1. Introduction

BACKGROUND

In recent years, industries based on information and communications technologies (ICT) have been the fastest-growing sectors in the economy (OECD, 2000), and one of the most important contributors to business and industrial innovation (for exmple Cairncross, 1997; Greenspan, 1998; de la Torre and Moxon, 2001; Schilling, 2005). ICT is pervasive, with impacts on many elements of industry as well as on many aspects of our daily life (Freeman and Soete, 1997). Since the 1990s, mobile communications and the Internet (data communications) have provided two of the most rapidly diffusing ICTs around the world. At the turn of the century, the potential technological convergence and integration of these two phenomena led many to believe that there would be a revolution through the advent of the so-called 'mobile Internet' (or wireless data communications). This expectation led to massive investments in firms associated with the mobile Internet, mobile commerce, mobile multimedia, mobile payments, third generation mobile communications networks (3G) and so on, and also impacted significantly on national regulations and policies concerning ICT industries in general, and 3G in particular. Until 2001, there was a strong belief that applications based on the mobile Internet would constitute a major breakthrough for radio technology, which is the base for modern mobile communications, and that they would 'take off' at an unprecedented scale internationally.

The reality has turned out to be something of a disappointment. Despite recent progress in mobile data communications – such as Cingular's Blackberry mobile data service (a service providing e-mails on mobile phone sets based on Mobitex data communications technology) in the United States, NTT DoCoMo's i-mode services (mobile multimedia) in Japan, and the booming GSM-based short messaging service (SMS) in Europe and Asia – the general market development of mobile data communications and 3G networks, at least from the consumer's perspective, is still fragmented and uncertain.

The development of the technology and industry from the perspectives of standardization institutes (and/or industry consortia), government regulatory bodies and mobile operators, on the other hand, is seen to be much more promising. Since the late 1990s, all these stakeholders in mobile data communications and 3G mobile networks have undertaken great efforts to develop, standardize, negotiate, license and plan the launch of 3G mobile communications networks and, based on these, mobile data communications. For example, by 2001, telecom operators worldwide had committed an estimated US$1,000 billion[1] investment (including licensing fees, infrastructure build-up, and marketing costs) in 3G systems (Forrester Research, 2001). This investment can be described as the largest 'technology push' ever witnessed in history. Microsoft, Intel, Cisco, IBM and Sun Microsystems, among other leading IT firms, have invested heavily in research and development (R&D) in mobile-related devices and applications. At the same time, the venture capital community has sponsored numerous new ventures based on mobile Internet technologies and applications (ARC, 2003). These developments reinforced a strong belief that a prosperous future lay in the convergence of mobile telephony and data communications in the mobile Internet. There was expectation of a so-called 'killer application' that would trigger the take-off of the mobile Internet. In this environment, mobile commerce (m-commerce) which, utilizing mobile data communications networks, promises to deliver electronic commerce capabilities such as monetary transactions from one party to another directly into consumers' hands – anytime and anywhere – was considered to have such potential. Mobile payments, as a vital tool in m-commerce, therefore attracted considerable attention. Mobile payments, a term referring to multiple, overlapping payment methods in mobile commerce, are defined as wireless transactions of a monetary value from one party to another using a mobile device (Mobile Payment Forum, 2002).

Mobile payment technologies are the result of convergence between the mobile communications and financial payment networks. The emergence and development of mobile payments, therefore, is inevitably a complex process: relying on familiar and well-defined industries, mobile payment technologies function as the interface for an emerging but sophisticated application that requires consumers to change their behaviour in payment activities. The application of mobile payments involves the use of credit cards and direct debit cards – which are almost ubiquitous, widely understood, well trusted by a wide range of consumers, and incorporate a transaction that is not conceptually radical – in a wireless environment. Security is guaranteed by another familiar device, the personal identification number (PIN), which is widely utilized by consumers who use ATMs (automatic teller machines), telephone and/or e-banking

services, and a range of other services where personal authentication is required.

Based on infrared technology, a Korean high-tech entrepreneurial start-up, Avaro InfoTech, Inc., introduced to the world its first infrared-based mobile payment 'showcase' – MAYZ Universal Mobile Payment Services (UMPS) – in April 2002. As pointed out in a *BusinessWeek* article on April 2, 2002, Korea brought the concept of ubiquitous m-commerce a step closer to reality.[2] In this article, Avaro was recognized as the independent inventor of this promising technology. In a more recent article in the *Economist* (July 23, 2005), 'Pay with a wave of your phone: Japan's leading mobile operator believes it has found the next big thing', Avaro was not even mentioned. NTT DoCoMo was put forward as the 'inventor' of infrared-based mobile payment technology. However, in April 2003, NTT Data, the consulting arm of NTT Group, signed an agreement with Avaro to use Avaro's MAYZ mobile payment technologies in trials by NTT DoCoMo (NTT Data, 2003).

