Chapter 3 Catching-Up of Chinese Firms-- the Huawei Case

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Catching-up is a concept originally developed at the national level. Catching-up at the corporate level, especially in emerging countries, has not been sufficiently studied. We propose a catching-up framework based on the theories of national catching-up, CE, and social networks. We tested this framework via a longitudinal case study of Huawei Technology Co., Ltd. By qualitatively and quantitatively analyzing Huawei's catching-up in the three network layers, we illustrate Huawei's three catching-up stages (pre-catching-up, catching-up, and post-catching-up) in the last twenty-three years. We argue that, as is the case nationally, corporate social capability is a necessary precondition for technological catching-up. Catching-up firms have the same characteristics as entrepreneurial firms in terms of growth- and opportunity-orientation.

We found that networking, as a CE strategy, is an important approach for catching-up firms. Structural, relational, and cognitive social capital can be gained from networking. This allows the catching-up firm to identify and address resource gaps and to create and respond to new opportunities. We further found that Huawei's network evolution (in terms of composition and structure) has a positive impact on Huawei's catching-up, especially in building an open system for knowledge acquisition, transfer, sharing, and creation. Huawei's sparse interfirm network with its increasing composition and strong ties coexists with an increasingly cohesive intrafirm network. This facilitates the efficient exploration of external opportunities and the exploitation of internal opportunities. The industrial-district network provides a snapshot of the intrafirm and interfirm networks in a particular location. This work contributes by supporting corporate catching-up theory, enriching social-network theory, and providing evidence for the value of combining other forms of networking (e.g., strategic alliances, M&As, and corporate venturing) into an open-innovation paradigm.

3.1 Introduction

Catching-up is a concept that originally developed in the field of economics. Its central idea is the technological and economic convergence between leading and following countries (Abramovitz, 1986). Freeman (2002) argued that technology and innovation are central to the catching-up process. When latecomers acquire enough time and sufficient productive capability as well as other resources (especially the human capital necessary for new technologies), catching-up can be achieved by taking advantage of a "window of opportunities" (Perez & Soete, 1988). National catching-up has been studied from two angles. The first is based on the growth model of Romer (1990), the theory of national competitive advantage (Porter, 1990), and national innovation systems (Nelson, 1993). It seeks the factors behind the catching-up, including the development of innovation-enhancing policies and infrastructure and increasing financial and human-capital investment. The second uses empirical studies to explain catching-up factors. For instance, Japan's catching-up is explained by government regulations, shop-floor innovation, and social institutions such as life employment and keiretu (Freeman, 1988). Korea's success is a result of the learning path from imitation to innovation, the technological regime that provides a catching-up ladder, and leapfrogging catching-up patterns (Lee & Lim, 2001).

As the largest emerging economy, China's spectacular economic growth and unprecedented success in catching-up have attracted enormous attention from academics and practitioners alike. Studies attribute China's catching-up to government policies such as FDI, innovation in state sectors (close financial controls, state ownership of firms, and political controls in favor of economic growth), and proactive and pro-business approaches (see the description of the Beijing consensus (Huang, 2010). However, the contribution of corporate catching-up to China's growth cannot be overlooked. By 2011, there were 61 Chinese firms in the Fortune 500 (an increase from 37 in 2009); in comparison

there were just 7 Russian and 7 Indian companies in the list. The LUBS report (Jan. 2009) states that Chinese multinationals should no longer be regarded as "apprentices" on the international stage but instead considered as a new troop of "emerging catch-uppers."

Early studies in this field (e.g., Young, Huang, & McDermott, 1996) emphasized the importance of inward and outward internationalization. They stressed the emerging mode of outward joint ventures and acquisitions and the role of Chinese SOEs[1]. China's economic reform now allows greater scope for corporate initiatives. However, Zhang and Van Den Bulcke (1996) studied the institutional context, observing that outward FDI is heavily dependent on local and central government. They concluded that "those enterprises which developed an early link between the influence of governmental bureaucratic systems and the real entrepreneurial logic are likely to be more successful and competitive than those which have based their international business strategy only on the privileged position which they received from the government."

Child and Rodrigues (2005) studied Chinese firms' inward internationalization through OEM and joint ventures and outward internationalization through acquisition and organic expansion abroad (to acquire advanced technology, R&D capabilities, and brands). Mu and Lee (2005) investigated the Chinese telecommunication industry. They claim that in the technology regime where leapfrogging catching-up occurs, the strategy of trading markets for technology, knowledge diffusion, and industrial promotion by the government are important catching-up factors. Fan (2006) also focused on the telecommunication industry. Fan stresses that endogenous factors such as innovation capability are the key to catching up with multinational corporations. Similarly, Duysters et al. (2009) studied Haier and conclude that alliances, acquisitions, and internal R&D are the main growth strategies. The leading Chinese economist Liu (2008) concludes

[1]Most receive sufficient financial support from the government to carry out outward joint ventures and acquisitions.

that the basic elements of catching-up are market size, market-oriented innovation, global alliances and open innovation, the spillover of FDI, and the role of the government.

There are only a few studies of corporate catching-up in China. This might be the result of a research mindset that focuses on *catching-up factors* rather than *catching-up logic*[2] and *catching-up mechanisms*[3]. On the one hand, previous studies either used internationalization as a label to reflect Chinese catching-up or emphasized the importance of innovation capability. No study measures the degree of Chinese corporate catching-up. On the other hand, catching-up theories are diverse but fall within international business theory. For instance, in early research, international business economics was mainly used to explain the internationalization of developed-country MNEs. Examples include the product life-cycle model[4] (Wells, 1983), the model of third-world enterprises (Lall, 1983)[5], international process theory based on Luostarinen's internationalization model[6] (Luostarinen, 1979) and inward and outward international business activities (Welch & Luostarinen, 1993), and Dunning's OLI theory (Dunning, 2001). Chinese (semi-) state-owned enterprises are the main research targets in the existing literature. International business theory has been expanded by consideration of the political and sociological factors that operate through a country's institutions (Toyne & Nigh, 1998, Child & Rodrigues, 2005).

[2]We define catching-up logic as the process of developing a goal, planning the catching-up, forming a strategy, and executing the plan.
[3]The catching-up mechanism is a firm-specific strategic process that elaborates motivations, strategies and methods, interactive factors, and consequences.
[4]This consists of a chain of events from innovation in an advanced country to technology transfer and diffusion to firms in developing countries, and then to local innovation followed by exports or by FDI if export restrictions exist (Wells, 1983).
[5]Lall (1983) assumes the ability to innovate along different lines from those of developed nations. This model of localized technological change emphasizes the distinctive character of the proprietary assets developed by third-world MNEs and therefore the emergence of different types of multinationals (Young, Huang, & McDermott, 1996).
[6]The model includes product (P), operation (O), and market (M) strategies; this is the so-called POM posture.

However, the literature has not explained the empirical fact that many private Chinese firms have successfully caught up in the global market.

We investigate catching-up mechanisms by studying Huawei Technologies Co., Ltd. We view Chinese catching-up through the lens of resources, CE, and cooperation-based networks. Huawei's catching-up accompanies the process of acquiring social capital in the network to develop social capability. Therefore, we argue that the catching-up logic of nations and firms is similar. In other words, nations enhance their social capability through national institutional systems; correspondingly, firms increase social capability by integrating multiple layers of networks. In Huawei's catching-up process, CE strategies were used to address resource deficiencies. Thus, national catching-up theory, which emphasizes social capability (e.g., Abramovitz, 1986), can be transplanted to the corporate level.

We applied theories of resource-based views and network social capital in the corporate context. Based on Huawei's catching-up process, which advocates open innovation and CE, we propose in Fig. 3.2 a conceptual framework for the catching-up mechanism. The framework indicates that catching-up firms are similar to catching-up nations in that they need sufficient social capabilities to exploit the technology already employed by the technological leaders. They are also similar to entrepreneurial firms that emphasize growth and innovation for technology exploration. There must be large resource gaps, so that addressing these gaps motivates the development of catching-up strategies. The Huawei analysis indicates that cooperation-based networks facilitate the switch from competitive disadvantage to competitive advantage. Therefore, our study supports the theory on the catching-up of emerging-country firms, extending international business theory (Child & Rodrigues, 2005) and CE theory to the catching-up field. Also, since Huawei is a private firm, this study addresses the question of how such firms catch up rapidly without governmental financial support. It also addresses the question of how private firms take advantage of

political support and institutional systems. This contributes to the debate on the role of government versus markets in catching-up (Amsden, 1989; World Bank, 1993; Chang, 1994).

Our intention is to stimulate further discussion rather than to provide a definitive conclusion. This study is organized as follows. Section 2 presents the theoretical background and the conceptual framework. Section 3 discusses the methodology: the sampling, data collection, and data analysis. Section 4 presents our findings for each of Huawei's catching-up phases, and Section 5 provides a discussion and conclusion.

3.2 Theoretical Background and Conceptual Framework

3.2.1 Catching-up theory and social capability

The development of Germany, Japan, South Korea, Taiwan, and some other latecomer countries led to the development of catching-up theory. At the national level, catching-up is equivalent to convergence: the per-capita income of poor countries will grow faster than that of rich countries. Economists continue to debate the determinants of the catching-up process. Neoliberals argue that free-market and free-trade policies are the key to a region's rapid growth and industrial transformation. Developmentalists stress the role of the state in economic development and advocate state planning and policies. Left-wing neoliberals believe that the state should intervene to overcome specific market failures and also stress the importance of market forces. This debate forms the theoretical base for China's growth drive.

The World Bank, using the notion of social capital, has unified two meta-theoretical formulations (from Gerschenkron (1962) and Abramovitz (1986)[7])

[7]Gerschenkron (1962) stressed that "the more backward a country's economy, the more likely was its industrialization to start discontinuously as a sudden great spurt proceeding at a relatively high

into a new formulation of the catching-up process. It incorporates elements of Gerschenkron's perspective of the state into Abramovitz's framework by acknowledging the influence of both state policy and market forces. This formulation emphasizes social capital as a basic element of national catching-up, because it can establish a country's ability to overcome productivity-retarding characteristics (Abramovitz, 1986). Therefore, a country's potential for rapid growth is strongest when it is technologically backward but socially advanced (Abramovitz, 1986, p. 388).

We argue that gaining social capability through social-capital accumulation is the most effective way to become socially advanced. However, it is difficult to measure social capability, although it was recognized by Abramovitz more than twenty years ago. Based on the studies of Ohkawa and Rosovsky (1973) on Japan's economic growth, Abramovitz claimed that the social capability of a country represents its potential for a productivity increase. It is associated with *technical competence* (for example, determined by the quality of the education system), *experience with the organization and management of large-scale enterprises*, and the *nature of the broader economic system*, in particular its openness to competition (pp. 388–9).

Studies of corporate catching-up are rare, and the theory is extremely limited. We assume that catching-up theory is similar at the national and corporate levels. We assume that corporate catching-up logic starts with social advance and proceeds with a combination of social-capability development and social-capital acquisition. We present the parallels between national and corporate catching-up in Fig. 3.1. The left-hand side explains the conditions that allow *latecomer countries* to catch up; the country should be technologically backward and

rate of growth of manufacturing output" (pp. 353–4). He argued that borrowing technologies from advanced countries was one of the primary factors underlying this "sudden great spurt." Abramovitz (1986) claimed that "countries that are technologically backward have a potentiality for generating growth more rapid than that of more advanced countries, provided their social capabilities are sufficiently developed to permit successful exploitation of technologies already employed by the technological leaders" (p. 390).

socially advanced. It must develop social capability through educational systems, experience with the organization and management of large-scale enterprises, and changes to the broader economic system, in particular via an openness to competition. As shown on the right-hand side of Fig. 3.1, firms should establish social capability via similar approaches: for instance, internally through an in-house R&D system in an intrafirm network and externally through collaborations and the expansion of external networks.

