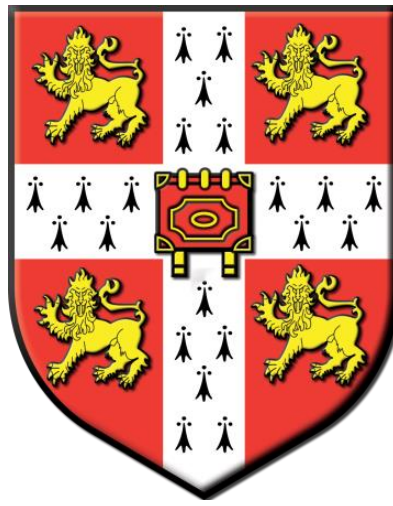


Industry Emergence and the Underlying Ecosystems

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PREFACE

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text. It is not substantially the same as any that I have submitted, or, is being concurrently submitted for a degree or diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text. I further state that no substantial part of my dissertation has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University of similar institution except as declared in the Preface and specified in the text.

The dissertation does not exceed the limits of 65,000 words and 150 tables and figures put forth by the Degree Committee of the Department of Engineering.

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September 2022

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ABSTRACT

In this digital era, the emerging industries enabled by digital technologies such as cloud computing, big data, and artificial intelligence have shown different patterns in contrast to the product-centric industries in the industrial era. Rather than producing a standard product at lower costs through mass production, the key to the emergence and development of contemporary emerging industries is delivering customised and complex solution and services for different customers. The increasingly complex value proposition requires external resources and knowledge from different industries, thus making ecosystems more important as a new way of organising innovation and business.

The service-centric, customised, and boundary-crossing trends in the digital age have challenged the classic product innovation and industry evolution theories that are largely based on evidence from the industrial age. Although the stages of industry emergence have been examined, apart from the process perspective, we still need to uncover how the transitions between stages are achieved as well as how a new industry is created by a set of actors from an organisational perspective. Moreover, the cumulative research on industry emergence from diverse disciplines requires integration.

The aim of this research is to explore: how does a new industry emerge based on the underlying ecosystems? Specifically, the two sub-questions are: (1) how does industry emergence unfold in the digital era? and (2) how do the underlying ecosystems enable the transitions and emergence? To answer these research questions, I conducted an in-depth longitudinal study of the cloud computing industry in China from 2008 to 2021. Through multiple methods to theorise from process data, I developed the holistic process model of industry emergence and the industry ecosystem models from actor and activity perspectives.

Concerning the industry emergence process, four stages and four transitions characterised by dominant design dynamics are identified. The findings show the decoupling between the dominance of technology design and the dominance of business model design and how the dominant design dynamics influence industry emergence, which fills the gap in industry emergence research and contributes to dominant design theories. Concerning the underlying ecosystems, this research firstly identifies the role of ecosystem shapers, complementors and facilitators at different stages of industry emergence. Secondly, it explains the generic transition mechanism by identifying the multi-level industry ecosystem as the linkage between the supply side and demand side and by introducing cross-industry innovation and application scenario as new elements in the industry ecosystem. This fills the gap in ecosystem research at the industry level, and gives strategic and policy implications.

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Chapter 1 INTRODUCTION

1.1 Research Background

Nowadays, as technologies and markets are changing rapidly, industries are developing and evolving at an accelerating pace with a shorter lifecycle. A technological breakthrough may create obsolescence for an industry (Sosa, 2013). An unprecedented number of new-to-the-world industries have emerged in the past two decades and digital technologies such as cloud computing, Industrial Internet of Things (IIoT), Artificial Intelligence (AI), warehouse robotics, and smartphones have disrupted the old industries (McDonald and Eisenhardt, 2020). The industrial challenge is how to navigate and shape an emerging industry. However, knowledge of the early stages is much sparser than that of the later stages (McGahan et al., 2004). Compared with mature industries, emerging industries have been relatively understudied due to the paucity of available data (Sanderson and Simons, 2014). Considering that new industries keep emerging and products keep upgrading in this digital era, the necessity and feasibility of industry emergence have increased.

The emerging industries enabled by digital technologies such as cloud computing, big data, and artificial intelligence tend to be solution- and service-centric, in contrast to the product-centric industries in the industrial era (Suarez et al., 2013). Rather than producing a standard product at lower costs through mass production, the key to the emergence and development of contemporary emerging industries is providing customised and complex solutions or services for different customers through mass customisation (Chesbrough and Appleyard, 2007; Kapoor and Furr, 2015). In addition to technology design, business model design has become increasingly important for materialising a new value proposition in a new market, and should be prioritised in the contemporary strategy framework and business building (McDonald and Eisenhardt, 2020).

Another major change in this digital age is the rise of ecosystems as a new organising form for innovation and business. The increasingly specialised nature of organisations means that a single firm only possesses part of the resources to develop and commercialise a complex value proposition (Chesbrough and Appleyard, 2007; Kapoor and Furr, 2015). The knowledge and resources required to innovate are often located outside the firm or even industry boundary, and with the development of digital technologies the cost of accessing external knowledge and resources has dropped dramatically (Baldwin, 2012); therefore, “ecosystems are becoming a desirable, or even necessary, form of organising digital innovations” (Wang, 2021, p.3). The ecosystem participants providing complementary innovations, products, or services “might belong to different industries and need not be bound by contractual arrangements – but have significant interdependence nonetheless” (Jacobides et al., 2018, p. 2258). Furthermore, with technological innovation of large companies and cross-industry innovation becoming increasingly salient, the Triple Helix of university–industry–government relations is not valid in this new context (Etzkowitz and Leydesdorff, 2000), thus requiring us to rethink technological innovation and commercialisation.