The Avaro case suggests that the contribution of independent high-tech entrepreneurial start-ups to industrial innovation is often undervalued and commonly misunderstood. It has long been recognized that technological evolution plays a critical role in industrial development and industry life cycles (Tushman and Andersen, 1986; Dosi*, et al.*, 1988; Anderson and Tushman, 1990; Utterback and Suarez, 1993; Utterback, 1994; Freeman and Soete, 1997). The diffusion of any innovation involves a process of technological improvement and development, and a continuous stream of technological changes (Rosenberg, 1976; Christensen and Rosenbloom, 1995). It may be that industry incumbents contribute more than start-ups to this continuous process of technological improvement and development; as Baumol (2002: p. ix) argues, highly efficient sets of innovative activities are carried out within 'innovative oligopolistic corporations'. However, it is often high-tech entrepreneurial start-ups that initiate breakthroughs in the technological development process. In some ways, this 'transition' from entrepreneurial-led innovations to corporation-driven ones indicates the evolutionary cycle of an industry, within which two different patterns of innovative activities, described as Schumpeter Mark I and Mark II models, take turns in leading (Nelson and Winter, 1982). According to the industry life cycle view (Anderson and Tushman, 1990), at the early stage of an industry's development, technology changes rapidly, uncertainty is high, barriers to entry are low and entrepreneurial firms are often the major innovators, bringing in 'technological discontinuities'. At this stage, entrepreneurial firms are considered to be key elements in industry dynamics; Nelson and Winter (1982) describe this as the Schumpeter Mark

I pattern of innovation. When the industry develops and matures around a 'dominant design' (Utterback and Abernathy, 1975; Anderson and Tushman, 1990; Utterback and Suarez, 1993), technological changes follow well-defined trajectories, and economies of scale, broad technological capabilities, absorptive capacity and financial resources become important in innovative activities. At this stage, incumbent firms show more competitive advantage in industrial innovations; Nelson and Winter (1982) describe this as the Schumpeter Mark II pattern of innovation.

Technological merits alone cannot guarantee the success of the firm that owns them. A technology can be altered according to the choices made by influential actors in a society to serve certain objectives, '...because technology is political … under current political auspices and for the foreseeable future, the new technology will invariably constitute extensions of power and control' (Noble, 1986: p. 351). As Tuomi (2002) demonstrates in the Linux 'open source' development model, fundamentally innovation is a social development in which not only the merits of the technology, but also its meaningful use grounded in social contexts, are very important. This point will be illustrated in both the case of Avaro and the Chinese case presented in Chapter 7, where a joint venture between the world's largest mobile operator[3] – China Mobile Communications Corporation (CMCC) – and the People's Bank of China (the country's central bank), which was endorsed by the central government, has started to introduce and diffuse mobile payment solutions in the country, based on a mobile payment technology invented and trialed by a Chinese high-tech entrepreneurial start-up firm.

In both the Avaro (Korean) and Chinese cases, the real issues relating to the diffusion of the new technology by high-tech start-ups were those of dealing with the challenges of technological uncertainty, complexity and the discontinuous nature of technological development in the context of a highly specific institutional environment including government regulatory policies, (cross-national) industrial standards consortia, and cooperation and competition involving industry incumbents from stakeholders in two established industrial sectors (mobile communications and financial payments). These cases raise the fundamental question: how do entrepreneurial high-tech start-ups contribute to the development of an emerging technology such as mobile payments, and under what conditions?

RESEARCH QUESTIONS

In a high-tech environment, entrepreneurial activity often arises out of technological advances, rather than from the recognition of new commercial opportunities (Kelly and Rice, 2001). Technological advances and diffusion have produced increasing numbers of products that have new functions and, therefore, substitute for existing product offerings, sometimes across industries. This, as a result, has blurred the boundaries of industries or created new industries (Bettis and Hitt, 1995). High-tech entrepreneurial ventures are recognized as one of the key forces in the creation of technological advances (Fontes and Coombs, 2001). However, the economic value of any innovation remains latent until it is adopted and commercialized, and it often generates different economic value depending on the business model upon which the innovation is commercialized (Chesbrough, 2003). Mainstream technology diffusion studies try to understand adopters' behaviour and its consequent impact on the diffusion curve (Bass, 1969; Rosenberg, 1972; 1976; Singhal, 1994; DeBresson, 1995; Moore, 1995b; Rogers, 1995; Geroski, 2000; Baptista, 2001). These studies assume that the 'agents' that manage technology diffusion are large organizations. This is, to some extent, true, because as Rogers (1995: p. 34) claims '…diffusion is fundamentally a social process', and to successfully manage it requires the solution of multiple issues – marketing, distribution, pricing, regulations, finance and politics – that large firms are better resourced to deal with.