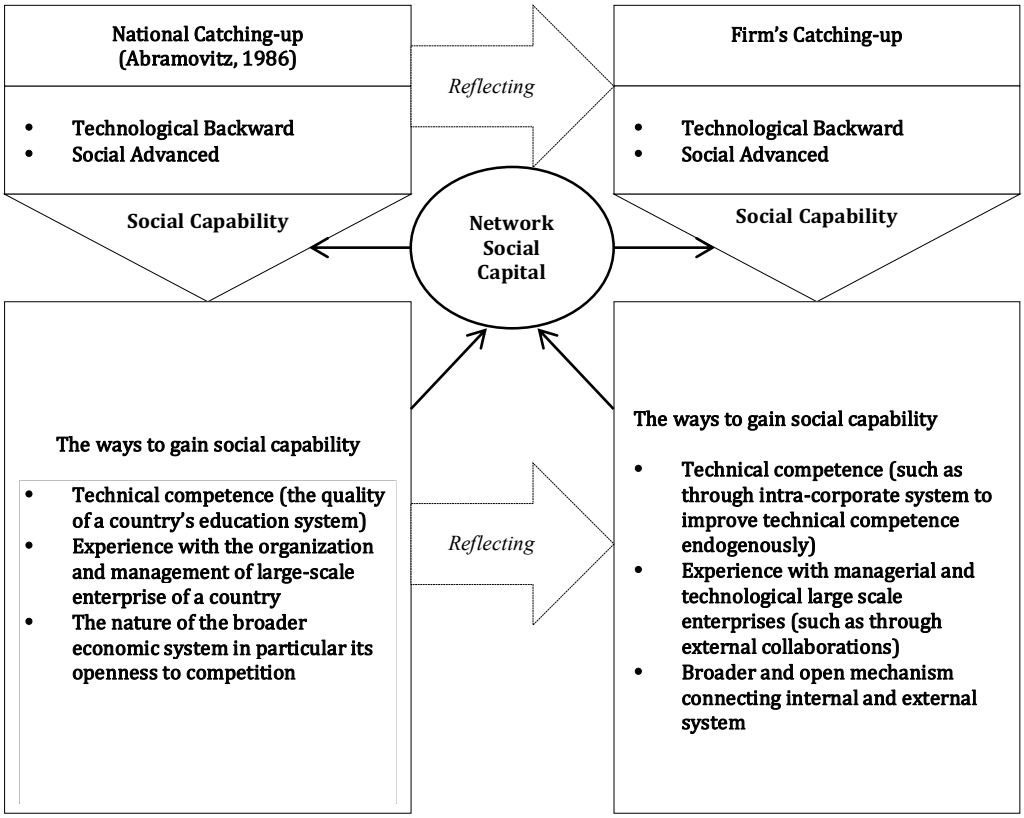


Figure 3.1. Catching-up through social capability at national and corporate levels

3.2.2 Social networks and network social capital

As indicated in Fig. 3.1, either internally or externally, the social network plays an important role in generating social capital and social capability. Social networks provide organizations and individuals with knowledge, resources, markets, and technology acquisition. Social network research at both the interpersonal and interfirm level consists of social-capital research and network-development research (Carpenter, Li, & Jiang, 2012).

Networks have many forms, including intrafirm business units, strategic alliances, franchises, R&D consortia, buyer-supplier relationships, business groups, trade associations, and government-sponsored technology programs. Networks can be classified into *intrafirm networks, strategic-alliance networks, and industrial districts.* An intrafirm network consists of a group of organizations within a firm. The subsidiaries and the headquarters share common values and goals and are controlled by the same owners. In the literature, intrafirm networks are also called *interorganizational groupings* because valuable insights into their internal structures and operations can be obtained from network-related concepts (Ghoshal & Bartlett, 1990). *Strategic-alliance networks* have been studied intensively. In these networks there are multiple alliances with a number of partners. The partners enter into voluntary arrangements that involve the exchange, sharing, or co-development of products, technologies, or services (Gulati, 1995). An *industrial district* consists of independent firms operating in the same or related markets in the same area. Through their partnership they benefit from external economies of scale and scope (Brown and Duguid, 2000). The concept includes industrial clusters, networks of producers, supporting organizations, and local labor markets (Scott, 1992).

Social-capital research takes precedence over social-network research, because social capital can capture the effects of a social network on its participants (Adler & Kwon, 2002; Lin, 2001). In this subfield, there are two distinct yet interconnected core ideas: social capital and embeddedness. Social capital

describes and characterizes firms' relationships in the network and their access to new sources of knowledge and interfirm learning. It reflects the instrumental utility and beneficial consequences of a social network (Burt, 1997; Lin, 2001). For both individuals and organizations, social-capital benefits may include power and influence (Brass & Burkhardt, 1993; Sparrowe & Liden, 1997), enhanced performance (Baldwin, Bedell, & Johnson, 1997; Mehra, Kilduff, & Brass, 2001; Peng & Luo, 2000), greater access to resources (Shane & Cable, 2002; Uzzi, 1996), and reduced transaction costs (Gulati, 1995).

Although there are many definitions of social capital, the fundamental concept is the *ability* of actors to secure benefits by virtue of their membership in social networks or other social structures (Portes, 1998). From this point of view, social capital is equivalent to social capability. Nahapiet and Ghoshal (1998) defined social capital as the sum of the actual and positional *resources* embedded within, available through, and derived from the network of relationships possessed by an individual or social unit. Based on this, social-capital benefits have two sources: resources that are inherent to the social network and the structural patterns of connections across actors (Adler & Kwon, 2002). Social capital can be viewed as a *private good* possessed by individuals (e.g., Burt, 1997; Useem & Karabel, 1986; Leana & van Buren, 1999) or the *public good* of an organization (e.g., Coleman, 1988; Bourdieu, 1986; Leana & van Buren, 1999). Social capital is also highlighted in the field of national catching-up (e.g., Abramovitz, 1986), so it is also emphasized at the national level. We argue that social capital can have advantages for the individuals who create it and the organizations that are involved in it, and that it can help a country to become socially advanced.

Another core idea of social-capital research is embeddedness, which is the contextual influences of social ties and networks on participants' actions (Granovetter, 1985). Embeddedness provides a mechanism through which networks provide participants with resources and structural benefits and generate social capital (Moran, 2005; Walker, Kogut, & Shan, 1997). Drawing on

this, Nahapiet and Ghoshal (1998) connect social capital and embeddedness by stating that social capital has three dimensions, *structural, cognitive,* and *relational*. These correspond to two forms of embeddedness: *relational embeddedness* in concrete ties and *structural embeddedness* in a network (Granovetter, 1992; Moran, 2005).

First, the structural dimension of social capital is similar to structural embeddedness, referring to the pattern of relationships between the network actors (Inkpen & Tsang, 2005). This dimension includes two properties: *social cohesion* and *network range* (Argote, McEvily, & Reagans, 2003). It emphasizes the implication of network structural features (Carpenter, Li, & Jiang, 2012) such as structural equivalence (Turner, 1985) and structural holes (Burt, 1992). *Social cohesion* represents the extent to which a relationship is surrounded by strong third-party connections (Argote, McEvily, & Reagans, 2003). *Network range* is the prevalence of ties that cross institutional, organizational, or social boundaries (Burt, 1992, pp. 148–149).

Secondly, the relational dimension of social capital is similar to relational embeddedness. It represents the personal relationships that people have developed with each other through a history of interactions (Granovetter, 1992), including aspects such as trust and trustworthiness, norms and sanctions, obligations and expectations, and identity and identifications. It is opposed to the structural dimension, indicating those invisible assets that create and bond relationships. It focuses on the effects of network closure (Burt, 2001; Coleman, 1990), incorporating strong ties and the cohesive network formed by those ties to promote a normative environment of trust and reciprocity (Granovetter, 1973; Portes, 1998).

Thirdly, Nahapiet and Ghoshal (1998) define the cognitive dimension of social capital to be the resources providing meaning and understanding between network members, such as shared representations, interpretations, and systems of meaning. Structurally, shared goals and shared cultures (Inkpen & Tsang,

2005) are mostly used. Shared goals refer to the degree to which network members share a common understanding of and approach to network tasks. Shared culture is similar to tie modality, referring to the set of institutionalized rules and norms that govern appropriate behavior in the network.

We argue that network social capital can reflect network structure (the pattern of relationships that exists among a set of actors; see Phelps (2010)), network composition (the types of actors characterized in terms of their stable traits, features, or resource endowments; see Wasserman & Faust (1994)), and network content (the actors' organizational roles and experience; see Kijkuit & van den Ende (2010)).

There are two theories for the network structure of social capital. The first is the traditional view of social capital, which is supported by network closure theory (Coleman, 1988, 1990). It stresses the positive effect of cohesive social ties or "network closure" on the production of social norms and sanctions that facilitate trust and cooperative exchanges and diminish the risk of opportunisms that can affect cooperative relationships (Granovetter, 1985; Raub & Weesie, 1990). The second is structural-hole theory (Burt, 1992, 1997), which claims that the benefits of social capital result from the diversity of information and brokerage opportunities created by the lack of connections between separate clusters in a social network. Players occupying brokerage positions between these clusters have better access to information and enjoy advantages in negotiating relationships. They are aware of more opportunities and secure more favorable terms in the opportunities they choose to pursue (Gargiulo & Benassi, 2000).

Network-development research focuses on the development and evolution of networks as social phenomena, mainly concentrating on patterns and precursors of network formation (Carpenter, Li, & Jiang, 2012). The forces that drive the formation of linkages with other organizations include network development opportunities provided by strategic inducements (Ahuja, 2000b); these arise

from homophily[8] (McPherson & Smith-Lovin, 1987; McPherson, Smith-Lovin, & Cook, 2001) and instrumentality[9] (Bourdieu, 1986; Li, 1982; Provan, Fish, & Sydow, 2007). Following this logic, networks evolve as social phenomena (Ahuja, 2000a; Gulati & Gargiulo, 1999) on a path-dependent process in which the future development of a network relies on its current structure (Gulati & Gargiulo, 1999; Shipilov & Li, 2008; Watts, 1999).

3.2.3 Corporate entrepreneurship

CE emphasizes for established firms the *capacity* to identify new ways of doing business, develop new technologies and products, and enter new markets in new organizational forms (Covin & Slevin, 1991). CE is also defined as a *process* through which firms innovate, form new business, and transform themselves by changing the business domain or processes (Guth & Ginsberg, 1990).

We consider CE because of our view that successful catching-up firms are characterized by autonomy, innovativeness, risk-taking, high growth, proactiveness, and competitive aggressiveness (Covin & Slevin, 1991). These features also characterize entrepreneurial firms. We argue that catching-up firms must be entrepreneurial firms, because they must be alert to opportunities (Kirzner, 1973), growth-oriented (Stevenson & Jarillo, 1990), and innovative (Covin & Slevin, 1991). Innovation, strategic renewal, and corporate venturing are the three basic components (Zahra, 1995, 1996). Teng (2007) defines innovation as the creation and introduction of new products, production processes, and organizational systems. Zahra (1996) defines strategic renewal as the transformation or revitalization of a company's operations by a change in the scope of its business, its competitive approach, or both. Corporate venturing involves the creation or purchase of new organizations (Block & MacMillan, 1993; Chesbrough, 2002). It allows a firm to take advantage of opportunities in

[8]The tendency for actors to form social ties with similar others (McPherson, 1983).
[9]The value of networks to actors, determined by the actors' demands and the resources available from networks and partners (Brass et al., 2004; Provan, Fish, & Sydow, 2007).

new markets that are unattainable for the current organization (Block & MacMillan, 1993).

CE involves carrying out new combinations (Schumpeter, 1934), leveraging existing resources to obtain additional resources (Greene, Brush, & Hart, 1999), and the pursuit of opportunities (Brown et al., 2001, p. 954). Thus, entrepreneurial firms are likely to experience resource gaps (Teng, 2007), as do catching-up firms. To address these gaps, interfirm relationships such as M&A and alliances are developed to access valuable resources not owned by the firm (Das & Teng, 2000). We argue that similar connections can assist catching-up firms. First, the resource-based view of competitive strategy suggests that firms in the same industry perform differently because they differ in their resources and capabilities (Barney, 1986). Therefore, networks can overcome the disadvantage of "resource poverty" (Welsh & White, 1981) by enabling firms to link activities and resources (Andersson & Wictor, 2003). Secondly, the dynamic-capability view suggests that firms need to develop new capabilities to identify opportunities and respond to them quickly (Jarvenpaa & Leidner, 1998). Networks can develop these capabilities by radar-scanning and connecting internal and external situations.

We depict a conceptual framework for catching-up in Fig. 3.2. First, being socially advanced is the primary condition for corporate catching-up; we presented arguments for this based on national catching-up theory in Section 3.2.1. Secondly, catching-up firms act similarly to entrepreneurial corporations in terms of being alert to opportunities (Kirzner, 1973), growth-oriented (Stevenson & Jarillo, 1990), and innovative (Covin & Slevin, 1991). Both types of firms also have resource gaps (Section 3.2.3). Thirdly, networks are an effective way to address resource gaps; this is shown by CE theory (Section 3.2.3) and corporate catching-up theory (Section 3.2.1). Therefore, technical advance can be achieved if the firm is socially advanced. Fourthly, entrepreneurial opportunities in the catching-up process can be identified through networks at

the intrafirm, interfirm, and industrial-district levels, motivating catching-up firms to be innovative, growth-oriented, and alert to opportunities. These four points form the catching-up logic and indicate that the catching-up framework based on a network approach is an open-development system.