Therefore, the short industry lifecycle, complex value proposition, and blurred organisational and industrial boundaries of this digital era have challenged the existing industry and innovation literature, which is primarily based on the manufacturing sectors of the industrial age. As the contemporary ways of organising for distributed innovation, the dynamics and functions of ecosystems in emerging industries should be further explored (Baldwin, 2012; Baldwin and von Hippel, 2011).

This research aims to answer the research question: how does a new industry emerge based on the underlying ecosystems? To answer the question, I conducted an in-depth longitudinal study of the cloud computing industry in China from 2008 to 2021. Through documenting and analysing the stages and transitions of industry emergence, I developed a holistic process model of industry emergence. Concerning the transition mechanisms, I identified the impact of dominant design dynamics on industry emergence as well as the

decoupling of dominant design between the dominant technology design on the supply side and the dominant business model design dominance on the demand side. This research enriches dominant design dynamics by elaborating the dominant design of fundamental technology, application technology, and business model. Having exploited the process and transition mechanisms in industry emergence, with the method of coding, I developed the industry ecosystem from activity and actor perspectives. This research explains the generic transition mechanism by identifying the multi-level industry ecosystem as the linkage between the supply and demand sides and by introducing cross-industry innovation and application scenarios as new elements in the industry ecosystem. Moreover, it identifies the role of ecosystem shapers, complementors and facilitators at different stages of industry emergence. This fills the gap in ecosystem research at the industry level by providing an industry ecosystem framework for understanding industry emergence.

Potentially, this research contributes to industry emergence literature and innovation literature by bridging the gap in transition mechanisms of industry emergence and uncovering the black box of dominant design. The findings also contribute to ecosystem literature by developing a multilevel ecosystem model as a linkage between the demand side and the supply side. Practically, this research has implications for managers, entrepreneurs, and policymakers to develop a strategy to cope with an emerging industry as well as to facilitate and shape the emergence. Traditionally, R&D investments have been emphasised by firms and policymakers; this research suggests that, in the playground of contemporary emerging industries, the search for profitable business models and application scenarios is crucial and deserves more attention in strategy framework and policymaking.

1.2 Research Objectives

This research aims to explore how a new industry emerges based on the underlying ecosystems. Specifically, the literature review of industry emergence research and

ecosystem research suggests three research gaps. First, although the stages of industry emergence have been examined, apart from the process perspective, we need to uncover how the transitions between stages are achieved as well as how a new industry is organised from an organisational perspective (Gustafsson et al., 2016). Second, the cumulative research on industry emergence from diverse disciplines (e.g., strategic management, entrepreneurship, economics, marketing, and organisation studies) requires integration (Benner and Tripsas, 2012; Hannah and Eisenhardt, 2018; Moeen et al., 2020), and we need a holistic and dynamic understanding of the industry emergence process. Concerning the extant ecosystem research, we need to advance our understanding of the synergy between different levels of ecosystems (Jacobides et al., 2018), and the dynamics and mechanisms of industry-level ecosystems (Bogers et al., 2017).

The overall research question is: how does a new industry emerge based on the underlying ecosystems? Specifically, the two sub-questions are:

- (1) How does industry emergence unfold in the digital era?
- (2) How do the underlying ecosystems enable the transitions and emergence?

1.3 Dissertation Structure

My study highlights a critical issue: how a new industry emerges. The mechanisms enabling industry emergence deserve scholarly attention. The structure of this report adheres to the sequence shown in Figure 1.1.

Overall, this dissertation consists of seven chapters. Chapter 1 introduces the industrial and research backgrounds of the study and presents the main structure of the thesis. Chapter 2 reviews the extant literature on industry emergence and ecosystems, leading to the specific research gaps. Chapter 3 presents the research methodology in addressing the proposed research questions and objectives, states the epistemological positions determining the choice of research methodology, and outlines the detailed procedures for

data collection and analysis. Chapter 4 presents the case studies of major cloud computing vendors in the Chinese cloud computing industry and outlines the stages and milestones for the major cloud ecosystems and the industry. Chapters 5 and 6 present the findings about industry emergence and industry ecosystem. Chapter 7 outlines discussions, theoretical and practical implications, limitations, and future research.