An innovation often requires considerable *modification* before it can function successfully in a new environment. The process of modification, or re-innovation (Rothwell and Gardiner, 1988), often involves a high order of skill and ability, which may be beyond the capabilities of the entrepreneurial start-ups that invented it and, perhaps, first introduced it to the market. As Rosenberg argues (1976: p. 186, italics added): 'The *selection* of a technology as appropriate in a particular context, and its *adaptation* and *modification* in order to enable it to function efficiently in an environment different from the one in which it originated, are activities which typically require a very high degree of technological sophistication.' Thus, it can be argued that the diffusion of an innovation is inextricably interwoven with its *development*, which often involves the participation of incumbent organizations and complementary assets (Teece, 1986; Teece*, et al.*, 1997). In other words, in order for an innovation to become technologically mature and commercially viable, the innovation process needs complementary contributions from different players, especially incumbents in the industry in question. However, in practice, alliances and

technology licensing contracts between high-tech start-ups and large incumbents often involve heavy transaction costs, which, as a result, may squeeze start-up firms out of competition (Christensen, *et al.*, 2005). This suggests that the significant contribution made by entrepreneurial start-ups in the process of technological development and diffusion may be neglected because while small firms are able to set the innovative agenda in the early stages, incumbents tend to take an increasingly dominant role in organizing and maturing the technology (Miller and Garnsey, 2000).

Traditionally, a high-tech entrepreneurial start-up's role is considered to be that of a technological 'challenger' (Schilling, 1998; Chesbrough, 2003) or an 'agent' for technology transfer (Fontes and Coombs, 2001) rather than a direct engine of economic growth (Miller and Garnsey, 2000). Entrepreneurial start-ups, constrained by a lack of internal resources – known variously as liability of newness (Singh, *et al.*, 1986) or liability of adolescence (Fichman and Levinthal, 1991), liability of smallness (Baum, 1996), and liability of foreignness in the international market (Zahra, *et al.*, 2005) – confront severe challenges in their early stages of development. On the other hand, traditional variables measuring the contribution of a firm in economic activity (such as sales revenues, profits, taxes, employment, export outputs, investment in R&D and so forth) do not provide accurate measurement of the contribution made by high-tech entrepreneurial start-ups, especially before they can generate sustainable growth.

Baumol (2002) believes that most of the utility in technological products comes from more routine innovation that takes place after the product has entered the marketplace. In other words, most improvements in economic welfare are due not to major breakthroughs, but rather to routine improvements in existing products and processes. Baumol's view (2002: p. ix), emphasizing the importance of 'systematized, bureaucratized, and highly efficient sets of parallel activities' carried out within 'innovative oligopolistic corporations' in the development of technological innovation, fails, however, to recognize the contribution of independent innovators (often entrepreneurs) who may provide the breakthroughs that initiate the technological development process. By introducing a new technology into the marketplace, entrepreneurs can potentially stimulate the development of an entire new industry. Due to path dependency – the way that relatively small historical events may have a great impact on the final outcome (Arthur, 1989; 1994) – entrepreneurial start-ups' initial efforts to introduce their innovations to the marketplace often have a profound impact on the trajectory of the diffusion, especially if those innovations are 'selected' by the market.

In this context, this book aims to answer several questions: What *roles* do entrepreneurial start-ups play in the emergence and development of a

new technology in the networked economy? What are the main *strategic choices* that enable entrepreneurial start-ups to contribute to the emergence and diffusion of a new technology? What major *factors* constrain the innovation strategies of entrepreneurial start-ups?

INTELLECTUAL MAP AND ANALYTICAL FRAMEWORKS

A technological system such as mobile payments can be examined at different levels of analysis, such as at national, sectoral, network or component levels. The development of a technological system involves not only its construction, but also its use. In a complicated technological system which consists of various components and subsystems, both the attributes of and relationship between the components or subsystems influence the development of the system. The development of a technological system, therefore, is influenced by numerous interrelated social, legal, institutional, economic, organizational and technical factors, and often involves changes in industrial structure, technical standards and regulations or the creation of new industries (Rosenberg, 1976; Anderson and Tushman, 1990; Rogers, 1995; Baptista, 2001; Schilling, 2005). In other words, the development of a technological system often causes the creation of a new 'value network' – the context within which a firm competes and solves its customers' problems (Christensen and Rosenbloom, 1995). According to Carlsson and Stankiewicz (1991), for an emerging technology to evolve into self-sustaining and self-reinforcing applications with economic value, there must be three underlying elements: (1) innovative ideas, or an embryo; (2) mechanisms for getting the diffusion process started (often entrepreneurs); and (3) a favourable institutional environment for the applications, embedding the technological ideas to be adopted and diffused by users. These three elements suggest that in order to investigate the questions outlined in the previous section, a set of research issues must be developed from the literature on innovation management, high-tech entrepreneurship and their institutional context.