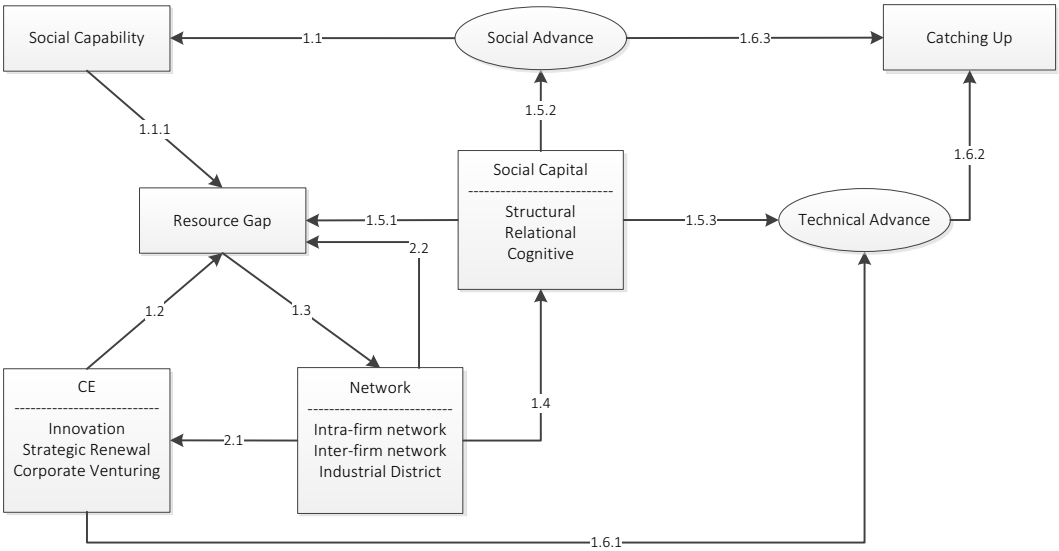


Figure 3.2. Conceptual framework for catching-up

Notes: According to national catching-up theory, catching-up has two components: social advance and technical advance. We list below each step in the process.

1.1: Social advance requires the acquisition of social capability

1.1.1: Resource gaps are identified during the process of gaining social capability

1.2: CE leads to resource gaps

1.3: Three network levels address resource gaps

1.4: Social capital is gained through networking

1.5: Social capital has three functions

1.5.1: It addresses resource gaps

1.5.2: It allows social advances

1.5.3: It allows technical advance

1.6: Catching-up has three components

1.6.1: CE contributes to technical advance

1.6.2: Technical advance leads to catching-up

1.6.3: Social advance leads to catching-up

2.1 Networking, serving as a radar screen, allows a firm to recognizes opportunities for innovation, strategic renewal, and corporate venturing. The process returns to step 1.3.

2.2 Through networking, further resource gaps are recognized. The process returns to step 1.3.

3.3 Research Design

Our methodology is that of the case study, for two reasons. First, corporate catching-up is a socially constructed process. Different firms may use different catching-up mechanisms. This topic requires a qualitative approach that emphasizes processes and meanings without rigorous examination (Denzin & Lincoln, 1994). Thus, instead of measuring "catching-up quantity, amount, intensity, or frequency" from a macro perspective, we use the method of postpositivism (it is the opposite of positivism) (Morgan & Smircich, 1980). It is more appropriate because it appreciates the different constructions and meanings that people place upon their experience (Easterby-Smith et al., 1991). It also focuses on insight, discovery, and interpretation rather than hypothesis testing (Merriam, 1988). Secondly, case studies have been criticized for their lack of scientific rigor and for being unreliable because they lack generalizability (Johnson, 1994). However, they enable researchers to gain a holistic view of a phenomenon or series of events (Gummesson, 1991). A descriptive case study captures the emergent and immanent properties of life in organizations and the ebb and flow of organizational activity, especially where it is changing rapidly (Hartley, 1994). We executed a longitudinal case study. Event analysis was used to study the firm's network in each catching-up period qualitatively and quantitatively.

Sampling

We chose the telecommunication infrastructure industry because it has developed rapidly as a result of global population growth and sustainable economic development. Companies such as AT&T, Vodafone, Verizon, SBC Communications, Bell South, and Qwest Communications appear to be the sources of technology for this industry. In reality, telecommunication infrastructure and solution providers are the engine of technological change and innovation.

We study Huawei Technologies Co., Ltd. for three reasons. First, Huawei is a private enterprise, with 100% of the shares held by the employees; the existing literature focuses on Chinese (semi-) state-owned companies. Secondly, Huawei's internationalization and innovative performance have been widely acknowledged. By 2010, Huawei was serving 45 of the top 50 telecom operators in the world, covering one-third of the global population. It surpassed Nokia and Siemens to become the second largest global supplier of mobile equipment after Ericsson. Huawei reached position 397 in the Global Fortune 500 in 2010, with annual sales of USD 21.8 billion and a net profit of USD 2.67 billion. It was the only private Chinese company in the list. In 2010, Huawei was ranked the fifth most innovative company in the world (by Fast Company, a respected and award-winning US-based monthly magazine). It was behind only Facebook, Amazon, Apple, and Google. Huawei has announced that its expected growth rate is 38% annually.

In terms of technological capability as evaluated by patent grants, in 2008 Huawei was number one in the world, with 20% more than Ericsson (which ranked second in the industry) and 14 times as many as Cisco Technologies (WIPO, 2008). By 2010, Huawei had filed 49,040 patent applications under the Patent Cooperation Treaty (8,279 overseas) and held a leading position in essential LTE (long-term evolution) technology. Huawei invests more than 10% of its annual revenue in R&D. More than 10% of R&D costs are allocated to pre-R&D. It has 20 R&D centers in China and abroad[10] and 36 training centers worldwide. More than 51,000 employees (46% of the workforce) are engaged in R&D. Huawei's rapid catching-up has been a great success and deserves to be studied.

[10]In China, Huawei has R&D centers in Shenzhen, Shanghai, Beijing, Nanjing, Xi'an, Chengdu, and Wuhan. The locations of the overseas R&D centers include Stockholm, Sweden; Dallas and Silicon Valley, USA; Bangalore, India; Ferbane, Ireland; Moscow, Russia; Jakarta, Indonesia; Istanbul, Turkey; Amsterdam, the Netherlands; and Lahore, Pakistan.

Data collection

We collected data from interviews, site visits, archival records, the Thomson SDC database, and other sources. The process took almost a year. Since the European market is the most important challenge for Huawei, we informally contacted managers who work in R&D (in Sweden), technology sales (in Belgium), and marketing (in the Netherlands). We also executed a formal round-table interview with executive officer Mr. Leo Sun at Huawei's Western Europe office in Brussels (on 21 September, 2011). Mr. Sun has been working for Huawei for more than fifteen years; he was previously the executive officer in the France office. His career has developed along with Huawei's overseas market (especially in Europe). He was chosen as our interviewee for his rich knowledge of Huawei's catching-up.

The interview questions were semi-structured and explored Huawei's networks, collaborations, major developments, and catching-up stories (Appendix I). We agreed with the interviewee to divide Huawei's development into three stages: 1989–1997 (pre-catching-up), 1998–2006 (catching-up), and 2007–2011 (the frontier stage). These stages are defined based on Huawei's internationalization and innovation performance. Specifically, in the first stage, Huawei focused solely on serving the Chinese market and building its own absorptive capacity. In 1998, Huawei officially stepped into the international market in South East Asia, South America, the Middle East, and Africa and started applying for patents in the international market. Since 2007, Huawei's revenue from overseas markets has exceeded that from the domestic market, and its technological capability has received approval worldwide.

We used archival data to provide nonreactive measures of changes in practice or performance (Webb, 1981). For instance, when the interviewee claimed that Huawei has shared technology and patents with leading players (competitors), we sought confirmation via archival documents such as newspapers, magazines, websites, and corporate newsletters. To investigate Huawei's network evolution,

we collected data on its alliances and acquisitions from the Thomson SDC database. This database includes information on all forms of alliances and is compiled from public information sources (e.g., newspaper reports, industry and trade journals, and Securities and Exchange Commission filings). As scholars have suggested (e.g., Anand & Khanna, 2000; Sampson, 2007), the SDC database is among the few comprehensive information sources that can support large-scale empirical research on alliances and alliance networks. It provides highly inclusive data about partners and the nature of alliance activities (Schilling, 2009). However, it records only collaborations with other firms. We collected information about Huawei's collaborations with universities, research institutes, and other types of organizations from alternative channels such as company newsletters, websites, and the media.

We cannot guarantee that this study has included all the relevant data for the twenty-year period. Therefore, the network ties in this study are event-type; they have a discrete and transitory nature and can be counted over periods of time (Boratti & Halgin, 2011). We count any connections relating to Huawei as a partner, collaborator, customer, or supplier. We also count its involvement in strategic alliances, mergers and acquisitions, licensing, and corporate venturing.

Data analysis

The data analysis has four steps. We first recorded time-ordered events and the corresponding external relationships. Secondly, for each significant relationship, we added an explanation of its specific configuration. Thirdly, we sent a summary to industrial and academic experts for verification. Finally, we chose variables to measure Huawei's network evolution in the three stages. We analyzed the three dimensions of social capital (structural, relational, and cognitive) at the three network levels (intrafirm, interfirm, and cluster). We also investigated the nature of the network social capital in terms of network size and embedded resources such as the resource range (variety) and contact

resources[11]. Finally, we identified the practical catching-up mechanism across the three stages (according to the conceptual framework in Fig. 3.2). We also statistically depicted Huawei's ego-network[12] evolution over the three stages.

3.4 Findings: Huawei's Catching-Up Mechanism

In this section, we test the conceptual framework and identify Huawei's catching-up mechanism. We investigate how Huawei identified resource gaps via networking in the first stage and via CE at the second stage. We also explore how it addressed these gaps through external and internal networks, and how it enhanced CE through intrafirm, interfirm, and industrial-district networks. In summary, networking and social capital act both as catching-up instruments and as the engine for further innovation and growth. Huawei's story demonstrates that the potential for catching-up is primarily determined by a firm's social advance. The social capability generated by the social capital helps the firm to identify more opportunities, find more resources, and increase its technological capability.

According to Lee and Lim (2001), a reasonable measurement of the degree of catching-up should reflect both marketing and technological advances. Therefore, we selected indicators of international market share and technological capability (as a function of both technological effort and the existing knowledge base). We investigate Huawei's performance in the three catching-up stages. Its technological capability is estimated by the number of patent grants as an output and the R&D investment as an input. We use patent

[11]According to Flap (1994), social capital is a combination of network size, relationship strength, and the resources possessed by those in the network. Previous studies of social capital focused on measures of embedded resources and/or network positions. Network positions include bridges, density, closeness, betweenness, eigenvectors, and embedded resources. According to Lin (1999), embedded resources are composed of network resources and contact resources. Network resources are the resources embedded in ego-networks and represent accessible resources. They are measured by the resource range and variety. Contact resources are the resources embedded in contacts used for instrumental actions. They are measured by the contact's wealth, status, and/or power.

[12]An ego-network (Burt, 1992) is the cloud of nodes surrounding a given node, together with all the associated ties.

data to measure technological capability for several reasons. Patents are valid and robust indicators of knowledge creation (Trajtenberg, 1987). They provide codifiable protection of a firm's technical knowledge and correlate with measures that incorporate tacit knowledge (Brouwer & Kleinknecht, 1999). They give a measure of the novel inventions that are externally validated through patent examination processes (Griliches, 1990) and a reliable measure of innovation in the telecom equipment industry (Hagedoorn & Cloodt, 2003). Figure 3.3 shows Huawei's technological capability development in terms of patent grants over the last twenty years[13].

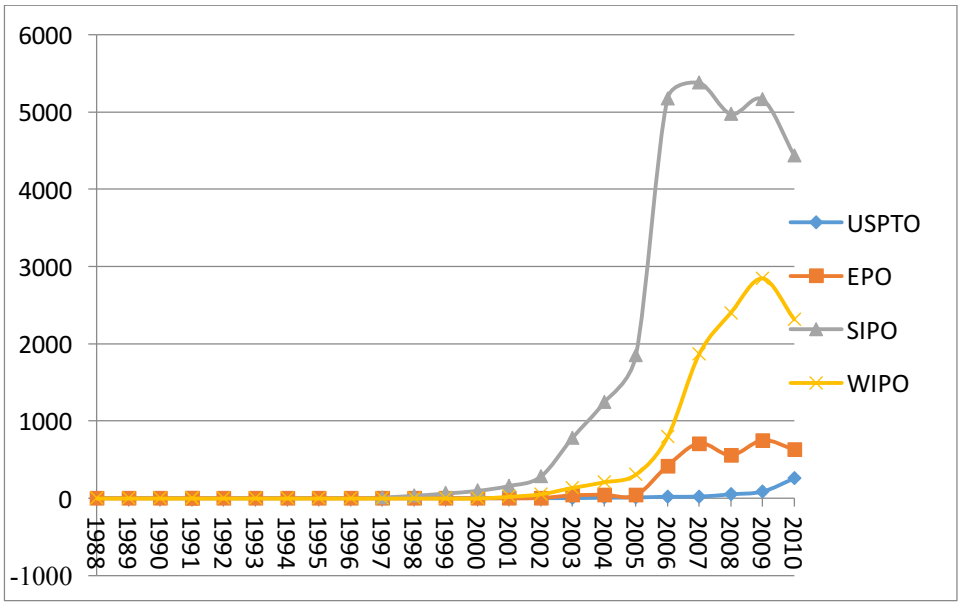


Figure 3.3 Huawei's patent grants in USPTO, EPO, SIPO, and WIPO
Source: USPTO, EPO, SIPO, and WIPO; data collected by author

[13]By 1997, in the first catching-up stage, Huawei had just 11 patents granted by SIPO. In 2005, the number of patents from the four patent offices increased to 2,201. In 2009 the figure was 8,834 and in 2010 it was 7,627. Huawei had patents granted in Europe from 2001 and in the USA from 2002. By 2010, Huawei had 445 USPTO grants (more than any other Chinese firm) and 3,187 EPO grants.