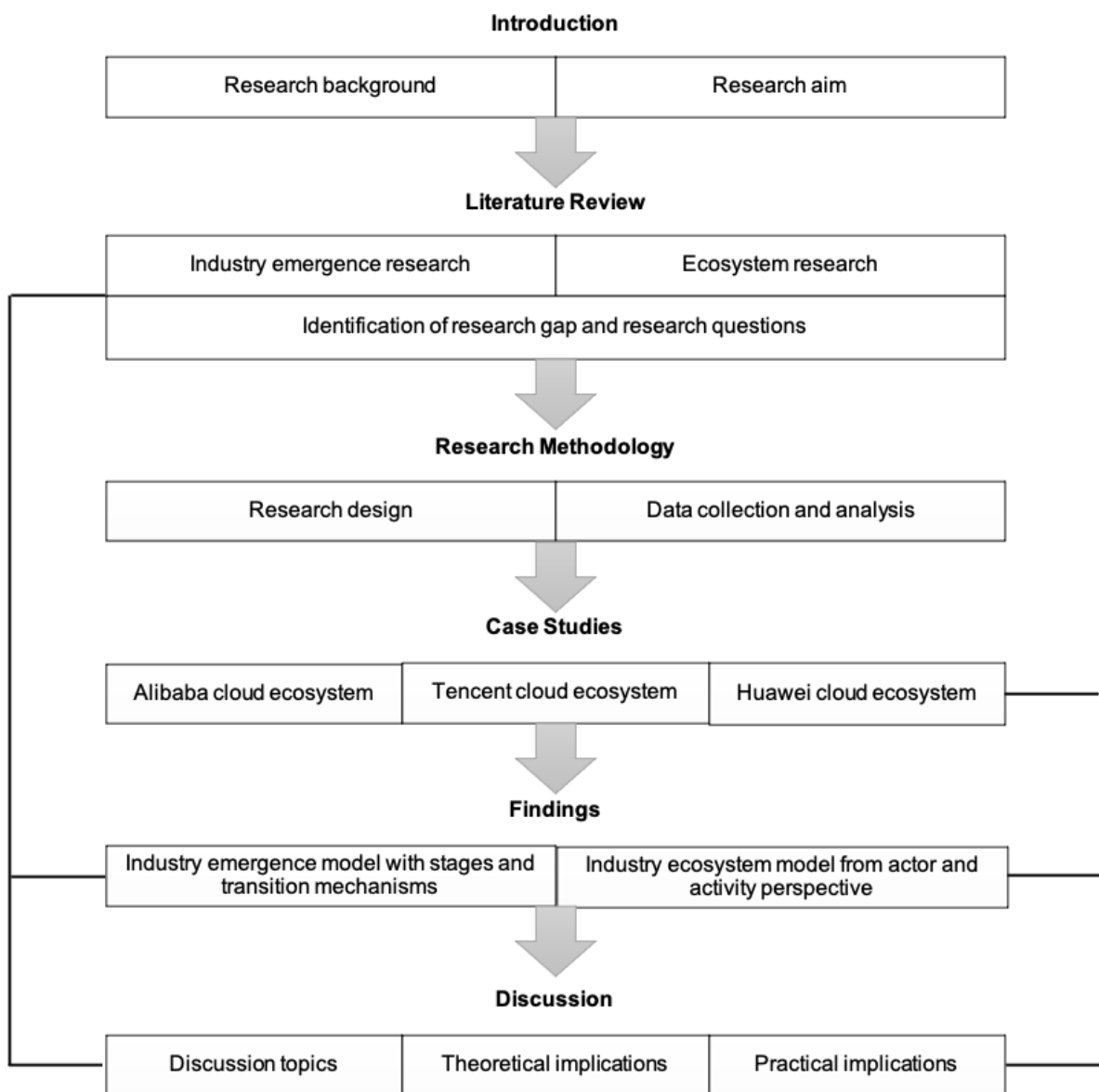


Figure 1.1 Report structure flow chart

Chapter 2 LITERATURE REVIEW

This chapter provides a literature review from a coherent multi-disciplinary perspective, covering insights from industry emergence research and ecosystem research. The literature gaps in the two literature bodies are also presented and summarised at the end of this chapter.

2.1 Industry Emergence

This chapter is to examine the literature that is relevant in addressing industry emergence. This is a phenomenon-oriented research topic, so a multidisciplinary approach is employed to complete a comprehensive literature review of industry emergence research. There are five main themes in this research area: 1) industry emergence and evolution; 2) technological and product innovation; 3) business model and technology commercialisation; 4) strategy and entrepreneurship in emerging industries; 5) Institutions and policies for industry emergence.

2.1.1 Industry emergence and evolution

Industry emergence is generally triggered by technological discoveries (Moeen and Agarwal, 2017), unmet needs (Shah and Tripsas, 2007), or mission-oriented grand challenges (Agarwal et al., 2017; Mowery et al., 2010), and the nascent or emerging stage ends with industry sales take-off, which is an early sign of commercial viability and industry transition to growth stage (Eggers and Moeen, 2021; Moeen et al., 2020). According to Schumpeter (1942), creative destruction, enabled by innovation efforts, is a key part of the process leading to the emergence of new sectors. Category-defying products and services can be driven by new technologies, new business models, new ideas about market demands, or new regulatory environments (Klepper, 1997; Zuzul and Edmondson, 2017). Van De Ven (1993) provides a social system framework for understanding innovation development and industry emergence and stresses the

community infrastructure composed of institutional arrangements, resource endowments, and proprietary functions. The innovation dynamics in an emerging sector are characterised by high growth and high levels of technological pervasiveness, as well as the entry of many innovators and various actors (Cecere et al., 2014). Scientific breakthroughs and patent dynamics have also long been recognised as critical in understanding the emergence of new technologies and industries (Guerzoni et al., 2014).

Studies exploring the ageing patterns of industries have inspired the development of industry lifecycle (ILC) theory to explain changes in technological development and industry structure (Peltoniemi, 2011; Abernathy 1978; Abernathy and Utterback 1978; Abernathy and Clark 1985). The research in this field describes the characteristics of different stages and offers different strategies, including the emerging stage. According to ILC, industry emergence is a result of a technological opportunity and a driving force for firm entry and product innovations (Klepper, 1996; Peltoniemi, 2011). The key characteristic of the emerging or nascent stage of a new industry is the multifaceted uncertainty that unfolds from multiple dimensions including technology, demand, ecosystem, and institution (Moeen et al., 2020). The rapidly changing customer base, complementary technology, and business models require the efficient reconfiguration of firms (Benner and Tripsas, 2012; Santos and Eisenhardt, 2005; Zuzul and Tripsas, 2020). From an organisational perspective, scholars suggest that the organisation and emergence of new industries sometimes follow the pattern of social movements (Hiatt et al., 2009; Sine and Lee, 2009; Zuzul and Edmondson, 2017), leaving the detailed organisational mechanism to be further explored.