In recent decades, the primary source of wealth in many industrialized countries has been knowledge itself (Cairncross, 1997; Teece *et al.*, 1997; Schilling, 2005). As Dunning (2000) points out, in high-tech industries, innovations occur so frequently that the market is never in equilibrium. The acquisition of technological capabilities is believed to be a complex learning process at all levels in a society (Dodgson, 1993a; Kim, 1997; Schilling, 2005). We propose therefore, when examining a technological

development, analysis should begin with its *technical* system (components and relations between them), then move to its *technological* system (interfaces and standards based on which different components or subsystems interact to serve a specific function), then to its *actor* system (the stakeholders along the value chain of the system in question), and finally to its *institutional* system (in which all these elements at different layers operate).

Hence, two sets of analytical lenses in their institutional context are needed to examine the central research questions. They are depicted in Figure 1.1. The first, developed from the literature on innovation management and diffusion, addresses issues related to the technical and technological systems, as well as the institutional system of a technological development. The second, developed mainly from the entrepreneurship literature, addresses the issues of the actor system, again within an institutional context.

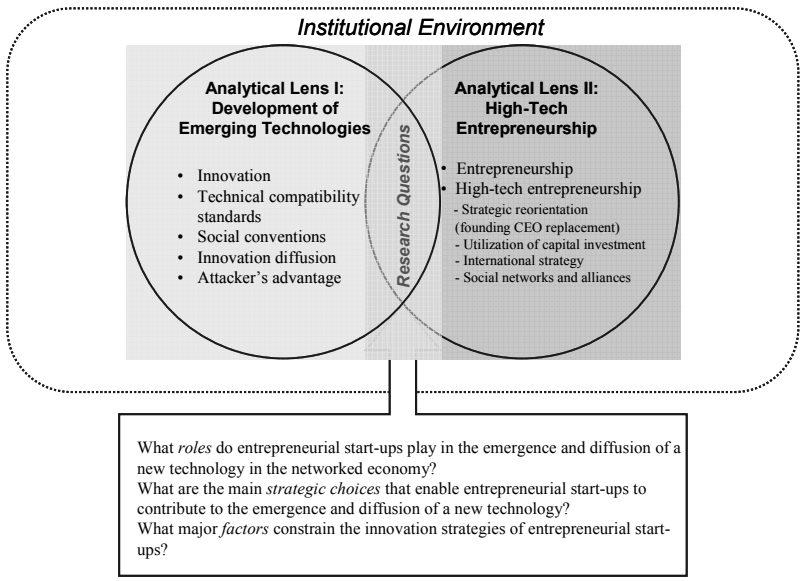

Figure 1.1: Intellectual map

The Global Network Economy

Innovation is a complex and lengthy process that involves not only the innovative firm but also a system of interactions and interdependencies

between the firm and other organizations and institutions around it (Dodgson*, et al.*, 2005). Traditional studies of the diffusion of innovation mainly focus on adopters' behaviour and their consequent impact on the diffusion curve (Moore, 1995a; Rogers, 1995). However, due to the importance of *network effects* (or network externalities), whereby products and services rely on being compatible within networks of users and which helps explain the long lead times for many innovations, followed by explosive growth in the diffusion of *interactive technologies* (Farrell and Saloner, 1985; Katz and Shapiro, 1985; Arthur, 1996), an inferior technology or network, instead of superior alternatives, may be adopted by the market as a standard (David, 1985; Rosenbloom and Cusumano, 1988). This phenomenon has drawn attention from a wide range of researchers (Katz and Shapiro, 1985; 1986; Robertson and Gatignon, 1986; Arthur, 1990; Katz and Shapiro, 1994; Saloner and Shepard, 1995; Liebowitz and Margolis, 1998). Given that network effects are a typical characteristic of the modern network economy (Castells, 1996; Shapiro and Varian, 1998), it can be argued that the market alone may *not* be adequate in picking up the optimal technology or network for society; therefore, other factors in a broader context may play an important role in the development of emerging technologies. To understand this dilemma, it is useful to consider the nature of the global network economy, its boundaries and characteristics.

Towards the end of the last century and into the twenty-first century, major western economies, at least *partly*, have undergone a transformation from '…processing of resources to processing of information, from application of raw energy to application of ideas' (Arthur, 1996: p. 100). This transformation implies that a new mechanism of economic returns has started to kick in to determine underlying economic behaviours and business competition in part of the modern economy.