Pre-catching-up phase: 1988–1997

The telecommunication industry is a high-tech industry, and Huawei was considered a latecomer in the early 1990s. Huawei was established in 1988 in the city of Shenzhen (China), primarily specializing in the sale of HAX switches imported from Hong Kong. Our interviewee stated that although Huawei at that time was an unknown small company, its ambition was to develop competitive advantage through innovation (this is stressed by Huawei's former CEO, Mr. Ren Zhengfei).

Huawei covered 24% of the domestic market in the industry by 1997, competing with 200 Chinese counterparts and major domestic competitors such as ZTE and Datang. To avoid direct competition with Shanghai Bell[14] (the most competitive joint venture in the industry in China in the 1990s), Huawei explored rural markets with support from the government's policy for the development of rural telecommunication infrastructure. In 1994, it launched the HONET integrated access network and the SDH product line, becoming the first Chinese firm to install long-distance transmission equipment. A milestone was the successful development in 1995 of the first digital transmission technology, C&C08, for China's rural and less-developed regions. This led to Huawei's dominant position in the Chinese market.

There are many reasons for Huawei's early success. It invested heavily in R&D; it was the only Chinese firm to invest more than 10% of annual revenue in R&D[15] and the only indigenous company willing to pay higher salaries than those paid by multinationals. Other important factors are its private ownership, corporate culture and strategy, accurate assessment of China's segmented markets, and adoption of Mao's warfare philosophy: *encircle and conquer cities by first focusing*

[14]The first joint venture in China, initiated in the 1980s by the Chinese government. BTM (Bell Telephone Manufacturing Company) held an equity share of 32%, the Belgian government held 8%, and PTIC (Post and Telecommunication Industrial Corporation) held the remaining 60%.
[15]Chinese firms in that period mostly manufactured components for multinationals. Their technologies were mostly embedded in equipment imported from other countries.

on seizing the countryside. C&C08 was achieved by addressing the resource gap through technology diffusion from Shanghai Bell[16] (the source of System-12)[17] and the Centre for Information Technology (CIT)[18].

Huawei did not have all the resources necessary to solve its problems. As noted, its initial success owes much to technology diffusion from inward FDI in China (Shanghai Bell). However, its success was also a result of its attitude to collaborations. In the late 1990s, Huawei became frustrated with its corporate management, corporate culture, organizational ineffectiveness, resource wastage, and long-term R&D processes. As a small firm, it did not have the resources to solve all these problems. It therefore chose to collaborate with leading companies, leading Chinese universities, and leading international consultants. This decision was based on the collaborators' rich social capital and resources, cohesive networks, and international reputations.

For instance, by collaborating with top Chinese universities such as Tsinghua University and Renmin University, Huawei identified numerous managerial and technological shortcomings. It identified a series of key factors for its past success and expected future challenges. In 1995, five professors from Renmin University were invited to join Huawei's organizational revolution. These professors had regular discussions with Huawei's executives on CE, corporate strategic transitions, marketing, and HR management. They were also invited to jointly design *Huawei's basic law*[19]. This strategic collaboration led Huawei to re-

[16]The technology diffusion from Shanghai Bell was both passive and active. First, movement of labor from Shanghai Bell to other companies occurred frequently. Secondly, Shanghai Bell published its technological advances in a journal, *Telecommunications Technology*.
[17]System-12 and HJD-04 are the underlying technologies of C&C08. System-12 technology is mainly for switches at level C3 and above (the transit-switch network in provincial capitals and autonomous regions). HJD-04 allowed Chinese language operation and was therefore popular in less-developed regions.
[18]CIT, together with PTIC and the Luoyang Telephone Equipment Factory (LTEF), set up an R&D consortium to encourage knowledge diffusion from Shanghai Bell to indigenous firms.
[19]This became the formal version of Huawei's corporate culture (the wolf culture). Ren Zhengfei proposed the three characteristics of this wolf culture: an acute sense of smell, aggressiveness, and collaboration.

consider issues such as *intrafirm resources, intrafirm and interfirm networks*, and *CE*.

To maintain a leading position in the Chinese market by exploiting incremental technologies and exploring new technologies, in 1997 Huawei initiated a technological alliance with Tsinghua University (the top engineering university in China). Meanwhile, to facilitate open-source research, it set up a research center in Silicon Valley for the development of chips, a research center in Shenzhen for the development of core-technology ASIC chips, the Huawei Beijing Research Institute for data-communication research, and the Huawei Shanghai Research Institute for the development of mobile telecommunication technologies.

In the mid-1990s, with Huawei's increasing reputation in China and international ambitions, Huawei executives were sanguine about their company's prospects. However, Ren Zhengfei recognized that Huawei had many limitations. In the collaboration with Renmin University, these limitations were identified as a lack of organizational expertise and the absence of a viable long-term strategy. Therefore, in 1997 Ren Zhengfei visited MNEs in the USA and decided to establish a new managerial system by collaborating with IBM Consulting. Huawei subsequently installed a new system consisting of integrated product development (IPD) and an integrated supply chain (ISC). Ren Zhengfei commented (Cheng & Liu, 2003): *"…thanks to collaborating with IBM, many of Huawei's problems in the managerial system were recognized and solved, such as lack of accurate and forward-looking assessment in customer needs, duplication of useless work, walls among different departments, dependence on heroes rather than procedures, disordered project plan and management."*

Huawei also worked with other leading consultants to solve the systematic deficiencies in HR management (working with the Hay Group), financial management (working with PwC), and production and quality management (working with Fraunhofer Gesellschaft).

We stress that although collaborations with universities and consulting firms are common for western MNEs, they were unusual for Chinese firms in the late 1990s. At that time, the national innovation system had not completely transferred to an enterprise-centered system. Firms were not free to initiate collaborations with universities and research institutes but had to be assigned by the government to appointed collaborators. Moreover, this was not considered a "smart" option, because firms that solved their own problems were regarded as "superstar companies." However, since Huawei was a private firm, it operated under fewer political and communist-slogan constraints.

Numerous factors contributed to Huawei's initial success. Of these, its openness to collaboration must not be overlooked. Huawei's strong ties with leading consulting firms and universities gave it the potential to catch up. It accumulated social capital by adding players rich in social capital to its network. This led to the acquisition of management skills, technologies, and an improved social capability.

Huawei's strong ties in the first stage with rich-in-capital partners could be expected to lead to a cohesive network and more knowledge acquisition. This is because a cohesive network transfers the benefits of social capital more easily than a noncohesive network (Reagans & McEvily, 2003). A cohesive network allows firms to increase social capital and diffuse technology.

To summarize the network at the intrafirm level, Huawei accepted IBM's advice to establish IPD and ISC systems. Using these together with the updated HR, financial, and production and quality management systems, it systematically connected its headquarters with all its departments, branches, and research centers. At the interfirm level, Huawei has worked with five leading consulting firms, two international telecommunication operators (from Russia[20]), and two

[20]Russia's market was similar to that of China. Huawei used Russia as a testbed, in preparation for future international endeavors at the next stage.

Chinese universities. Following prior studies (Koza & Lewin, 1999; Rothaermel & Deeds, 2004), we identified exploratory and exploitative connections. We designated alliances covering upstream activities of the industrial value chain (basic research, R&D, etc.) as exploratory connections, and connections focusing on downstream activities (manufacturing, marketing and sales, service, etc.) as exploitative connections. Thus, Huawei's first catching-up stage has two exploratory and seven exploitative collaborative actors.

Huawei's accumulated embedded social capital was used to gain managerial and technological knowledge and to acquire opportunities to reach other network actors in the future. It had not yet moved into overseas industrial districts but primarily acted in Chinese industrial clusters[21] in, for example, Shanghai, Beijing, Xi'an, Nanjing, and Wuhan. It shared resources with its Chinese counterparts. In Table 3.2 we summarize the structural, cognitive, and relational dimensions of the social capital accumulated at this stage. The three components of the CE activities are listed in Table 3.3.

Figure 3.4 shows Huawei's interfirm network. This graph excludes Chinese telecom operators; it includes only technological and managerial collaborators, as indicated by the SDC database.

[21]These cities formed the first generation of national high-tech zones. Huawei chose these locations so that it could share technical resources with its counterparts. Moreover, these cities have many universities: Beijing has 74, Shanghai has 43, Hubei (where Wuhan is the provincial capital) has 61, Jiangsu (where Nanjing is the provincial capital) has 100, and Shaanxi (where Xián is the provincial capital) has 50. Therefore, Huawei could easily find sufficient human capital in these cities. This is another way in which it took advantage of entrepreneurial policies.

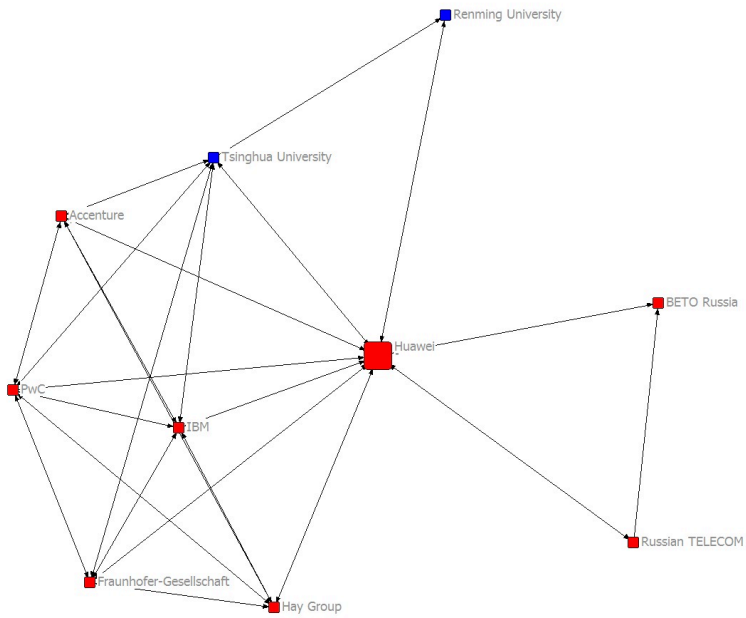


Figure 3.4. Interfirm alliance network: First stage
Notes: Blue: Universities and research institutes. Red: companies.

In this graph, Huawei is the focal actor, or ego. To reflect the ego-network structure, we calculated the ego-network density, efficiency, and constraint. Based on Burt (1992) and Borgatti (1997), Phelps (2010) provides a comparison of the three measures.

The density, efficiency, and constraint of this network were calculated as follows:

$$Ego\ Network\ Density_i = \left[\sum_j \sum_q x_{jq} \Big/ \{N(N-1)\}/2 \right] \times 100\%,\ j \neq q$$

where x_{jq} is the relative strength of the ties between alter j and alter q, and N represents the number of alters to which ego i is connected. The value of x_{jq} is 1 if a relationship exists and 0 otherwise. The term $N(N-1)$ is divided by 2 because alliances are undirected ties. The variable range is 0–100%.

$Density = 38.9\%$

$$Ego\ Network\ constraint_i = \sum_j \left[p_{ij} + \sum_q p_{iq} p_{qj} \right]^2, q \neq i, j$$

where p_{ij} is the proportion of alter i's ties invested in the relationship with alter j. This index measures the extent to which the contacts are connected, i.e., do not have structural holes (gaps between network nodes) (Burt, 1992). This measure ranges from 0 to 1, with higher values indicating more constraint (i.e., fewer structural holes).

$Constraint$=0.315

$$Ego\ network\ efficiency_i = \left[\sum_j \left(1 - \sum_q p_{iq} m_{jq} \right) \right] / N, j \neq q,$$

where p_{iq} is the proportion of alter i's ties invested in the relationship with alter q, $m_{jq}$is the marginal strength of the relationship between alters j and q (the value of m_{iq} is 1 if a tie exists and 0 otherwise), and N represents the number of alliance partners to which the focal firm is connected. This measure ranges from 0 to 1, with higher values indicating greater efficiency (i.e., structural holes).

$Efficiency = 0.654$

Catching-up phase: 1998–2006

The second catching-up stage started in 1998 when Huawei formally stepped into the international market. As stated in its basic law, Huawei aimed to *become better rather than larger, smart and efficient*, by switching from being an equipment manufacturer to being a complete solution provider in the ICT industry. In a 1998 speech entitled *How long can Huawei's red flag wave?* Ren Zhengfei commented (Cheng & Liu, 2003): *"…We must aim at the best companies in the telecom industry, including Ericsson, Alcatel, Siemens, Nokia, Lucent and Bell Laboratory. We must try to catch up with them and surpass them."* The reaction to

this goal was astonishment; even company executives did not believe it would be achieved. However, in retrospect, we must acknowledge Huawei's spirit and its successful achievement of this goal.