Although there is a rich body of literature that has contributed to empirical and theoretical advances regarding industry lifecycle and industry evolution theory, the focus on industry structure, especially during mature stages, underpins several research gaps in the formative stages. Moreover, the division of industry lifecycle stages has been subjected to debates, and researchers use varied terms to describe the industrial emerging stage, such as formation, opening, creation, incubation, etc., with different time

scales and dimensions. We need further research to better understand the very early stage of industry emergence. With the literature on industry lifecycle reviewed, an operational measure to determine the boundary of industry emergence suggests itself.

First of all, the emergence of dominant designs is the key milestone of the industry emergence process. As a new industry emerges and grows, the standards of this industry are gradually inaugurated and adapted, and a design that embodies the beliefs about a product as it standardises several key features of a product technology gradually dominates (Frenken, 2006). The dominant design can be new technology, product or a set of key features incorporated from different distinct technological innovations introduced independently in prior product variants (Utterback and Suárez, 1993). The emergence of a dominant design results from a fortunate combination of technological, economic, and organisational factors, and has a strong and significant effect on firms' survival (Suarez and Utterback, 1995). Second, the progress in commercialisation and changes in sales indicate the maturity of the industry. Sales take-off means the new product has reached the growth stage from the introductory stage (Golder and Tellis, 1997). Sales in new markets are initially low due to the primitive commercialised forms of innovations, and, as new firms enter, actual and perceived product quality improve (and prices may drop), which leads to the take-off in sales (Agarwal and Bayus, 2002). Anderson and Tushman (1990) find that sales always peak after a dominant design emerges. Third, the industry structure changes along the industry lifecycle. According to Deans et al. (2002), the industry concentration index falls during the opening stages, rises during the scale stage and focus stage, and begins to decline in the last stage. The number of firms in an industry – the industry's density – is also directly affected by the emergence of a dominant design (Suarez and Utterback, 1995). Forth, concerning technological change, the extent to which the incumbent threatened industry is replaced by the emerging industry also represents the emergence of a new industry (Moeen et al., 2020; Tripsas and Gavetti, 2000).

This research aims to cover the process of creating something from nothing, which covers a wider range than incubation. Based on the previous definition and my observation of

the four evolutionary trends of the industry lifecycle, my working definition of industry emergence is: *the process by which a new industry is established, starting from new technology or unmet demand, before the sales take-off* (Agarwal and Bayus, 2002; Moeen and Agarwal, 2017)

From the perspective of technology, Utterback and Abernathy (1975) presented the evolution of innovation and related industry development as shown in Figure 2.1. Furthermore, Suarez (2004) summarises the five stages and milestones of the technology dominance process: (1) R&D build-up stage, beginning when a pioneering organisation applies R&D; (2) technical feasibility stage, beginning with the emergence of the first working prototype; (3) market creation stage, beginning with the first launching of a commercial product; (4) decisive battle stage, beginning with the appearance of a clear early front-runner; (5) post-dominance stage, beginning when one of the alternative designs becomes dominant.

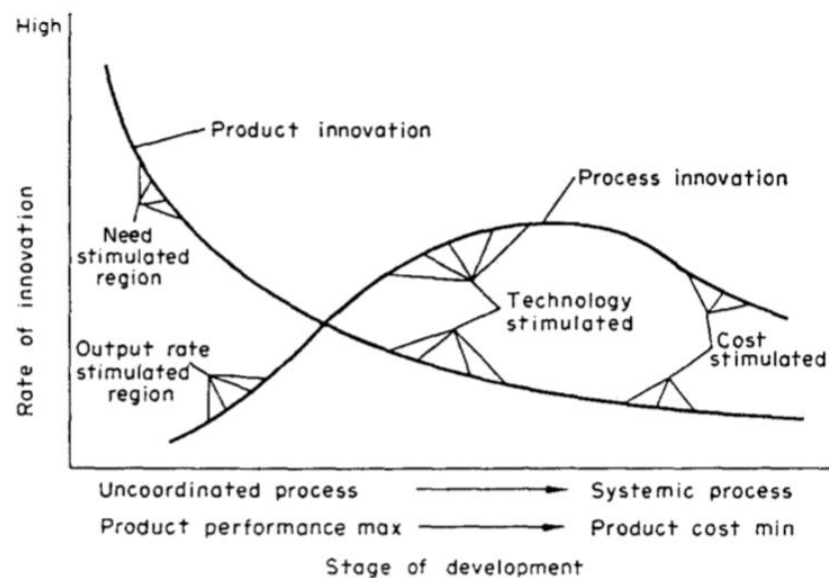


Figure 2.1 Rate and stage of innovation (Utterback and Abernathy, 1975)

Concerning commercial activity, as is shown in Figure 2.2, the existing research suggests three distinct stages of industry emergence (Agarwal et al., 2017; Agarwal and Bayus, 2002; Gort and Klepper, 1982; Moeen et al., 2020; Moeen and Agarwal, 2017): (1) the

incubation stage before first commercialisation, during which the industry knowledge base and trajectory is forming and shaped by technological investments from diverse actors (Moeen and Agarwal, 2017); (2) the pre-firm take-off stage before firm take-off, which is a monopoly stage with only a few commercialising firms until the firm take-off (Gort and Klepper, 1982); and (3) the pre-sales take-off stage, with low customer penetration before sales take-off, then various products provided by more entrant firms meet a broader range of customer preferences and result in sales take-off (Adner and Levinthal, 2001; Agarwal and Bayus, 2002).