Indeed, the world economy is experiencing a number of broad trends including the rise of an economic environment characterized by increasing globalization and inter-connectedness, in which knowledge has grown in importance as an input to a range of products and service and a revolution in ICTs (Cairncross, 1997; Greenspan, 1998; Shapiro and Varian, 1998; Bartlett and Ghoshal, 2000; Doz*, et al.*, 2001). In *Death of Distance,* Cairncross (1997) describes how distance no longer determines the cost of electronic communications and how this has driven fundamental structural changes in modern society. The business and financial press has adopted the term 'new economy' to describe these societal changes (Greenspan, 1998), while academics tend to use the terms 'network economy' (Shapiro and Varian, 1998), 'information economy' (Castells, 1996) or 'knowledge

economy' (Doz *et al.*, 2001) to define the changes related to globalization, the ubiquity of ICT facilitating connectivity and the increasing knowledge content of business. All terms have their merits in highlighting different aspects of these changes in society; however, the concept of 'new economy' is, to some extent, misleading – in fact, the world economy, led by the advanced capitalist economies, is continually in a process of 'creative destruction' as Schumpeter (1934) described it many decades ago. Shapiro and Varian (1998) reinforce this point in their book *Information Rules*, arguing that durable economic principles do *not* change while technologies do in today's frenetic business environment.

Indeed, not all parts of the modern economy are 'new'. There are two types of economies existing alongside with each other. As Arthur (1996: pp. 100-101) points out, the modern economy has split into two interrelated parts of business corresponding to the two types of economic returns: *diminishing returns*, based squarely upon the assumption that '…products or companies that get ahead in a market eventually run into limitations, so that a predictable equilibrium of prices and market shares is reached'; and *increasing returns*, mechanisms of positive feedback that can cause possible customer 'lock-in'[4] within markets, businesses and industries, which reinforce '…the tendency for that which is ahead to get further ahead, for that which is losing advantage to lose further advantage'. Hence, increasing returns reign in the newer part of the modern economy – the high-tech driven 'network economy'[5] – while diminishing returns operate in the more traditional part of the economy – the processing industries (Arthur, 1996; Shapiro and Varian, 1998).

The central difference between these social and business structures, according to Shapiro and Varian (1998), is that the 'new' part is driven by economies of *networks*, while the 'old' part is driven by economies of *scale*. The result is that new firms such as Yahoo! and eBay, amongst others, have emerged as leaders in shaping their respective *new* industries. On the other hand, not every new firm can win in the 'newer' part of economy: many high-tech entrepreneurial start-ups and their innovative ideas never take-off because further development of their innovations relies fundamentally on existing infrastructure and assets, and such firms do not have the ability to leverage resources in well-established industries. Numerous new firms that were created to take advantage of the opportunities of e-commerce or m-commerce, for example, failed simply because they did not have the resources to deal with the rules that still control traditional commerce (this being especially true in the business-to-consumer (B2C) sector) (Kalakota and Robinson, 2001).

The network economy – the 'newer' part of the modern economy – is characterized by two distinctive features: (1) network effect or network

externalities[6] – the advantage of being connected to a larger network, real or virtual; and (2) temporary monopolies – today's leading market positions are more likely to be replaced by emerging start-ups with superior technologies, and in shorter intervals (Arthur, 1996; Shapiro and Varian, 1998; Casson, 2000). In the network economy, the standardization and standards-setting process of any emerging technology is strongly influenced by social conventions and public policies that are customary and self-reinforcing. In this process, the institutional setting (including government regulatory bodies, cultures, and business systems) plays a critical role. Indeed, to commercially exploit any technological innovation, technological capabilities must be coupled with the right business capabilities (such as regulatory frameworks, business systems, culture and business strategies) in a society (Kim, 1997; Dodgson, 2000b). It becomes essential to differentiate between technological and business capabilities at different layers of network. Figure 1.2 depicts a three-layered network model (*infrastructure*, *architecture* and *application*) to show the general structure of a 'network' or an interactive technological system, where the distinction between the system and sub-systems (components) is clear and the interdependency between them is important. Many modern high-tech industries are operating based on such a structure in the network economy. At each layer, there are distinct characteristics, which require different strategies (business and technology) in managing the development of emerging technologies.