By 1998, in the domestic market, Huawei had overtaken Shanghai Bell, becoming the largest manufacturer of digital automatic switches. By 2006, it had been leading the Chinese telecommunication industry for more than eight years, and its overseas market was larger than its domestic market. To enter the international market, Huawei used the same strategy that it earlier used to exploit the domestic market. From 1998, it started moving into emerging markets including Russia, Africa[22], South-East Asia, Central Asia, and Latin America. In less-developed markets, Huawei provided "superior pricing, customer service and brand awareness." It believed that it was "not making it cheaper, but making it better." From 2000, Huawei's international markets were enlarged to include Middle Eastern nations, the UK, the USA, Sweden, and the Netherlands. Huawei's patent grants at this stage ranked number one in China. It was also the top Chinese firm for international patent grants. Huawei provided products and services for switching applications, integrated access networks, NGN, xDSL, optical transports, intelligent networks, GSM, GPRS, EDGE, W_CDMA, CDMA2000, routing applications, and other LAN applications. Its products were equivalent to Cisco's but were 30% to 50% cheaper[23]. John Chambers (the former CEO of Cisco) stated in 2002: "*In the coming years, we will just have one rival which is Huawei.*"

As a private enterprise that receives limited financial support from the government, Huawei's success in the domestic market owes much to its decision

[22]Huawei was the first telecommunication-equipment supplier to enter Kenya and has now become the largest CDMA product provider in Africa.
[23]According to our interviewee, this was because of Huawei's large pool of engineers and its cheaper human resources.

to exploit governmental policies for the telecommunication industry[24]. By 2006, Huawei had become the largest solution provider for more than twenty-seven of the thirty-one provincial telecom administrative bureaus. Because of this large inflow of sales income from the domestic market, Huawei's investment in R&D increased rapidly.

Collaboration-based networks facilitated Huawei's development. It enjoyed large rewards from its collaborations with consulting firms such as IBM and universities such as Tsinghua and Renmin. Ren Zhengfei stated: "*It is not only latecomers who believe in development through opportunities, but also front players (such as IBM) who develop dependent on creating opportunities.*" He emphasized: *"This progress of opportunity-creating is not only dependent on the technology and innovation you have, but also is interdependent with the network and resource you embraced"* (Cheng & Liu, 2003). This implies that networks serve as instruments to create opportunities. In 2001, Huawei's goal was to compete with Cisco in the data-communication division, Alcatel in the networking division, and Siemens in the optical networking area. Ren Zhengfei stated that Huawei must "*take advantage of strategic alliances to change the competition structure.*" Our interviewee commented: "*What Huawei did was not initially perfect, but Huawei has been improving by being stimulated to come up with new ideas, new solutions, and new designs through collaboration with clients, counterparts, and universities.*"

The Huawei basic law states that one of Huawei's core values is *to develop advanced core technological systems by open collaboration.* Our interviewee said: *"We are quite proud of sharing a stable collaboration network with our clients. We keep standing, thinking, and working with our customers by sincerely considering our customers' problems as ours."* Except in the customer network, where Huawei was committed to cohesively embedding, the network actors were carefully

[24]From the late 1990s to the early 2000s, the government called for the use of domestic products in the telecommunication industry. It offered firms buyer credits and financial support from the People's Bank of China as incentives.

chosen. As before, it typically chose partners rich in network resources and power in the industry. At the second stage, it had thirty-two collaborations with leading global companies. It focused on alliances with NEC (2001), Agere (2002), Microsoft (2002), 3Com (2003), and Siemens (2003) for the TD-SCDMA technology. It formed alliances with Avici Systems (2003), Infineon Technologies AG (2003), Information & Communication (2004), Nokia Siemens Network (2004), and Motorola for the UMTS and HSPA technologies. By 2005 it had built ten joint research centers with Texas Instruments, Motorola, IBM, Intel, Angere Systems, Sun Microsystems, Altera, Qualcomm, Infineon, and Microsoft.

Collaborations with universities are another characteristic of Huawei's interfirm network. By 2006 it had closely worked with five universities (four Chinese, one Brazilian) on, for example, networking technology (INATEL university), video technology (Beijing University), and a joint research framework (Northwest Polytechnic University). These universities acted as a second intelligent tank for the development of technological capability. Huawei was able to monitor and absorb new scientific ideas because of the open knowledge flow in academia: Huawei's university partners were embedded in cohesive networks with other leading international universities. Thus, Huawei's partners could spontaneously transfer knowledge across networks.

At the intrafirm level, Huawei established more than forty overseas branches and offices in Europe, the USA, Asia, South America, and Africa. By 2006, it had established ten R&D centers around the world, collaborating with suppliers, customers, universities, and leading players. These offices, branches, and R&D centers work together organically under a shared platform, an intrafirm platform developed from the IPD at the first stage.

At the industrial-district level, Huawei aimed to locate each branch close to customers, counterparts, and suppliers. For instance, its branch in the Netherlands is located in the commercial town Amsterdam Bijmer ArenA, where many well-known companies are based. It offers geographical proximity to

Huawei's customers KPN, Vodafone, and T-mobile, as well as other clients and competitors such as Cisco. By being based in an industrial cluster, Huawei can provide fast service to clients, partners, and others.

Huawei established Huawei University in China in 2005 to build its own industrial-district network. This university allows Huawei to bring together talented engineers in the industry. It also helps to spread Huawei's technology in China's ICT sector. This university has seven subsidiaries across China (in Beijing, Xi'an, Nanjing, Hangzhou, Chongqing, Kunming, and Kuilin), enhancing intrasector communication and providing training, conferences, and technology forums. Huawei is therefore considered the Chinese ICT "knowledge hub."

The three levels of networks bring Huawei many benefits. There are indirect returns from technology and knowledge transfer, exchange, and absorption. However, the most valuable acquisition is embedded social capital. The social-capital returns are instrumental and expressive (Lin, 1999). Instrumentally, Huawei acquired new social capital to address its resource gaps. Expressively, this social capital (especially in terms of the relational and cognitive aspects) is a means to consolidate resources and a defence against possible resource loss (Lin, 1999). Huawei was an alter in the ICT industry network in the second catching-up stage, and there was an asymmetric relationship between the ego(s) and Huawei as an alter. In other words, Huawei was able to accrue social credits from egos such as more connections with network-weighted actors whereas the egos were creating social debts to the alters.

The three levels of Huawei's CE (see Table 3.3) were facilitated by its three levels of network social capital. First, Huawei's products and services had been competitive in the global market. Innovation sourcing from collaborations is one of Huawei's competitive advantages. To improve its intrafirm organizational effectiveness, Huawei restructured its organizational system into a shared platform based on IPD, ISC, IT-based HRM, financial management, and quality-control systems. Secondly, to enlarge its business scope and serve more

customers, Huawei created new business domains by expanding its business arena to devices and professional services. Thirdly, to strengthen its technology capability, Huawei executed corporate venturing by acquiring business units/companies from India (targeting Huawei Telecom (India) Co., Pvt in 2003), the USA (3com Corp. in 2003), Hong Kong (Sunday Communications Ltd in 2004), the UK (Marconi Corp. PLC in 2005 and Harbour Networks Holdings Ltd in 2006), and Nigeria (Intercellular Nigeria Ltd in 2006).

To summarize, the second stage of Huawei's network is multidisciplinary, multilevel, and multiregion. Huawei has successfully *kept abreast of the latest technology and quickly incorporated new technology into its knowledge base.* Huawei's network at the second stage is presented in Fig. 3.5: the number of actors has increased to 42, with 26 exploratory connections and 16 exploitative connections. Huawei's centrality in the ICT industry is increasing, with its density reduced to 0.268, efficiency increased to 0.746, and constraint reduced to 0.088. Its connections have two traits: long-term connections and large resource pools of the partners. With the increased social capital and social credits, Huawei's network position in the ICT industry began to center. Together with the firm's improved performance, this cohesive network paved the way for Huawei's next stage of development as an industrial leader.

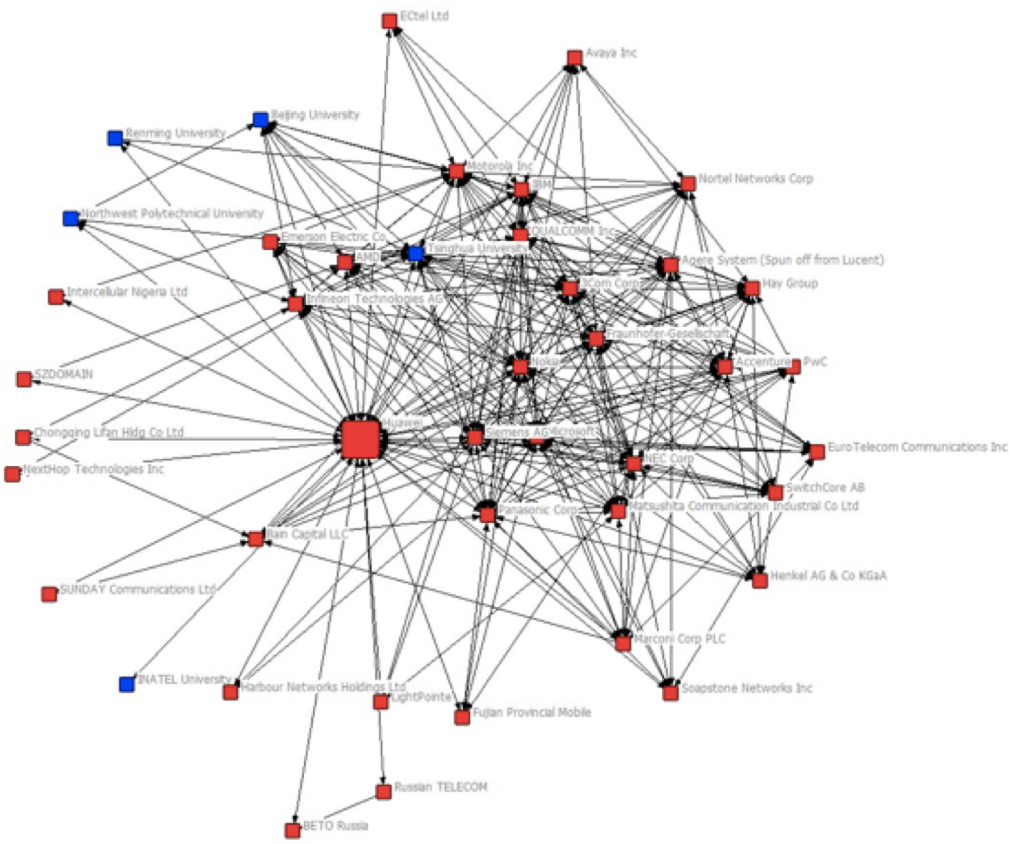


Figure 3.5 Interfirm alliance network: Second stage

Post-catching-up phase: 2007–2011

Huawei's third catching-up stage began in 2007. Its main goals were to maintain its market position and to play a leading role in the ICT industry worldwide. Therefore, it aimed to establish its own ego-technology system and to explore new business arenas. In the 1990s Huawei was a technology follower in the 2G era. In the 2000s it was abreast with the leading players in the 3G era. Currently, given its LTE (4G) patent grants and its international market share, Huawei is the forerunner of its industry and the most proliferate inventor in any industry. In 2008, Huawei was the largest patent owner in the world (WIPO, 2008), with

on average three patents granted each day. In 2011, Huawei invested USD 3.76 billion in R&D[25] and served 45 of the world's top 50 telecom operators[26], covering more than one-third of the global population. Today, Huawei has 16 regional organizations, more than 100 branch offices, 20 R&D centers, 36 training centers, and 120,000 engineering-background employees globally. It is ranked in the top three companies in the industry segments of internet switches, fixed-line networks, and wireless networks.

In 2009 the Wall Street Journal[27] wrote: *"European telecommunication-gear companies—global market leader Telefon AB L.M. Ericsson, Nokia Siemens Networks, a joint venture between Finland's Nokia Corp. and Germany's Siemens AG, and Paris-based Alcatel-Lucent SA—are likely to face increased pressure from world No. 2 Huawei in their own backyard."* In 2011, the Economist issued its Innovation Award to Huawei and commented (April 20, 2011):*"...Having just passed Nokia and Siemens, Huawei looks on track to overtake Ericsson, the industry leader, this year."* In 2011, Huawei did indeed overtake Ericsson to become the world's top wireless equipment provider.

Huawei has entered cloud computing and the smartphone business. Its business arenas include Cloud (building blocks for the cloud, including applications and services, storage and securities, and O&M), Pipe (radio access, fixed access, core networks, transport networks, data communication, energy and infrastructure), and Devices (personal devices, home devices, and devices for enterprises). Huawei's smartphones and Android tablets have become popular (with a golden price between USD 70 and 200) in Africa and Latin America. In the next five

[25]In 2011 Ericsson's investment in R&D was SEK 32.6 billion (around USD 4.83 billion). However, Ericsson's R&D efficiency as expressed in its annual report had decreased, which according to our interviewee might be due to the high cost of R&D and the small pool of engineers in Europe.