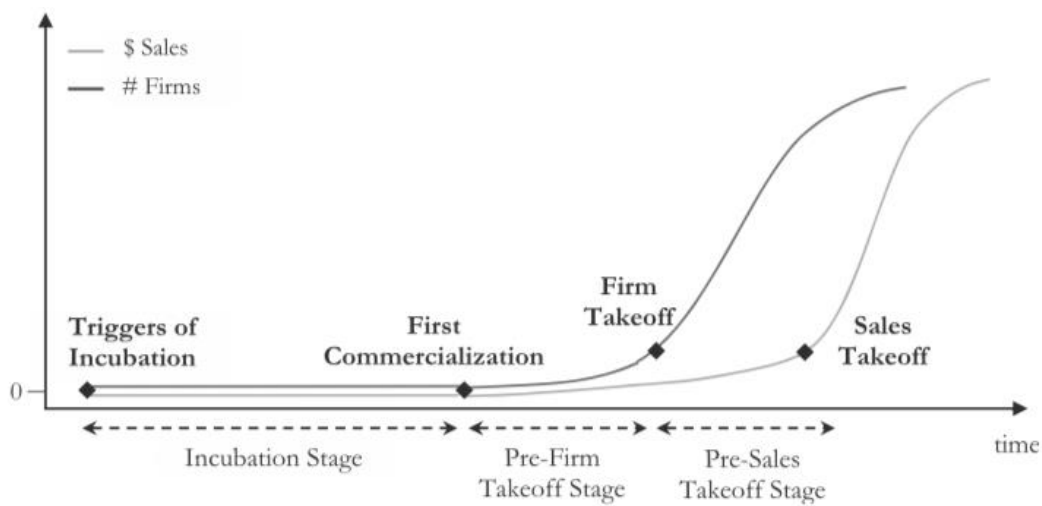


Figure 2.2 Nascent industry milestones and stages (Moeen et al., 2020)

Using a roadmapping method, Phaal et al. (2011) identified the following phases and transitions of science-based industry emergence: 1) precursor phase (science-dominated emergence); 2) science-technology transition (S-T); 3) embryonic phase (technology-dominated emergence); 4) technology-application transition (T-A); 5) nurture phase (application-dominated emergence); 6) application-market transition (A-M); 7) growth phase (market-dominated emergence). The industrial emergence framework is shown in Figure 2.3, which provides a framework for further research on the detailed transition mechanisms and dynamics.

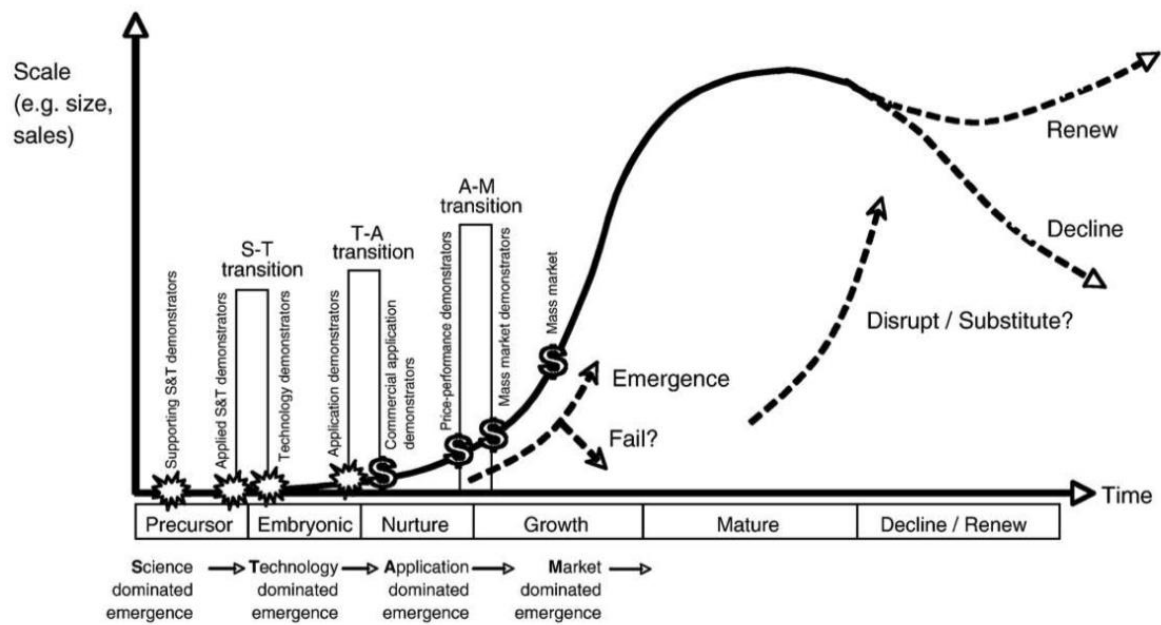


Figure 2.3 Emergence of technology-intensive industries (Phaal et al., 2011)

Centred on industry structure, economists developed industry evolution theory and evolutionary theory of innovation diffusion. According to Nelson and Winter (1982), the historical sequence, or time path, of events is the critical determinant of the ultimate structure of new product markets. Based on this assumption, Gort and Klepper (1982) divide the lifecycle of the industry from its beginning up to, but not including, the period of eventual decay into five stages: (1) commercial introduction of a new product by its first producer; (2) the period of a sharp increase in the number of producers; (3) the period in which the number of entrants is roughly balanced by the number of exiting firms, leaving net entry approximately zero; (4) the period of negative net entry; (5) the period that continues until the eventual shrinkage of the market.

Although the extant research has generated temporal stylised facts about what the stages and transitions of nascent industry stages are, little is known about how to achieve the transitions and enable industry emergence, or the impediments to the emergence (Moeen et al., 2020). From a knowledge-based view, “industry emergence through key milestones” is enabled by “knowledge-generation processes by diverse actors” (Moeen et al., 2020, p. 218). According to Meijer et al. (2007), during the first transition of the pre-development

phase, perceived uncertainties seem to block some actors, but can also induce other actors to fulfil key activities that are essential for achieving a transition. The interaction between market (demand side) and technological (supply-side) forces and events is a key driver for industrial emergence, as a co-evolutionary process (Phaal et al., 2011). Foray and Raffo (2014) find that there are two forces – functional specialisation and the development of generic tools – that foster the dynamics of the tool industry evolution. More research efforts are required to gain a more precise understanding of the dynamics and transition mechanisms of industry emergence (Murmann, 2013).