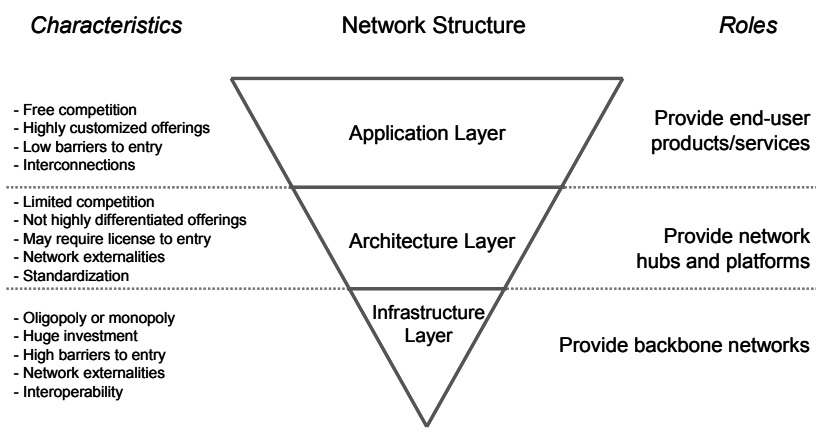

Figure 1.2: Network structure

The largest network in the world, the Internet (world wide web), is composed of three distinctive layers: public telecommunications networks

and international 'gateways' which provide backbone telecom infrastructure and link the telecommunications (Internet) networks across different continents by telecom carriers in each country; access networks which provide Internet access to users (they are often leased from telecom carriers by a limited number of Internet services providers (ISPs)); and application services providers (ASPs) and Internet content providers (ICPs) which provide end-users applications.

In the case of mobile payment technologies, because the distinction between systems and components is clear and interdependency between them is important, the technological system can be analysed using this network structure model: mobile communications and payment infrastructures are at the infrastructure layer; mobile payment platforms are at the architecture layers; and different payment solutions are at the application layer.

Analytical Lens I: Development of Emerging Technologies

Successfully managing the development and diffusion of emerging technologies is a complex, dynamic and multi-faceted task in the network economy (for example, Rosenberg, 1972; Rogers, 1995; Geroski, 2000). Where the increasing returns mechanisms and network effects drive the development of the industry, technological prowess alone is not enough to guarantee an emerging technology's success (for example, Anderson and Tushman, 1990; Utterback, 1994; Funk, 2003; Schilling, 2005). The diffusion of an emerging technology is a function of multiple factors, including the marginal utility offered by the new innovation; the state of enabling technical systems and their complementary or competing systems; the status of customer expectations; the threat of competitive forces (new entrants or incumbents); the issue of whether the industry faces increasing returns; and, fundamentally, a firm's internal and external resources. The collective result of these factors is that a particular technology may have a better chance to be selected as a technological standard or a 'dominant design' if it is institutionalized and selected by certain social conventions (Anderson and Tushman, 1990; Besen and Farrell, 1994; Utterback, 1994; Schilling, 2005). As a result of network externalities, the status derived from being recognized as a technical standard often leads to positive feedback and increasing returns working in favour of the firm which possesses this standard technology. At a social level, customers may subscribe to the 'network' embedding this technology, not just because of their individual assessment of the quality and usefulness of the network, but because of 'herding' pressures caused by the number of customers that have already adopted this 'network' (Schelling, 1978; Bikhchandani*, et al.*,

1992; Shiller, 1995; Choi*, et al.*, 2000). Standardization and standard setting, from both a technological and social perspective, have changed the very nature of competition in the network economy, especially in emerging industries.

Analytical Lens II: High-Tech Entrepreneurship

High-tech entrepreneurial start-ups are recognized as one of the driving forces behind innovative technological changes in the modern economy (Schilling, 2005). On the other hand, limited by liabilities of newness, smallness and foreignness, high-tech ventures often face enormous challenges to develop viability and long-term growth (for example, Dodgson and Rothwell, 1989; Garnsey, 1998; Schilling, 2005). However, history has shown that many successful high-tech entrepreneurial ventures, such as eBay, Yahoo!, Microsoft and Dell, among others, have become vital players in their respective industries and have, in fact, created new industries or changed the structure of existing ones. One thing these successful high-tech ventures have in common is that they undertake a strategic re-orientation at a certain point in the course of their developmental cycle (Gersick, 1994), changing their resource base from *entrepreneurial* capabilities – the ability to identify new opportunities and develop the resources necessary to match the opportunities in the start-up phase (Arthurs and Busenitz, 2006) – to *dynamic* capabilities – the ability to adapt quickly to the changing environment (Teece *et al.*, 1997; Dodgson *et al.*, 2005). In the course of their development, such firms often need to make several critical strategic choices. For example the entrepreneurial firm needs to:

- identify and analyse the business model necessary to bring their business vision and technological innovation to the marketplace;
- think ahead about whether or not the venture takes an early internationalization approach and, if so, where to obtain the required resources;
- consider whether to collaborate with established companies, which itself can be a matter of life or death for the start-up;
- consider whether to share control under a new governance structure in return for necessary financial capital;
- acknowledge the need for the venture to undergo a strategic re-orientation, in which the founding CEO may need to be replaced by professional managers.

DEFINITIONS

This book aims to gain an understanding of how high-tech entrepreneurial start-ups contribute to the vitality of an emerging technology and what factors and conditions are critical in enabling them to do so. In order to provide clarity, it is necessary to give clear definitions of the key concepts in the central research questions, and also to establish the authors' position in relation to these concepts.