[26]Four of the remaining five are American, and the other is Rogers.

[27]http://online.wsj.com/article/SB1000...tions_business

years, it aims to conquer the European market, becoming one of the top five mobile-phone manufacturers globally.

Huawei technology is well-known for its energy-saving nature. Huawei's advanced green policies have reduced energy consumption by more than 60% per station, up to 5700 Kwh of electricity annually, and have reduced carbon dioxide emissions by 1.7 tons. The Huawei GSM base station has been called the most eco-friendly in the business, because it has reduced energy usage by at least 47%.

Huawei's intrafirm structure has a matrix form, where the business and regional units are both profit centers. They are under the management of Huawei's customer-centric innovation system. The policy is that *business success is the ultimate measure of the value of any technology, product, or solution/process improvement*. Innovation is passionately pursued with unmatched R&D capabilities and by cooperation with industry peers to deliver value to customers.

Huawei claims that its success is relevant to open collaboration, especially collaboration directed by the customer-first principle. Its collaborations in the third stage are characterized by the joining of prestigious alliance clubs and associations. As one of the leading players in the industry, Huawei joined numerous alliance associations to share technologies, IP, and ideas. In May 2006, Huawei was invited to join the SCOPE alliance network and committed to supporting SCOPE's mission of promoting the availability and interoperability of open-carrier grid-base platforms. In July 2007, Huawei joined the HomePlug® Powerline Alliance[28]. Huawei contributed major progress in "smart grid" and

[28]The HomePlug Powerline Alliance is an industry-led initiative established to create specifications for high-speed powerline networking products and interplatform command and control within the home, and home broadband access. The alliance accelerates demand for HomePlug-enabled products and services worldwide through the sponsorship of market and user education programs. Its membership has grown to include more than seventy-five industry-leading companies. Sponsor companies include Cisco (CSCO); Comcast (CMCSK); GE Security, Inc., an affiliate of General Electric Co. (NYSE: GE); Intel Corporation; LG Electronics (Korea Stock Exchange: 6657.KS); Motorola

"green energy" technologies and high-speed to-the-home and in-the-home communications. In December 2008, it joined the Open Handset Alliance Network.

In February 2009, Huawei joined the Open Patent Alliance (OPA), a group formed in June 2008 by members of the WiMAX ecosystem including Alcatel-Lucent, Cisco, Clearwire, Intel, and Samsung Electronics. It aims to form a WiMAX patent pool and aggregate patent rights to implement the WiMAX standard. To acknowledge Huawei's significant contribution to OFDM and MIMO broadband wireless technologies, in 2010 OPA awarded it an "Outstanding Contribution and Leadership Award." A Huawei representative said: *"Huawei's joining OPA will ultimately promote Huawei to offer broader choice and lower TCO for WiMAX technology and also will help them deliver more products of high quality around the world at affordable prices"*[29]. In May 2011, Huawei joined the Wi-Fi Alliance[30] as a key sponsor and the director of the organization board.

Huawei's work with other organizations has continued. On its website and in its annual report, Huawei has started using the term "alliance" rather than "collaboration." For instance, Huawei has formed alliances with leading operators such as TeliaSonera and Telenor in Norway and Sweden; Vodafone and BT in the UK; Deutsche Telekom and Telefonica O2 in Germany and Spain; Orange in France; Telecom in Italy; KPN in the Netherlands, France, and Spain; PT in Portugal; Belgacom in Belgium; and ONO in the UK and Spain. In May 2007, Huawei and Symantec signed an agreement to establish a joint venture in order

(MOT); RadioShack Corporation (RSH); Samsung Electronics Co., Ltd. (SSNGY.PK); Sharp Laboratories of America; TCL Group Holding Co., Ltd (TCL Group); and Texas Instruments Incorporated (NYSE:TXN) (TI). Contributor members include Arkados (OTCBB: AKDS); Conexant (CNXT); Corporate Systems Engineering; Gigle Semiconductor; Huawei Technologies Co., Ltd.; Intellon Corporation; and SPiDCOM Technologies.

[29]See Huawei's global website: http://www.huawei.com

[30]The Wi-Fi Alliance is a global nonprofit industry association of hundreds of leading companies devoted to the proliferation of Wi-Fi technology across devices and market segments.

to provide end-to-end solutions in converging networks, security, and storage and computing technologies. In April 2010, PerSay, the voice-authentication technology provider, formed an alliance with Huawei to "pre-integrate" voice biometric solutions into its IP-Contact Center offering. In March 2010, ARA Networks and Huawei announced an original equipment manufacturing (OEM) agreement[31]. In January 2011, Qatar Telecom (Qtel) formed an alliance with Huawei to develop joint solutions for key industries across Qatar and the Middle East.

Huawei continues to form alliances with universities for joint scientific research. It treats universities and institutes as *knowledge and talent incubators.* It has established more than twenty "Huawei High-Level Talented-Person Cultivation Bases" (in Chinese: Huawei Rencai Pei Yang Ji Di) for *advanced research labs* and *joint programs* with Chinese institutes and universities. These joint programs have allowed Huawei to recruit many talented IT graduates.

Huawei has also formed alliances for scientific research and technological training with a number of foreign universities. These include INATEL University, Brazil (since Sept. 2003), Shrif University, Iran (Jul. 2009), the Ministry of Communication and Information (MCI) of Indonesia and Bandung Institute of Technology (ITB), Indonesia (Nov. 2010), and the Royal Melbourne Institute of Technology, Australia (Dec. 2010). In April 2009, Huawei and the Hong Kong University of Science and Technology (HKUST) established a joint Huawei-HKUST Innovation Laboratory. It provides an innovative model for industry-university collaboration, aiming to connect and inspire researchers from both areas. The lab focuses on next-generation communication and networking technologies, bringing together research areas of interest to both Huawei and HKUST. It conducts state-of-the art research that is expected to have a large

[31]Through this agreement, Huawei provides the ARA Networks Jaguar5000 product as a Huawei cache product and also offers most of ARA Networks' solution portfolio. The Web Cache solution combines Huawei's leading network-consulting capacity with ARA Networks' industry-leading expertise. It is a compelling proposition for customers who seek network-infrastructure efficiency and web-caching solutions.

impact on the ICT industry, the research community, and society in general. In July 2010, Huawei developed this model in China by forming an alliance with the University of Electronic Science and Technology, setting up a Huawei-UESTC joint laboratory. This lab aimed to support frontier research in the information industry and Huawei's product development. Since 2008, Huawei has been sponsoring MIT's Communications Futures Program for the study of future telecommunication technologies. On June 14, 2011, Huawei, TELUS, and Carleton signed an agreement worth more than $1.4M to establish a research lab for enterprise cloud services. This lab in Carleton University's new Canal engineering building provides students, faculty, and engineers a platform for research into the real-world problems associated with cloud computing, such as security and performance issues.

By forming alliances with universities from poor countries, Huawei meets its social responsibility to provide free technical training and education. An example is Huawei's "telecom seed for the future" program, which helps to update the skills of local telecom engineering graduates. Offered at Huawei's East Africa state-of-the-art training center, it provides students from Moi, JKUAT, and Nairobi Universities with advanced training in the latest technologies and the development of Android applications. The center has 2 training labs, 5 classrooms, 100 trainees at any one time, more than 25 professional instructors, and more than 50 part-time instructors. By 2010 more than 4500 students had graduated. Huawei has also granted the University of Engineering and Technology (UET) in Lahore authorized learning partner status for Datacom networking training and certification. Under this agreement, Huawei provides the latest networking equipment (worth USD 0.5M) in the Huawei-UET Telecom center, which trains and certifies engineers in enterprise networking technology.

A networking example at the industrial-district level is Huawei's embeddedness via its R&D center in Silicon Valley. This center has been operating for more than ten years and has produced many advanced technologies for Huawei and the ICT

industry. At the center's ten-year anniversary, John Roese, its senior VP said: *"within five miles, I can find a world leading company, a start-up, a great idea, or a university or somebody to work on everything. And when you want to solve ICT problems where you may suddenly be using information technologies in an energy sector and to create an entertainment experience, the most natural place to make it happen is here."* This comment shows that Huawei has taken advantage of its integrative interfirm network and industrial-district network to help meet its innovation goals, instead of simply aiming to be geographically close to its partners. Huawei's broad view of its so-called eco-system enables it to remove the barriers between enterprises, consumers, and carriers in the ICT industry.

Huawei's CE in terms of the three elements is not elaborated here; see Table 3.5. Huawei's network at the third stage is presented in Fig. 3.6. There are now 84 actors, with 61 exploratory alliances and 23 exploitative alliances. The density is 0.124, the constraint is 0.046, and the efficiency is 0.880.

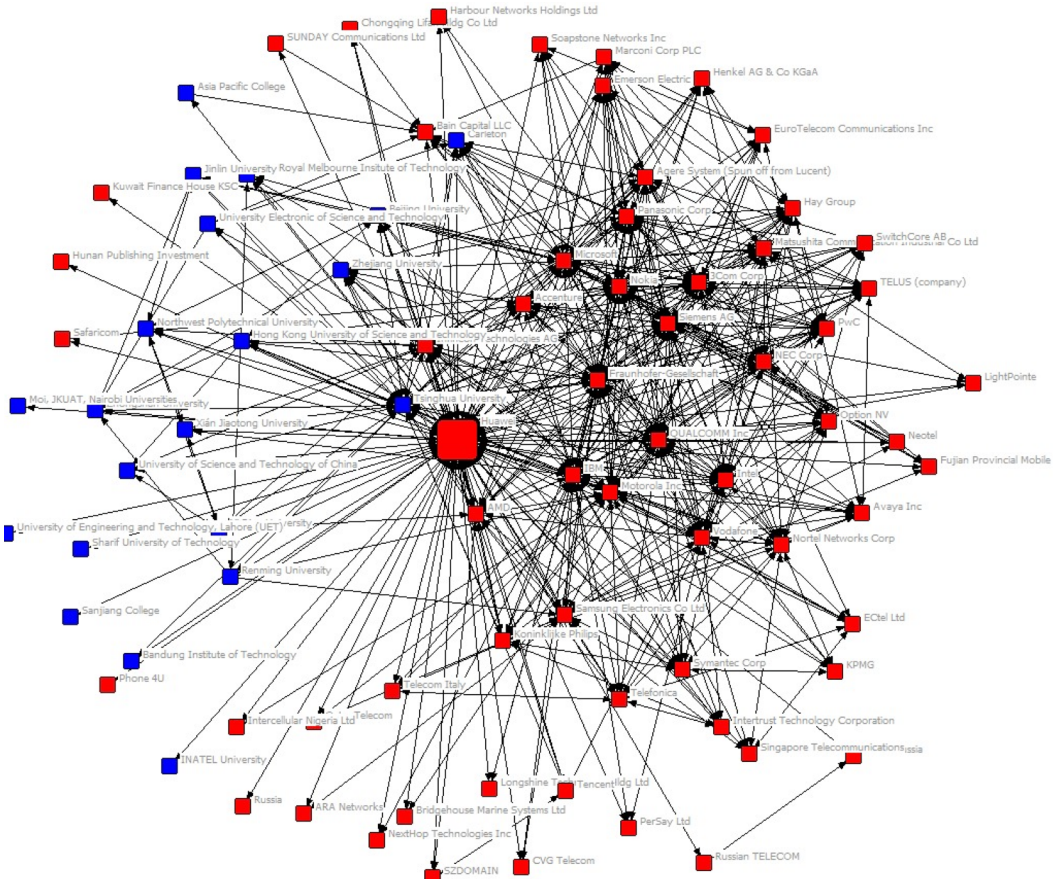


Figure 3.6 Interfirm alliance network: Third stage

Summary and analysis

To summarize, networking is an efficient approach for absorbing, transferring, sharing, and creating knowledge in Huawei's three catching-up stages. Many emerging-country firms catch up by moving from OEM to ODM and then to OBM (Lee, Lee, & Pennings, 2001). In contrast, Huawei's catching-up mechanism involves the networking mechanism and interaction between the internal and external corporate environments. Huawei's network has evolved for twenty

years across the three catching-up stages and the three network layers. This evolution can be summarized as network composition[32], the network structure of social capital, and knowledge transfer.

With regard to network composition, Huawei has focused on working with organizations from developed countries (56% of all actors): Japan, America, and Europe. Of its alliances with developed countries, 36% were with American, 43% with European, and 21% with Japanese firms. These partners all have at least one of the following: a strong industry reputation, excellent technology capability, and rich network social capital. Many (particularly at the first and second stages) are leading industrial players in their regions/sectors. These partners benefit Huawei in two ways. At the early catching-up stage, their strong technological capability and rich network social capital help Huawei to gain social capital and to accumulate absorptive capacity by knowledge diffusion and transfer. At the late catching-up stage, they facilitate Huawei's innovation by knowledge sharing and creation. This is shown by the reduction in the network density across the three stages. We can classify the partners into universities, telecom operators, tech firms, and consulting firms from three segmented regions: developed countries, emerging countries, and China (a total of 12 categories). Stage 1 includes 4 of these categories, stage 2 includes 7, and stage 3 includes 10. At the intrafirm level, the number of business domains and product classes increases. At stage 3, Huawei has 4 large business domains with 13 categories (see Table 3.4).

