.016***	0.012**	0.017***
	(0.003)	(0.006)	(0.004)
international expansion	-0.095	0.295	-0.322**
	(0.115)	(0.344)	(0.127)
scale parameter λ	4.134***	1.582***	4.516***
shape parameter γ	0.325***	0.104**	0.429***
Observations	3,676	744	2,932
Log Likelihood	-3,699.616	-818.186	-2,834.764

*: sign. at 0.1
**: sign. at 0.05
***: sign. at 0.01

Chapter 5
Conclusions

5.1 Summary

In summary, this dissertation shows that Huawei's particular global strategy is characterized by a strong reliance on offshore R&D, the acquisition of people rather than firms and the transfer of offshore ideas to its domestic locations. Article one analyzed the quality of Huawei's offshore and domestic R&D activities. The first step in analyzing the company's offshore R&D strategy was creating an overview of its worldwide R&D activities, which showed that inventors living in the US create most of the offshore patents along with Sweden, Germany and Canada. Using data from multiple patent offices provides a more nuanced picture of the gradient of R&D quality between the EMNE's locations. The results show that there is clear evidence for a higher quality of patents produced under foreign knowledge inflow compared to patents developed solely with inventors from the EMNE's home country. Higher patent quality can best be measured as the number of patent citations representing scientific impact or the number of countries in which it is used representing economic value. Another interesting finding is the low number of patents including inventors from technologically advanced neighboring countries of China such as South Korea and Japan. As a methodological insight, we find that patent family size and forward citations are the most suitable indicators for measuring patent quality. In addition, we conclude from the analysis that using data from more than one national patent office provides a more nuanced picture of EMNEs' international patenting activity.

Article two explained how Huawei's offshore experts helped the company to become globally competitive. We find that Huawei overcomes its liabilities by profiting from the embeddedness of its offshore hires in the global telecommunications industry, and the knowledge as well as experience those experts built during many years of working in the industry. This helps Huawei to build dynamic capabilities in combination with home country advantages such as cheap labor and access to credit. Hiring key personnel abroad opens the door to a virtuous circle that enables the company to gain more and more access to resources provided by the global industry such as access to standardization, EU projects, university cooperation, customers and suppliers as well as a pool of qualified employees. Those resources were not accessible for Huawei in its home market. Compared to acquisition, hiring offshore experts through R&D greenfield investments helps Huawei to avoid legitimacy concerns in the host markets and to signal technological competence and improve reputation. Another important feature of the offshore experts is that they are not only embedded locally. Through participating in global industry activities such as standardization or international research projects, they are well connected on a global scale. Moreover, Huawei does not only profit from the experts' contacts but from their ability to come up with new and innovative products, which is one of their main tasks at Huawei.

Article three examined the global split of R&D activities and finds that Huawei now mainly imports new ideas from their more research-oriented offshore locations to their more development-focused laboratories in China, where those ideas are turned into products. The company splits its R&D into research abroad in centers of state-of-the-art-knowledge and development at home, where it profits from cheaper labor and proximity to production. The offshore experts, who are better at idea creation through their industry experience and creative training, bridge the lack of innovation capability at Huawei's domestic locations. This strategic division of labor creates output capability, but it also shows that Huawei's domestic R&D has not yet achieved innovation capability because it relies on the inflow of ideas from abroad. This dependency might be risky in particular in host countries. The quantitative analysis indicates that the transfer of ideas to China is significantly more successful and faster than vice versa. The analysis also shows that sending and absorptive capacity as well as the intricacy of ideas play an important role for the success and speed of the transfer. Over time fewer ideas are transferred to China at constant speed, while the transfer of ideas from China increases in speed over time. This might be an indicator that the R&D in China is catching up on innovation capability.

5.2 Main findings

The following section integrates the findings from all three articles to point out the main findings. Even if it is risky, Huawei does its most influential R&D abroad because this way it can bridge the lack of innovation capability at home. Moreover, hiring experts abroad increases legitimacy for operating in the global industry, which is particularly important in sensitive industries such as telecommunications. This is achieved by the *global* embeddedness of the hires, which refers to their contacts and reputation in the global telecommunications industry. When studying high-profile hiring by MNEs abroad, we often assume that companies are looking for local or regional contacts from their new employees, but for Huawei we find that those contacts are global and interchangeable between the hotspots of the global telecommunications industry. Moreover, this points out how important the industry-specific global connectivity of places is for latecomers to enter mature industries.