2.1.2 Technological and product innovation

Technological innovation and product innovation are at the centre of the emergence of technology-based industry (Agarwal and Tripsas, 2008). Lifecycle terms – such as technology, product, and industry lifecycles– are frequently used interchangeably and are closely interrelated (Routley et al., 2013). “Industry evolution overlays the process of design evolution...‘industry-level operators’, involving entry, exit, and restructurings, do permit new firms and new product markets to be formed and old ones to be shut down when local conditions warrant it” (Baldwin and Clark, 2000, p. 409). Connecting technological and product innovation with industry evolution, dominant design not only represents a milestone marking the maturity of technology, but also functions as a mechanism that triggers the transition of industry from fluidity to a specific state through industry shake-out and sales take-off (Utterback and Abernathy, 1975).

In the early stage of a technology lifecycle, firms can frame the emergence process of a dominant design to gain a competitive advantage from innovation (Lee et al., 1995). If it fails, switching to the dominant design will also improve the chances of survival and market share for individual firms (Tegarden et al., 1999). As a single architecture that establishes dominance in a product class, a dominant design is significant for firm performance and the industry emergence process (Abernathy, 1978; Sahal, 1981; Anderson and Tushman, 1990). In the competition to define a dominant design, firms

build alliances and attract complementors to favour their preferred technology standard (Soh, 2009). Enabling commercialisation of the emerging technologies also requires downstream complementary assets and a thriving ecosystem (Rothaermel and Deeds, 2004). For Industry 4.0 technologies, such as AI, blockchain, and wearables, the original application and experimentation may happen long before there is clarity of a business case and far from the factory, as long as companies can see its trialability and ecosystem (Maghazei et al., 2022).

Despite the stylised facts documented above, the dominant design literature also presents anomalies in the industries with different patterns of entry and exit or complex design systems like telecommunications or healthcare, partly because the concept of dominant design is too abstract to be operational in analytical and empirical research in order to build a more cumulative research program (Murmann and Frenken, 2006). Moreover, predominantly based on manufacturing sector and vertically integrated industries (Agarwal and Tripsas, 2008; Murmann and Frenken, 2006), the dominant design theory has limited boundary condition that is needed to be expanded in this digital age.

Product lifecycle (PLC) has four stages of market introduction, growth, maturity, and decline such that the volume of product sales alters through these phases (Levitt, 1981). Williamson (1975, p. 215) divides the development of technology along the product lifecycle into three stages: "an early explorative stage" with "a new product of relatively primitive design", "an immediate development stage" with more refined manufacturing techniques, and "a mature stage" in which "management, manufacturing, and marketing techniques all reach a relatively advanced degree of refinement".

A product innovation is composed of new product development and the introduction of it into the market (Gort and Klepper, 1982). In new product development (NPD), product form design must be based on a thorough understanding of demand-side conditions, and catering to consumers' demands; it also has a direct influence on consumers' cognitive and emotional responses, thereby modulating the actual technological novelty of a

product innovation and facilitating how customers cope with it (Galanakis, 2006; Rindova and Petkova, 2007). The internal management for product innovation is also important in the new product development (NPD) process (Sun and Wing, 2005). Concerning the interactions between organisations, the product development path begins with exploration alliances predicting products in development, which in turn predict exploitation alliances, and concludes with exploitation alliances leading to products entering the market (Rothaermel and Deeds, 2004). In the next stage of the product lifecycle, diffusion – "the spread in the number of producers engaged in manufacturing a new product" – is subject to the technological change involved and the attributes of the relevant industry such as price and output (Gort and Klepper, 1982, p. 630). From the individual level, the rate of formation and the performance of different types of new firms are determined by the characteristics of firms and their networks (Andersson and Klepper, 2013).

Innovation studies provide insightful analysis of new industry phenomena from a product level, technology level, and regional level. However, the discipline fails to offer a holistic sector-level theory in the context of emerging industries. More importantly, technology application and adoption of the emerging technologies in the digital and Industry 4.0 age are shaped by the interaction between technology push from a thriving ecosystem and market pull from companies exploring the use case and business value of a technology, which no longer follow the traditional linear pattern in the industrial age (Maghazei et al., 2022). Thus, the enabling mechanism of emerging industries from emerging technologies remains an untapped territory within the field of innovation studies.

2.1.3 Business model and technology commercialisation

The concept of business model has gained increasing attention from both industry and academia in recent years as a holistic approach to explaining how firms do business (Zott et al., 2011). Chesbrough and Rosenbloom (2002) describe a business model as a construct that mediates the value creation process by selecting and filtering technologies

and packaging them into particular configurations to be offered to a chosen target market. Morris et al. (2005) propose a six-component framework for analysing a firm's business model, including offering, market, internal capability, competitive strategy, economic factors, and personal/investor factors. Similarly, Casadesus-Masanell and Ricart (2010) argue that a business model reflects a firm's realized strategy and emphasizes how a firm operates and creates value for its stakeholders. Shepherd et al. (2023) identify three approaches to understanding business models in the extant literature, including business models as real entities, cognitive and linguistic schema, and formal representations.