Figures 3.7 and 3.8 illustrate Huawei's network composition and knowledge flow in the three catching-up stages. The dashed lines in Fig. 3.7 indicate indirect connections, and the solid lines indicate direct connections with Huawei. There are three types of organizations: universities, technology-based firms, and telecom operators (corporations). They are located in three groups of countries:

[32]Network composition characterizes the actors in terms of their stable traits, features, or resource endowments (Wasserman & Faust, 1994).

China, developing countries, and developed countries. This is an open framework so that knowledge from each collaborator can be transferred, diffused, and shared. Huawei acts as a hub, receiving and delivering knowledge.

In the first stage, Huawei worked with Chinese universities, western consulting companies, and Chinese operators to update its managerial system, accumulate absorptive capacity, and dominate the domestic market. In the second stage, it formed alliances with technological firms and operators from western countries, operators from emerging countries, and universities, to access emerging markets, increase its technological capability, and accumulate social capital. In the third stage, Huawei started working with western universities and technological firms from China and emerging countries (where the firms now had an improved technological capacity). It aimed to develop exploratory technologies and to address the resource gaps caused by its enlarged business scale and scope.

Internally, we found that the knowledge transfer from Huawei's R&D subsidiaries and outward R&D alliances in developed markets (such as the research centers in Silicon Valley and Dallas in the USA and Stockholm in Sweden) to headquarters is larger than the conventional flow from headquarters to subsidiaries in developing markets (such as Bangalore in India and Moscow in Russia). Through technological alliances in the segmented international market, Huawei achieves both directions of knowledge transfer.

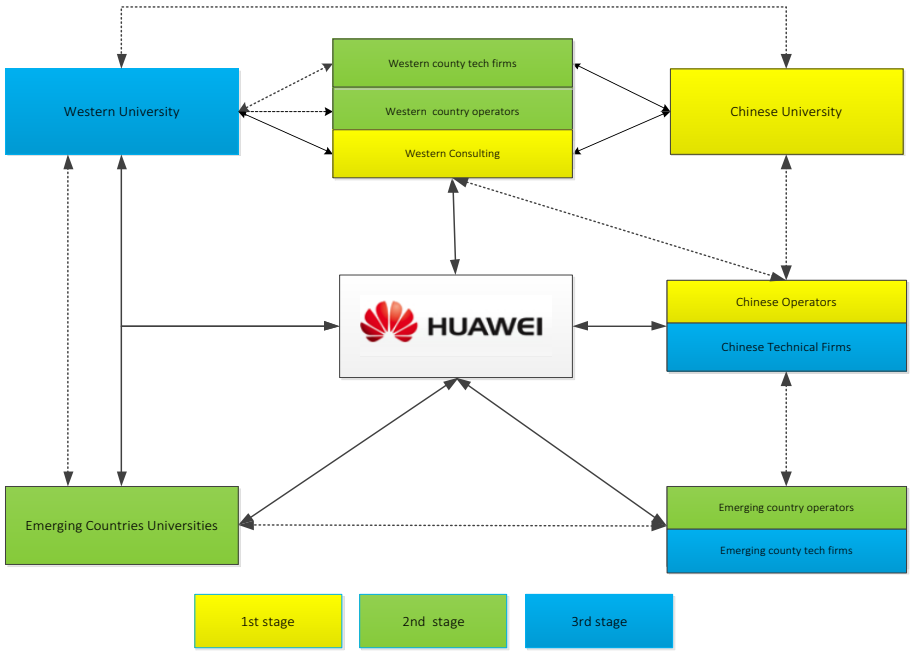
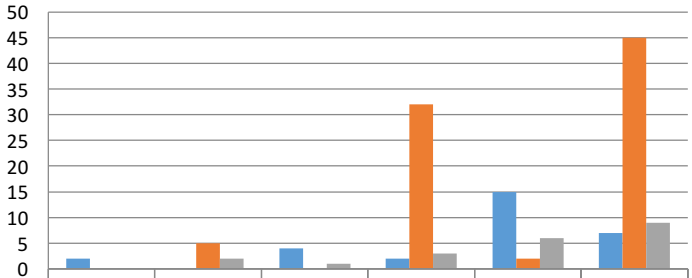


Figure 3.7 Huawei's network composition and knowledge flow at three catching-up stages



	University	Firms	University	Firms	University	Firms
	stage 1		stage 2		stage 3	
China	2	0	4	2	15	7
Developed Countries	0	5	0	32	2	45
Emerging Countries	0	2	1	3	6	9

Figure 3.8 Huawei's alliances through three catching-up stages

Because of the subsidiary mandates (proposed by Cantwell & Mudambi (2005)) and the expectations from headquarters, Huawei's subsidiary R&D centers and outward alliances in the USA, Europe, and other developed countries focus on competence creation. They are expected to introduce new knowledge that can be used by other corporate units or to become centers of excellence (Birkinshaw & Hood, 1998; Frost, Birkinshaw, & Ensign, 2002). They conduct applied research, identify advanced ideas, and transfer back new knowledge. In contrast, the partners in developing countries focus on competence exploitation. They are expected to implement established home-based knowledge effectively in the local environment (Cantwell & Piscitello, 2000). Therefore, in this case knowledge is transferred from headquarters to the subsidiaries.

We can categorize knowledge transfer at the interfirm level based on the typology of DiMaggio and Powell (1983) and Borgatti and Halgin (2011). In the *mimetic process* the ego actively seeks to copy a trait from a node in its environment; this dominates at the early stage. In the *apprentice process* both the ego and its environment are actively trying to help the ego get what the alter has started; this dominates at the late stage. Thus, at the early stage, Huawei acted as an information acquirer, receiving knowledge and social-capital credits from other egos, such as knowledge diffusion from Shanghai Bell and CIT. Later, Huawei became both an acquirer and a provider. As a provider, it offers knowledge and technologies to less-developed markets. As an acquirer, it obtains information from other contacts.

Huawei engages in asymmetric information exchanges: it is primarily a beneficial acquirer (Reagans & McEvily, 2003) in some relationships and a provider in others (Gargiulo, Ertug, & Galunic, 2009). This may be costly (Reagans & McEvily, 2003). However, this cost is diminished because Huawei acts as a provider in emerging markets (e.g., Africa and South America) and balances the knowledge distribution in the network as a provider and an acquirer. Asymmetric information exchanges (Wegner, 1987; Anand, Manz, &

Glick, 1998) do occur. We argue that they can be made symmetric by trading markets for information, balancing the knowledge distribution as a provider and an acquirer in a sparse network, and more importantly by Huawei's commitment[33] to strong ties. In the "brokerage" opportunities created by access to nonredundant information (Burt, 1992), we argue that embedded strong ties in the late stage of a sparse interfirm network facilitate the emergence of trust between the actors. This creates an incentive to cooperate out of concern for one's reputation and group sanctions (Granovetter, 1985; Coleman, 1988). This provides evidence for the reformulated structural hole theory (Burt, 2001, 2005), which indicates that network closure may be a precondition for realizing the benefits of brokerage in settings in which cooperation cannot be taken for granted because of a lack of mutual trust.

In the last twenty years, Huawei's managerial system has been adapted as a result of its collaborations with consulting firms. Therefore, its intrafirm network has become more cohesive and efficient (evolving from an IPD system to a customer-centric system). In contrast, the network density, efficiency, and constraint (Fig. 3.9) show that Huawei's interfirm network has become sparser and more efficient. These two points reveal Huawei's intention to increase its network identity and use networking as an instrument to improve innovation performance. At the early stage, Huawei secured the positive effect of cohesive social ties or "network closure" at both the internal and external level for the production of social norms and sanctions that facilitate trust and cooperative exchanges (Coleman, 1988, 1990).

The cohesive ties, indicated by the strong connections and high network density, have many advantages. They facilitate cooperation (Burt, 1992), accelerate the emergence of trust, and provide incentives to cooperate (Granovetter, 1985;

[33]According to Granovetter (1973), tie strength is a multidimensional concept involving the duration, frequency, and intimacy between the parties. Campbell (1984) argued that emotional closeness between the parties is another indicator. In Huawei's case, we assume that its commitment to relationships indicates the tie strength and the closeness to other contacts.

Burt, 2005) arising from reputation concerns and the high enforcement potential (Raub & Weesie, 1990; Gargiulo, 1993) They enhance the firm's ability to undertake concerted action (Burt, 2005) by amplifying reciprocity (Granovetter, 1974; Lin, Ensel, & Vaughn, 1981; Flap & de Graaf, 1986; Gargiulo & Benassi, 2000). They ease knowledge transfer by decreasing the competitive and motivational impediments that arise (especially when the transfer is beneficial for the recipient but costly for the source; see Argote, McEvily, and Reagans (2003)). They also improve the providers' willingness to devote time and effort to knowledge transfer.

Huawei's lack of social capital and limited knowledge base at the early stage was compensated for by network cohesion with partners rich in social capital and technological capability (Table 3.1). At the late stage, the enlarged interfirm network with a higher degree of centrality and more structural holes offered several advantages. It gave Huawei the freedom to monitor technological opportunities with diverse information, advantages in negotiating relationships, and more flexibility (Burt, 1992, 1997; Gargiulo & Benassi, 2000). It also helped to overcome the *forces of inertia* that may retain ties that no longer have value as social capital (Gargiulo & Benassi, 2000) and the *cognitive lock-in* that isolates a firm from the outer world (Grabher, 1993; Uzzi, 1997). *The cohesive intrafirm network and sparse interfirm network work together to allow Huawei to explore new opportunities through collaboration with external players and to exploit these opportunities by internal cooperation. This, together with the increasing network composition and consistent strong ties at both the intrafirm and interfirm levels, supports the work of Phelps (2010). Phelps' study shows that the benefits of network closure and access to diverse information can coexist in a firm's alliance network. The Huawei case study also shows that the combination of network closure and structural holes with high network composition can exist in a firm between its intrafirm and interfirm network levels (see Table 3.4).*

Huawei's social capital in the three stages based on the study of Lin (1999) is

shown in Table 3.1. Table 3.2 shows the three components of social capital across the three network layers over the three catching-up stages. Huawei's CE activities are summarized in Table 3.3. The evolution of Huawei's ego-network structure in terms of degree (exploratory and exploitative), density, efficiency, and constraint is shown in Fig. 3.9. Huawei's network evolution over the three network layers and the consequences are summarized in Table 3.4.

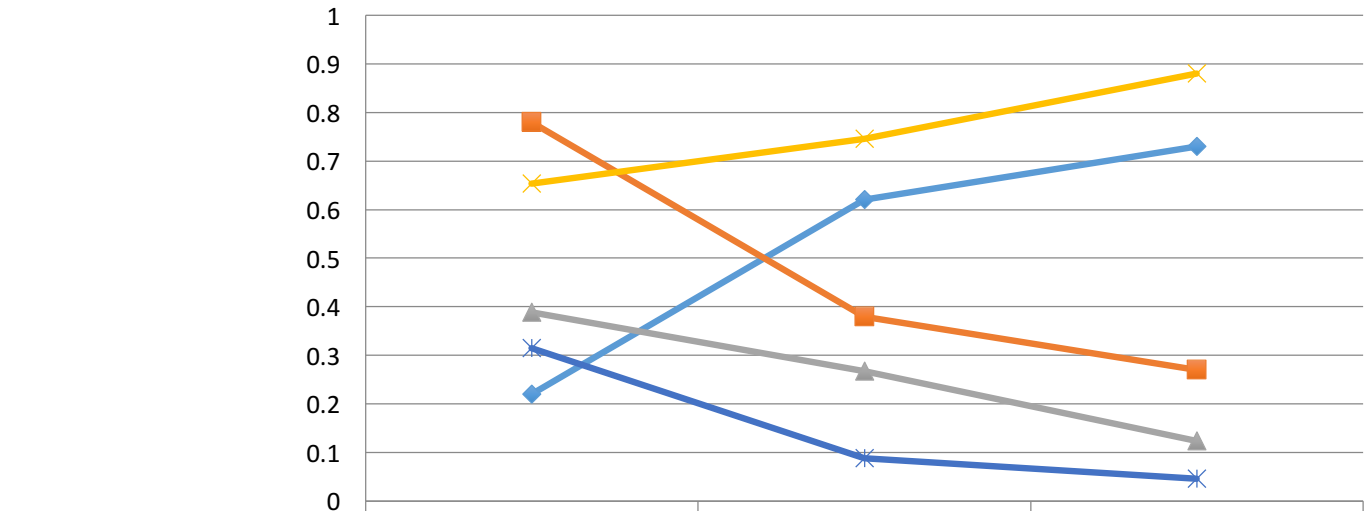
Table 3.1 Measuring Huawei's social capital in three stages