The articles also show that Huawei's offshore R&D is less focused on external innovation input than expected. For instance, it becomes apparent from the interviews that many of the university collaborations seen in the patent data are mainly aiming at boosting Huawei's reputation and providing access to highly educated employees. The company internalizes innovation by strategically hiring the people that have the knowledge and skills required. Instead of making use of their new employees' external networks, Huawei is more concerned with integrating them as creators for new ideas internally.

Another point is that Huawei's R&D internationalization today is not so much about absorbing knowledge as we would expect, but rather about bridging lack of innovativeness. Huawei has caught up on state-of-the-art technology, but not on innovation capability. This shows how scarcely available and immobile innovative skills are. If the right background knowledge and therefore absorptive capacity is available, latecomers can learn how to produce a new technology relatively quickly, while acquiring creativity and experience to create the idea for this technology are much more difficult. Therefore, innovation capability in the home market is the bottleneck latecomer companies need to overcome on their last mile to independent global competitiveness. As we can see for Huawei, dependency from abroad can still persist for companies that have become a market and technology leader. This dependency makes the company vulnerable in their host countries and is not favorable in the long run.

5.3 Policy implications

For policy makers in leading places of innovation, the implications from these findings are three-fold. First, latecomer companies entering established industry locations can be a means to absorb highly qualified employees during a downturn of industry cycles. Established companies often need a way to relieve financial pressure during this time and tend to cut down on R&D activities. Latecomer companies might not be subject to these cyclical industry developments yet, as they are not as interconnected in the industry and might seize the opportunity to hire highly qualified personnel. This way the competence and experience in the region that has often grown over years of industry activity can stay in the region and employees stay employed in the high-value creating jobs of the industry they are trained for. Second, higher education and research facilities also depend on industries for financing, cooperation and employment of their graduates. If a big part of or the whole industry in a region closes, after some time universities often need to refocus as well. Latecomer companies can help to balance out this effect and bridge or even substitute for the lack of R&D activities of established players. This became particularly clear in the example of Huawei stepping into Nortel's shoes in Ottawa, where a big share of employees came either from former Nortel or the University nearby. Third, the role of the industry-specific global connectivity of places is crucial. For latecomers coming from less connected places, international contacts are only accessible at offshore locations that are already embedded in the global industry. Employees having global contacts are highly valuable for latecomers, also over locally well connected employees. Therefore, policy makers seeking to attract latecomer OFDI should support initiatives seeking to better connect local industries globally through hosting global industry meetings or increasing international cooperation of local firms.

For policy makers from emerging regions, the findings imply that investments in R&D internationalization of latecomers can help to obtain knowledge and therefore absorptive capability, but achieving innovation capability is an even longer and more difficult process. Even if some latecomers might achieve industry leadership, policy makers should look closely at what is attached to the inflow of innovative output from abroad. There could be a hidden dependency on offshore innovation that might turn out to be unfavorable for the latecomer. Therefore, building up innovation capabilities at home should be a goal for emerging regions and their latecomers alike. In terms of measures taken, putting emphasis on creative capabilities in education may be a step in the right direction, but will take a long time to become effective and can not compensate the inherent lack of experience young local industries usually have.

For managers of latecomer companies, the results show that greenfield investments might be an alternative to acquisitions even in *knowledge*-seeking motivated R&D internationalization. This approach can also be a means for knowledge absorption and might be an easier, light-touch approach given high liabilities from abroad. The findings point out how important strategic hiring is and show that the most important characteristics for R&D employees engaged in idea creating tasks are experience and embeddedness in the global industry community, not necessarily at the hiring location itself. Therefore, for entering an established and globalized industry, the choice of R&D location should focus more on gateway locations of the global industry than on local connectivity.