According to Zott and Amit (2010), business model design is a crucial decision for new ventures in emerging industries, with design elements including content, structure, and governance, and design themes including novelty, lock-in, complementarities, and efficiency. The ability of firms in an emerging industry to gain a first-mover advantage or overcome a late-comer disadvantage depends on their business models and how they use them to compete with other entrants (Markides and Sosa, 2013). Business model design is based on antecedents including goals, templates, stakeholder activities, and environmental constraints (Amit and Zott, 2015). Chesbrough and Rosenbloom (2002) identify six attributes of a business model, including identified market segment, clear value proposition, elements of value chain, defined cost and profit, positioned in value network, and formulated competitive strategy. Baden-Fuller and Haefliger (2013) suggest four constitutive parts of a business model: customer identification, Customer engagement, value chain linkages, and monetisation. Central to understanding business models, an activity system is a set of interdependent organizational activities that may transcend the firm's boundaries but remain firm-centric, enabling the focal firm to create value with its partners and capture a share of the value created (Zott and Amit, 2010). Both technology and consumer orientations are important in business model design (Guo et al., 2020). More research is required to explore how to design superior interdependencies in activity systems by leveraging both demand-side and supply-side theories of strategy (Lanzolla and Markides, 2021; Massa et al., 2017).

Overall, the extant business model literature emphasizes the need for business model innovation (Chesbrough, 2010; Velu, 2015, 2017) to respond to changing market conditions and emerging technologies (Chesbrough and Rosenbloom, 2002; Demil and Lecocq, 2010). For example, Leiting et al. (2022) highlight the disruptive effects of the Internet of Things (IoT) on existing industries and the need for firms to adapt their business models to become IoT companies. Velu (2016) suggests that business model innovation can occur through coopetition and can be evolutionary or revolutionary, radical or moderate. Martins et al. (2015) propose rational design, experimentation, and cognitive framing as the basis for altering an existing business model and assembling a new one.

In a nascent industry characterised by uncertainty and ambiguity, rapid experimentation and evolutionary learning are important in designing a successful business model (McGrath, 2010; Snihur and Eisenhardt, 2022). Concerning early business model evolution, Lubik and Garnsey (2016) suggest that firms should exchange resources with their upstream and downstream ecosystems, employ early exploration, and select suitable markets. Geissdoerfer et al. (2022) suggest that prototyping, experimentation, and piloting are crucial in business model innovation. Experimentation with different business models is essential for improving business model choices and aligning activities, as well as avoiding premature commitment to inferior choices (Osterwalder and Pigneur, 2010; Bremner and Eisenhardt, 2022; McDonald and Eisenhardt, 2020). When unexpected consequences occur, trial-and-error learning is also beneficial (Bingham and Eisenhardt, 2011). Yi et al. (2022) further reveal that the relationship between both intra-industry and extra-industry stakeholder ties and business model innovation, and how the relationship is influenced by exploitative learning and exploratory learning.

In terms of technology commercialisation, a well-designed business model plays a crucial role in the success of technological innovations and new product developments. For a certain technology under similar market environments, the specific business model that a firm employs impacts the success of its technology commercialization (Chesbrough and

Rosenbloom, 2002). Teece (2010) emphasizes that technological innovation alone is not enough to ensure business success, and that companies must also have a well-defined business model that outlines their strategies for taking the product to market and capturing value. Baden-Fuller and Haefliger (2013) further explicate on the two-way connection between technology and business model, suggesting that the business model held by managers, entrepreneurs, and developers can shape the way in which technology is developed, as well as mediate the relationship between technology and firm performance. Osterwalder and Pigneur (2010) highlight the importance of business model innovation in the information technology industry. Wirtz et al. (2010) identify four basic types of prototypical Internet business models: content, commerce, context, and connection. Using the case of cloud platforms, Giessmann and Legner (2016) add that the design of the business model for a new product or service should be aligned with existing business models of incumbent firms, customer expectations and habits, and competitive pressures from rivals. Although these extant studies have examined how to design business model for a new technology and product, more research is needed to explore how business model innovation influences technology commercialisation and industry emergence.

2.1.4 Strategic management and entrepreneurship in industry emergence

Firms and entrepreneurs in an emerging or nascent industry are faced with various challenges in legitimacy, organisational learning, and adaptation due to high uncertainty and velocity (Zuzul and Edmondson, 2017). The ability to experiment and change in reaction to shifting conditions largely determines the success of a firm in nascent industries, which are characterised by ambiguity and uncertainty (McDonald and Eisenhardt, 2019; Zuzul and Tripsas, 2020). To cope with constantly changing operating conditions, firms in emerging industries can adopt strategies such as focusing on a limited demand, focusing on the incipient lifecycle, and following the lifecycle through windows

of access (Macdonald, 1985). To create value from new technology in the emergence of a technology-based industry, firms should demonstrate its functionality, reducing uncertainty and increasing customer receptiveness (Ford et al., 2014) and, in some cases, engaging in a research alliance with a technology licensing component (Klepper and Simons, 2000; Moeen and Agarwal, 2017).

Due to the uncertainties and challenges, strategic management and decision making in a nascent industry are much more difficult and complex compared to that in an established industry (Eggers and Moeen, 2021). As is presented in Figure 2.4, Suarez et al. (2015) have concluded that the existence of a window of opportunity for firm entry begins with the emergence of the dominant category and ends when the dominant design emerges. Hannah and Eisenhardt (2018) identify three distinct strategies – bottleneck strategies, component strategy, and system strategy – for firms to navigate cooperation and competition in nascent ecosystems. Bremner and Eisenhardt (2022) find that emerging industry firms with a coordination advantage perform better in innovation than those that rely on community-based innovation considering the importance of quick and accurate experimentation and problem-solving in the uncertain and fast-changing setting. However, most of the extant strategy research is from the perspective of focal firms or new ventures, and the strategic management dynamics of different kinds of firms should be further explored.