Social Capital		**Phase 1 (1988–1997)**	**Phase 2 (1998–2006)**	**Phase 3 (2007–2011)**
Measure 1: Network Size # of collaborators		9	42	84
Measure 2: Embedded Resources	Network Resources / Ranges, Varieties	2 universities, 5 consulting firms, 2 non-Chinese firms	5 universities, 5 consulting firms, 32 firms	24 universities + more than 20 universities cooperating on training. 6 consulting firms, 54 other firms
	Contact Resources / Powers	Strong structure of social capital, large resource pool, good reputation	Good technological resources, strong structure of social capital	Strong technological capability, strong structure of social capital

Table 3.2 Huawei's three components of social capital across three network layers over three catching-up stages

	Pre-catching-up (1988–1997)			Catching-up (1998–2006)			Post-catching-up (2007–present)		
	Structure	**Relational**	**Cognitive**	**Structure**	**Relational**	**Cognitive**	**Structure**	**Relational**	**Cognitive**
Intrafirm	No marketing branches overseas, only branches (rural market) in China. R&D centers overseas and in China	Huawei Basic Law (#19: efficiency as top priority, fairness as second. Try to be sustainably developed)	Huawei Basic Law (master consciousness)	Overseas and domestic branches	Shared platform	IPD	16 subregions, 100+ branch offices, and 36 training centers globally	Shared Platform	IPD
	Shenzhen is the headquarters, leading other domestic offices			Global headquarters in Shenzhen			Global headquarters in Shenzhen		
Strategic Alliances	2 universities, 5 consulting firms, 2 non-Chinese firms	Huawei basic Law (#24: focus on strategic alliances to learn and accumulate)	Customer requirements decide evolution of product development	5 universities, 5 consulting firms, 22 leading firms	Core Value	"Think and work by standing with customers."	24 key universities, more than 20 universities in training, 6 consulting firms, 53 other firms	Culture of customer - centric innovation	Culture of customer-centric innovation and innovative green solutions
	Closed in joint research,			Selectively closed			Closed and long-term in joint research,		Responsible people and

	marketing, and management						marketing, management, NPD		departments to organize
Industrial district	Shenzhen industrial zone and other industrial zones in China such as Shanghai, Beijing, Xi'an, Nanjing, Chengdu, and Wuhan.	Not much attention to industrial district, focus on competing with a few Chinese firms	Leading position. Large discourse power	Each overseas branch is intentionally located close to customers	Local employees, responsible department, training program in many universities (Huawei certificate)		16 subregions, 100+ branch offices, and 36 training centers in each industrial cluster globally. In Europe, 2 regional and 36 national spare-part centers, 6 training centers, total of 8000 service engineers, 83% from service partners	Working with customers and competitors in nearby locations; locally based to improve trust	Innovative green solutions
	Competing with Zhongxing, Datang, etc.			Huawei University			Geographically close and close partnerships		



	1997	2006	2011
Proportion of Exploratory Actors	0.22	0.62	0.73
Proportion of Exploitative Actors	0.78	0.38	0.27
Ego Network Density	0.389	0.268	0.124
Ego Network Efficiency	0.654	0.746	0.88
Ego Network Constraints	0.315	0.088	0.046

Figure 3.9 Evolution of Huawei's ego-network structure based on various measurements

Table 3.3 Huawei's CE activities

	Innovation		**Corporate Venturing**		**Strategic Renewal**	
	NP	OS	Creation of new business organization	Purchase of new business organization	Change of scope	Competitive approach
1st stage	• HONET integrated access network and SDH product line. • C&C08; • 1997: GSM products, CDMA, and UMTS …	Huawei Basic Law, wolf-like corporate culture	No	No	ICT infrastructure manufacturer	Competitive in rural regions
2nd stage	UMTS products and solutions, and HSPA, switching, integrated access network, NGN, xDSL, optical transport, intelligent networks, GSM, GPRS, EDGE, W_CDMA, CDMA2000 …	Shared platform and integrative product development (IPD) system	Establish business organizations such as terminal, core network, NGN, and digital communication	Acquired 6 new organizations	Complete solution provider	Competitive in international market mainly in developing countries and a few developed countries
3rd stage	Breakthrough innovation in WCDMA, GSM, CDMA, NGN, Datacom, optical networks, broadband, and intelligent networks, especially in LTE (4G) and cloud computing technologies …	Customer-centric innovation system (incorporating IPD)	Formation of 4 large business domains[34] and 13 scopes.	Acquired 4 new organizations	Established ego-network based on own technologies	Global competitive advantage: low price, high quality, innovation

[34] Cloud (building blocks for the cloud, including applications and services, storage and securities, and O&M), Pipe (radio access, fixed access, core networks, transport networks, data communication, energy and infrastructure), and Devices (personal devices, home devices, and devices for enterprises), and others

Table 3.4 Network evolution and consequences

		Intrafirm	**Interfirm**	**Industrial district**
Network composition		Up	Up	Up
Network Closure	Tie strength	Strong	Strong	Strong
	Density	Up	Down	Up
Network Structural Holes		X	Up	X
Benefits and Consequences		Increased norms, trust, and cooperation internally	• Increased network identity • Knowledge and market diversity • More opportunities • Cognitive and relational base for cooperation • Overcome cognitive lock-in and forces of inertia	Snapshot of intrafirm and interfirm network at particular location
		• Explore opportunities externally through structural holes; exploit opportunities internally through cohesive intrafirm network. • Secure function and flexibility function (Gargulio, Ertug, & Galunic, 2009) • Open innovation • Network closure and diversity can coexist (Phelps, 2010) • Network closure is precondition for structural holes (Burt, 2005)		

3.5 Discussion

Catching-up is a complicated topic, because it needs long-term observation at both the corporate level and the national level. An effective catching-up model for a firm is associated with the corresponding international development era. It is also closely related to the dispositions of the corresponding industry and its development inertia. The original Japanese corporate catching-up model is an example; it takes into account reverse engineering, the Japanese business management system, and in-house technology development. It has been effective in a manufacturing-based industrial system, but has faced challenges in adapting to the information-based economic system that emerged in the 1990s (Kondo & Watanabe, 2003).

Previous studies mostly focused on the development of Chinese SOEs from a political point of view. We aim to identify the Chinese catching-up framework from an entrepreneurial perspective. By echoing national catching-up theory at the corporate level, we argue that social advance is the precondition for technical advance, and catching-up firms need social capability to acquire social capital. Assuming that catching-up firms are similar to entrepreneurial firms in terms of innovation and growth-orientation, it is important that they address resource gaps.

By integrating national catching-up theory, network theory, and CE theory, we have proposed a conceptual framework for catching-up (Fig. 3.2) and tested it in the Huawei case. We have demonstrated that networking is an overall approach to help catching-up firms gain social capital, identify resource gaps, address these gaps, and create new growth opportunities. We further investigated the impact of the network as a predictor and the consequences for the catching-up process. First, as a predictor of catching-up, we found that diverse interfirm connections with consulting firms, universities, technological firms, and telecom operators provide catching-up firms with an enlarged network composition. This feature, together with an evolved sparse network and an increased degree of network centrality, gives catching-up firms opportunities to acquire, share, give, and create knowledge, technologies, and markets by contacting central and peripheral network actors. Thus, the increased information diversity is sourced from both the network composition and the structural holes.

Secondly, the increased diversity can be maximized by strong ties that provide the relational and cognitive basis for a common understanding among the different actors. Structural holes and a network composition that contributes to the structural component of social capital might reduce the advantages of network closure such as the acquisition of social capital. However, replacing weak ties with strong ties in a sparse network is able to compensate for this. This shows that network closure and structural holes do not conflict. In contrast, they can coexist and complement each other, because strong ties in a sparse network, with their positive impact on relational and cognitive social capital, can maximize the impact of the structural dimension of social capital. Therefore, interfirm network evolution from dense to sparse provides catching-up firms with sufficient windows of opportunities (Perez & Soete, 1988). These windows help the firm to gain "resources and abilities" to address the resource gap. At the early stage the firm can contact players with a similar technological

background in the cohesive network. At the late stage it can create more opportunities and respond to these opportunities via its sparse network with strong ties.

Thirdly, to achieve technical advance, the intrafirm network must work with the interfirm network. According to the Huawei example, a cohesive intrafirm network can effectively digest the external information acquired and exploit the opportunities found. We are not ranking the importance of the three network levels but instead emphasizing that network phenomena are another consequence of the process, in addition to consequences such as rewards and performance (Borgatti & Halgin, 2011). This means that network evolution is not only path-dependent but also layer-dependent.

Finally, the industrial-district network is a snapshot of the interfirm and intrafirm networks. The impact and evolution of the two network levels are reflected in a geographic region that includes diverse players and opportunities. Also, it is a snapshot of the open-innovation paradigm in firms from emerging countries.

This study makes several significant contributions to the literature on the catching-up of firms from emerging economies. First, we have provided a catching-up framework that captures motivations, options, modes, processes, and consequences. As far as we know, this work is the first study to provide a complete catching-up picture (from the perspective of technological and social capability) for Chinese firms.

Secondly, by presenting a longitudinal case study, this study has contributed to the controversial issue of the role of government versus markets (Amsden, 1989; World Bank, 1993; Chang, 1994). We have shown that the government's development of a national innovation system has helped firms to acquire social capital through cooperation-based networks. However, market forces compel catching-up firms to be more innovative and growth-oriented. We have also contributed to the debate on the Beijing consensus versus the Washington consensus (Huang, 2010) by supporting the Washington consensus from an entrepreneurship perspective.

Thirdly, we have contributed to network theory. We have shown that network closure is a precondition for structural holes (Burt, 2005). Network closure predicts catching-up and has network evolution as a consequence, leading to a reverse impact on CE activities. We have also provided evidence for endogeneity (the *network theory of networks* of Borgatti and Halgin (2011)) of network theory (the consequences of network processes and structures) and the theory of networks (the mechanisms and processes that interact with network structures to yield certain outcomes). We have shown that these two processes can occur together.

This study might initiate a new discussion on the "strength of weak ties" theory (Granovetter, 1973), because the argument that "bridging ties are unlikely to be strong" might conflict with the situation for catching-up firms. Granovetter (1973) uses getting a job and Burt (1992) uses getting promoted to demonstrate the role of weak ties as a bridge or structural hole (their terminology differs). However, the application of bridging ties / structural holes in the catching-up paradigm has not previously been demonstrated. Burt (1992, 2001) agrees that weak ties form a bridge based on his argument that weak ties are more likely to decay. Borgatti and Halgin

(2011) argue that weak ties are useful because they tend to bridge network clusters and their structural holes. In contrast, our case study demonstrates that strong ties can replace weak ties; they provide a greater value for novel ideas because they create relational and cognitive bases between partners.

This study also contributes to network theory by considering an ego's attributes (such as its creativity) and the attributes of the ego's contacts (e.g., their intelligence, gullibility, and power) (Borgatti & Halgin, 2011).

Finally, this study contributes to the open-innovation paradigm by providing new evidence from a multinational from an emerging country. It provides practical support for this paradigm and its drivers, modes, processes, and consequences (Beije & Dittrich, 2008). It also reveals an intersection between CE and the paradigm: using CE to identify/create and exploit opportunities (Ireland, Covin, & Kuratko, 2009) requires enterprises to be more open and collaborative. This study suggests that social networks should receive more attention as an aggregate form of the open-innovation strategy.

This study has several implications. First, Huawei's rapid catching-up at the technological and market levels implies that any company that aims to be a leading player internationally must act in an entrepreneurial manner. Secondly, accumulating social capital in networks is essential. This helps to address resource gaps, build absorptive capacity, and pave the way for further exploration. Thirdly, the selection of partners for the initial collaborations is important. At the first stage, firms should choose partners rich in social capital, for linking and learning. At the second stage, they should choose partners rich in technological and innovation resources, for leveraging and lifting (capability). At the last stage they should choose those willing to exchange and create knowledge, for maintaining and innovating. Moreover, firms should take advantage of the national innovation system that encourages universities, research institutes, and firms to work together. Without strong academic assistance, latecomer firms will struggle to catch up with and keep abreast of leading players. Open innovation at the national and corporate levels allows advanced companies to enrich their technological portfolios and their levels of innovation. It is also useful for latecomer firms, allowing them to catch up and to address resource gaps.

This study has two limitations. First, it focused on a single industry and a single company; reviewers might question its generalizability. However, this approach allows researchers to gain a holistic view of a phenomenon (Gummesson, 1991). Our method follows that of Dittrich, Duysters, and de Man (2007) for IBM, by extending the method of repeated observation in case studies (Yin, 1989) and combining qualitative and quantitative analysis. The combination provides a more solid basis for drawing conclusions than that offered by a purely quantitative description (Dittrich, Duysters, & de Man, 2007). Since we aim to stimulate discussion rather than to provide a definitive conclusion, we look forward to future studies that explore the catching-up mechanism of firms from emerging countries. Secondly, this study lacks first-hand data from Huawei's competitors, customers, suppliers, and collaborators. Such information would make the evaluation more comprehensive.

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