5.4 Limitations, contributions and future research

When critically reviewing the approach taken here, it is important to bear in mind that the findings from this case study are not applicable to all latecomers and industries. Using a single case creates limitations to generalizability and requires analytic instead of statistical generalization (Yin, 2014; Brinkmann & Kvale, 2018). Therefore, the findings need to be carefully viewed in the light of the case-specific features. Some of the findings concerning Huawei's *way to the top*, such as its extensive hiring from competitors, are more easily applicable to latecomers from China that share particular features such as strong government support for internationalization, easy access to cheap credit and often received skepticism in Western markets. Nevertheless, we need to differentiate between findings more specific to the company and mechanisms more widely applicable. For example, the findings on the role the offshore experts can play in catch-up and the transfer of ideas more easily apply to a wider group of latecomers.

Another point is that even if the mixed-methods approach particularly aims at uncovering the blind spots of patent data research, the embedded design of the interview sampling, which means identifying interviewees from the patent data, limits the conceptualization of innovation. One of the disadvantages is that it still only observes the kind of innovation processes that yield patentable output and neglects other forms of innovation and idea creation. Therefore, it might underestimate the innovativeness of Huawei's Chinese R&D in areas that are not using patenting as much and which are not as visible from the perspective of the offshore employees. Another blind spot of this research design is missing insights from Huawei's higher management. Even if relying too much on these sources for information was explicitly avoided (Tokatli, 2015), the current approach omits first-hand insights into the reasoning behind the decision making in the company.

Keeping in mind these limitations, the findings contribute to research in several ways. On a methodological level, this dissertation shows how combining patent data with qualitative interviews in a mixed-methods approach can fill in the blind spots we usually have when looking at data in general and patent data in particular. This sheds light onto the underlying processes that generate global patterns. For instance the innovation capability of senior offshore experts, who are preferred for hiring for their long standing industry experience, helps to explain the higher patent quality abroad and the flow of ideas from offshore to domestic locations. Understanding the micro-mechanisms of idea creation helps us make sense of the broader patterns we see in the data. Chapter 4 shows this in particular by integrating both types of data tightly. Moreover, by investigating the micro-level, the articles uncovered spatial dependencies and their antecedents that would not necessarily be visible by studying the company level alone. A better understanding of the role of the offshore employees and their relative spatial immobility helps to understand why the host locations are attractive for foreign investment directed towards knowledge-intensive activities. Identifying the key characteristics that draw foreign MNEs to a certain location has also implications for the local impact of the investment. For instance, the insight that Huawei mainly needed the global connectivity of its hires could help policy makers decide how to support this feature. Understanding the role of the offshore experts in creating innovative products helps us to learn more about the key characteristics of the host locations that attract knowledge-intensive foreign investment.

Coming back to the initial motivation and research questions, I find that even if Huawei's approach to create output capability before achieving innovation capability leaves the company vulnerable to political risks in the host countries, this strategy could be a middle step for other EMNEs and their regions of origin on their way to build innovation capability. Using greenfield investments in industry R&D hubs abroad and integrating them tightly into the internal creation of new technologies gives the company control over the whole process. This is different from the more common picture of established MNEs exercising control over global value creation by offshoring and potentially outsourcing highly standardized tasks that add less value to regions with lower labor costs. This usually leaves actors in those regions with little bargaining power over the upgrading of their tasks in the long term. Instead, the Chinese company profits from the same location advantages as established players while being in control of the spatial distribution of value creation and the orchestration of technology flow towards its home country. This might be a way to upgrade the knowledge-intensity and added-value of tasks performed in its home region in China in the long run, creating positive effects on economic wealth and welfare.

Based on the previously discussed findings and contributions, I would like to give four recommendations for future research. The first is to continue the effort of combining perspectives from EG and IB. This is important as companies form the meso-level of economic activity and are major players in orchestrating and shaping the landscape of those global economic activities. This study shows that taking into account different levels of analysis can create a more comprehensive picture of global patterns and its underlying mechanisms. By studying the role of experts from offshore locations and the pattern of Huawei's global innovative activities, I was able to generate a much more nuanced picture of the mechanisms that helped the company rise to technological leadership.