There is no clear-cut definition of a high-tech entrepreneurial start-up. This type of firm is sometimes referred to as a new technology-based firm (Bollinger*, et al.*, 1983; Autio, 1994; 1997; Fontes and Coombs, 2001; Colombo and Grilli, 2005). Nonetheless, it is widely agreed that this type of firm has several common characteristics. According to Bollinger *et al.* (1983), these attributes include: (1) a clearly identifiable nucleus of people, ranging from one to four or five, as the founders of the venture; (2) independence,[7] that is to say the venture is not a subsidiary of a large organization; and (3) innovation: the primary motivation for founding such a venture is to exploit a technically innovative idea.

An emerging technology, arising from a technological innovation, has the potential to change existing customers' needs, or create new customer demand and, as a result, to generate new consumption behaviours or new processes of production (Barney, 2002). This type of technology may take the form of a 'discontinuous' innovation (Robertson, 1971; Anderson and Tushman, 1990), making previous knowledge bases redundant. High-tech products, according to Arthur (1996: p. 103), are complicated to design and to deliver to the marketplace; '…they are heavy on know-how and light on resources…'. This rather simple and direct description implies three embedded attributes of high-tech products and/or services: (1) high up-front costs – these types of products or services often have R&D costs that are large relative to their unit production costs; (2) network effects (or network externalities) – many of these types of products or services rely on being compatible with a network of users; and (3) customer lock-in – these types of products or services are typically difficult to use and require user training (Arthur, 1996; Shapiro and Varian, 1998; Schilling, 2005). These attributes determine that in high-tech markets, increasing returns[8] mechanisms work to provide high-tech products or services that have gained initial market advantage with further advantage, making these markets unstable and subject to a lock-in effect (Schelling, 1978; Arthur, 1994; Dickson, 1995).

Mobile payment systems are the focal technological system examined here. Mobile payments are defined as wireless transactions of a monetary

value from one party to another using a mobile device (Mobile Payment Forum, 2002). Mobile payment technology has some unique features that make it an interesting focal technology through which to understand the phenomenon of technological convergence and its evolutionary path. First, given the rapid technological development and market growth of mobile payment systems, it provides a relatively short time frame within which to study the emergence and evolution of the dynamics of the industry. Second, mobile payment systems, relying on large infrastructure networks (mobile communications networks and payment networks), provide an excellent opportunity to appreciate the importance of large network characteristics such as network effects, standardization, scale economies and strong and complex system interdependencies. It has been noted that large infrastructure networks such as those in the telecommunications industry can present paradigmatic cases of standard setting in complex technological systems (David and Steinmueller, 1994). An industry such as mobile payments which relies on large networks is often one in which government has a strong interest in setting the standards (Funk and Methe, 2001).

An industry relying on large infrastructure networks has two inherent characteristics in its diffusion pattern: network externalities (Allen, 1988; Schilling, 1998; Shapiro and Varian, 1998; Mahler and Rogers, 1999; Mansell and Steinmueller, 2000), defined as a quality of certain goods and services such that they become more valuable to a user as the number of users increases (Mahler and Rogers, 1999); and critical mass (Allen, 1988; Moore, 1995a; Mahler and Rogers, 1999), defined as the minimum number of subscribers for an interactive product or service to achieve self-sustainable growth (Rogers, 1995), or the point at which an interactive innovation is perceived as valuable by potential adopters (Mahler and Rogers, 1999). The combination of these two aspects of a particular innovation can, in a favourable institutional environment, potentially speed up the diffusion process.

METHODOLOGY

Since the circumstances of high-tech entrepreneurship are characterized by technological complexity and environmental dependency in the global network economy, this book takes an *eclectic* multidisciplinary approach. It uses a process-oriented case inquiry to investigate the *processes* of technological development and diffusion of mobile payments initiated by high-tech entrepreneurial start-ups in Korea and China: nations that

respectively lead the world development and use of mobile payment technology and provide the world's largest mobile telephony market. The benefit of this approach is that it has the capacity to address processural matters and to deal with a multiple stakeholder environment (Stake, 2003). In order to examine the unique processes of each case in its original *context* – technological, national and so on – the research design of this study is targeted at obtaining data in a real-life environment, focusing on understanding the interactions of and relationships among many influential players.

High-tech entrepreneurship research engages with a holistic and dynamic process, involving numerous antecedent variables, and whose outcomes are extremely sensitive to 'events' – decisions, actions, activities and their interactions in a time series (Gersick, 1994). The *interactions* between the levels of analysis (such as entrepreneurial individuals, entrepreneurial firms, industrial settings and the societal/institutional infrastructure) in entrepreneurship study are vital for understanding the sequences of events within each case. Therefore, in this study, the *process of events* in each case study is treated as a holistic unit of analysis, which allows an examination of changes in the levels of analysis over time (Van de Ven and Huber, 1990; Van de Ven and Poole, 1990; Dansereau*, et al.*, 1999; Langley, 1999).

The study uses a two-pronged strategy, which is described as a 'double loop' approach (see Chapter 5). This means that the case studies are built upon conceptual structures that are anchored in analytical frameworks developed in Chapters 3 and 4; at the same time, in the process of constructing the case studies, the findings provide another channel by which to identify complex, situated, problematic relationships related to the research questions. The conceptual convergence between the findings developed from the analytical frameworks and the constructs from the empirical case studies leads to a set of abstracted propositions in the analysis process.

Both case studies are constructed in an eclectic way with a focus on *events* in a time process, drawing in phenomena such as the changing relationships and interactions between, as well as cognitions and feelings of, the stakeholders involved. The objective of these case analyses is to examine the dynamic processes of each case in the presence of multilayered and changing contexts, multidirectional causalities and feedback loops that often disturb a steady progression toward equilibrium (Langley, 1999). The two case studies were not chosen with the objective of direct comparison as, for example, would have been provided by two very similar firms in different places. Instead, each case is examined in such a way as to concentrate on understanding its own complexities and

dynamics. This approach can be described, according to Stake (2003), as a 'collective case study'. In addition, the two cases are embedded in their own unique national contexts – Korea and China – which differ considerably in terms of factors such as industrial policies, innovation systems, business systems, cultures and ideologies. All these factors, individually or collectively, have an impact on the emergence and development of high-tech activities.

The research design and protocols are detailed in Chapter 5.

REFLECTIONS ON THE BOOK'S CONTRIBUTION

Given the importance of technological innovation as one of the driving forces for modern economic growth, the role of high-tech entrepreneurial start-ups, often as the initiator of a new technological innovation, has not been given sufficient consideration in the literature dealing with technological development and innovation diffusion (Autio, 1997; Miller and Garnsey, 2000). This lack of recognition of high-tech entrepreneurial start-ups in the technological development process is even more relevant if the innovation from such a firm survives, but the firm fails to achieve viability and long-term growth. It is particularly interesting to examine high-tech entrepreneurship in the emerging technological powerhouses of Asia, and in countries like Korea and China where traditionally it is large, established firms that are presumed to be the technological leaders.

The major contribution of this book is to enrich our understanding of high-tech entrepreneurship by undertaking process-oriented case studies within their specific national and technological contexts. Many high-tech start-ups are competing in some emerging industries with radically new technologies that are awaiting government evaluation and sanction, for example, the adoption of 3G standards at a national level (Arthurs and Busenitz, 2006). The case studies in this book, by piecing together the 'events' that occurred in a time sequence (process) in their special conditions and environments, identify the factors (technological, industrial, institutional, cultural and social) that influenced the subject firms to make certain strategic choices, and specify the conditions and contexts in which the firms made those choices. The implications of this are relevant not only to the entrepreneurs who manage a technological development, but also to public policy makers. If they have an understanding of the critical factors that influence the success or failure of a high-tech firm in managing the development of a new technology, managers (entrepreneurs) can formulate their strategic choices in anticipation of these factors. Public policy makers

can also better consider policies which encourage the contribution of such firms to economic growth.

NOTES

1. According to Forrester Research's report (2001), total 3G implementation costs exceeded US$13 billion (around €10 billion) per operator in a large European country. For example, France Telecom was expected to spend US$14.5 billion on its 3G roll-outs – with US$6.43 billion for licenses, US$6.5 billion for network build and US$1.65 billion for marketing.
2. 'South Korea: A Nation of Digital Guinea Pigs.'
3. With 310 million mobile subscribers (as of the end of 2004), China Mobile Communications Corporation was the largest mobile operator in the world.
4. Williamson (1975) recognized the concept of 'lock-in' – an important concept in the network economy – which is explained in detail in Chapter 3.
5. In this book, 'network economy' is used to refer to the 'newer' part of the modern economy, which represents some fundamental structural changes in society.
6. Network externalities were first defined and discussed in Rohlfs (1974). The idea was dormant for several years until Katz and Shapiro (1985) recognized its importance for strategy and Farrell and Saloner (1986) explored the dynamics of installed base competition. Arthur (1989; 1994) has emphasized the role of positive feedback in the economy. This concept is discussed in detail in Chapter 3.
7. Independence, however, is hard to judge because, for example, one entrepreneur (or an entrepreneurial team) may found more than one venture at the same time, to which he or she may have cross-ownerships, and in some cases a bigger one may own a smaller one.
8. Schilling (2005) claims that path dependency (learning effects) and network externalities are two primary sources of increasing returns.