The second recommendation is to focus our attention on less studied entry modes for R&D internationalization. As we know that the approach of acquiring firms abroad does not always successfully lead to higher innovative output (Amendolagine et al., 2018), Huawei's catching-up by hiring strategy based on greenfield investment might be an alternative for latecomer companies. But in order to identify the right audience to which we should recommend this approach, more research is needed to contrast the mechanisms of the two entry modes directly. This is particularly needed with regards to mechanisms of knowledge integration and participation in innovative activity within and outside the firm. Such an approach could help us better understand the pro and cons of each strategy and help to identify situations or industries in which latecomers might choose one over the other.

The third recommendation I would like to make is to conceptualize more carefully what the literature usually studies under the term *knowledge* transfer. This dissertation has shown that in some cases, *ideas* might be the more precise way to describe the information that is transferred, while in others the term *knowledge* or *technology* might be more accurate (Andersson et al., 2016), depending on the purpose of the transfer. In particular chapter four shows that over time, different kinds of information such as ideas, technological or organizational knowledge might be required by the spatially disperse units of an MNE and therefore the object of transfer. Future research should look more into these changing needs, in particular in the context of EMNEs' catch-up process. Moreover, the development of channels and potential barriers for the transfer of these distinct kinds of information might differ and should be studied in greater depth.

My fourth recommendation is that further research should look into the role of industry standardization processes as a barrier to market entry for latecomer companies. This field has been studied from the perspective of countries and industries implementing technical standards, but only very little is known about the influence of exclusion from participating in standardization on firms, in particular latecomers and their access to global markets. Therefore, research should look deeper into the processes and negotiations in industry standard-setting in order to identify hurdles that exclude latecomers from contributing to industry standards and strategies of overcoming them. In particular the possible discrimination against companies from economically peripheral or emerging regions should be a central question in the investigations.

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Appendix

Interview guide

Experts

Where did you work / study before?

How did you come to work for Huawei? / Why did Huawei hire you?

What is your main task at Huawei?

Are your tasks at Huawei different from your tasks at your former employer? If yes: how?

Locations

How old / big was the offshore laboratory when you joined?

Does each of the worldwide R&D locations focus on a particular technology?

If yes: How do the locations choose their focus?

Is there a difference in technology / tasks between offshore locations / offshore and domestic locations?

Cooperation inside

Do you (regularly) work with colleagues from different locations at Huawei?

If yes: How closely do you work with Chinese expatriates at your location / offshore experts at other offshore locations / Chinese employees at locations in China?

How much knowledge exchange takes place between different R&D locations within the company?

Do you share newly created technologies within the company? If yes: How?

Do people from other R&D locations contact you with questions / collaboration requests?

How much knowledge exchange does usually take place between different locations?

How closely do you work with Chinese expatriates at your location / offshore experts at other offshore locations / Chinese employees at locations in China?
Do you encounter cultural barriers / language barriers at work?

Cooperation outside
Did you already live at your current job location when you were hired by Huawei?
Did you already have (local) professional contacts when you were hired by Huawei? If yes: How many?
Did you use previously established contacts in academia / the industry for your job at Huawei? If yes: what did you use them for?
Did Huawei profit from you contacts after you were hired? If yes: from which and in which way?
Do you (regularly) work with colleague from outside the company? If yes: How close do you work with people from outside the company? How does Huawei find partners for external cooperation?
Do you / Did you suggest the external partners you were working with?
Do you experience reservation / resentments from other companies / researchers against Huawei?
Are there any barriers for Huawei operating R&D abroad?

Short Curriculum Vitae

Kerstin J. Schäfer is a research fellow at the Institute of Economic and Cultural Geography at Leibniz Universität Hannover. She was born November 7th 1989 in Germany and received her higher education entrance qualification in April 2009 from Hannah-Arendt-Gymnasium Haßloch. She completed a bachelor's and a master's degree from Justus-Liebig-Universität Gießen where she graduated in October 2014 top of her class. During her masters she spent a semester at University of Wiscosin-Madison for which she received a scholarship from the Hessen-Wisconsin Exchange Program and the German-American Fulbright Commission. She started her PhD at Justus-Liebig-Universität Gießen in February 2015 and followed her supervisor Prof. Dr. Ingo Liefner to Hannover in October 2016. During her PhD she spent time as a visiting scholar at University of California Los Angeles in 2017 and at Universiteit Utrecht in 2019.