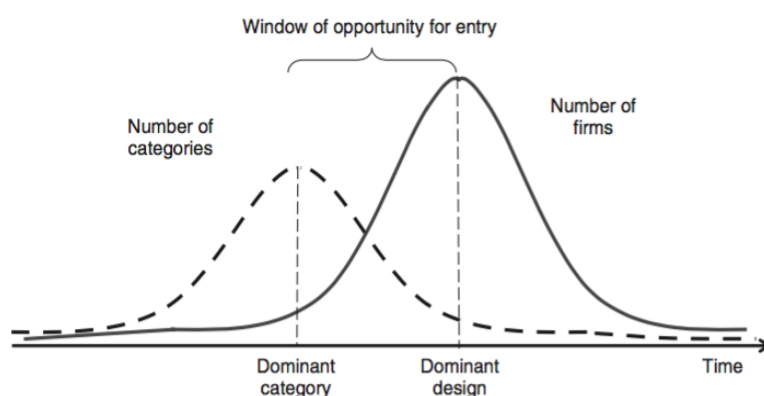


Figure 2.4 Window of opportunity for entry (Suarez et al., 2015)

The players in the nascent industry not only react to it strategically, but also shape the emergence process. By “offering products or services that defy existing categories”, entrepreneurs not only launch a new venture and business, but also “help to create a new, or nascent, industry” (Zuzul and Edmondson, 2017, p. 303). The successes of pioneers become models to emulate (Powell and Sandholtz, 2012); their failures can stunt the emergence progress (Zuzul and Edmondson, 2017; Ozcan and Santos, 2015). Companies match innovative technologies to certain applications and shape the environment to their advantage (Ford et al., 2014). Enterprising actors overcome varied difficulties and bottlenecks stemming from their nascent status; they “carve out a new market”, raise capital for the new venture, and recruit and train employees (Aldrich and Fiol, 1994, p. 645); they shape and legitimise the nascent industry by “developing new category labels” and “building an ecosystem architecture” (Zuzul and Tripsas, 2020, p. 422).

The existing research has explored the role of established incumbents and new ventures in the emergence of a new industry. Lechevalier et al. (2014) argue that the industry emergence is mainly triggered by established large firms rather than by new firms, based on evidence from the service robot industry. However, Giarratana (2004) claims that the core of new industry emergence lies in new firms and linkages to them, based on evidence from the encryption software industry. Audretsch and Thurik (2001) found a paradigmatic shift towards entrepreneurial regimes, support for new entrants, and a reduced role for incumbents. A successful start-up, such as Uber, eBay, and Airbnb, can spark the emergence of a new industry with its advantage in flexibility over established firms (Zuzul and Tripsas, 2020).

Technological change can lead to new products and markets, but it is entrepreneurs that discover or create opportunities in which to exploit the new technology (Shane, 2000). Entrepreneurship theory suggests that opportunities stem from competitive imperfections of a market or industry and opportunity recognition and development lead to the business formation (Ardichvili et al., 2003). The formation of an entrepreneurial opportunity can be described as a discovery or creation process, or a combined one

(Alvarez and Barney, 2007; Zahra, 2008). Discovery theory assumes that competitive imperfections arise from technological innovations, changes in consumer preferences, or some other exogenous attributes (Kirzner, 2015, 1997), whereas creation theory asserts that opportunities are created, endogenously, by entrepreneurial actions to produce new products or services (Baker and Nelson, 2005; Gartner, 1985). The entrepreneurial process includes two phases: the pre-entry phase, during which opportunity recognition happens, and the post-entry phase, during which opportunity exploitation is conducted (Baron, 2006).

A growing number of entrepreneurship studies have begun to focus on nascent industries (e.g., Agarwal et al., 2017; David et al., 2013; Kirtley and O'Mahony, 2023; Santos and Eisenhardt, 2009). New ventures engage in experimentation, blending action with cognition, and prototyping designs to design business models in nascent markets (McDonald and Eisenhardt, 2019). For new ventures, entrepreneurial strategic postures and organic organisation structures are more salient and effective in emerging industries than they are for new ventures in mature industries (Covin and Slevin, 1990). The probability of failure for new ventures is higher in nascent industries than in established industries (Dobrev and Gotsopoulos, 2010). Considering the different characteristics of established firms as diversifying entrants and new ventures as entrepreneurial entrants (Sosa, 2013, 2011), a thorough understanding and comparison of the strategies for the two kinds of entrants are needed to strengthen strategic management and entrepreneurship research in the context of industry emergence.

2.1.5 Institution and policy for industry emergence

Industry emergence is bound up with the field and market emergence (Lawrence and Phillips, 2004; Mitchell, 1989), which reflects the process of building identity and legitimacy (Navis and Glynn, 2010; Wry et al., 2011), establishing social and regulatory institution (Aldrich and Fiol, 1994; Moeen et al., 2020), and constructing meaning and value in a new market category (Duran and Khaire, 2017; Khaire and Wadhwani, 2010).

As the durable social arrangements between organisation and society (Ansari and Phillips, 2011; Lawrence et al., 2002), fields are instrumental to the dissemination and reproduction of socially constructed expectations and practices (Greenwood et al., 2002; Scott, 1995). For example, in the emerging field of HIV/AIDS treatment advocacy, actors involved in institutional entrepreneurship facilitate the creation of the new institution by leveraging resources and connecting the new practices to stakeholders' routines and values (Maguire et al., 2004). As a basis for market emergence, market categories "provide a cognitive infrastructure that enables evaluations of organisations and their products, drives expectations, and leads to material and symbolic exchanges" (Durand and Paoletta, 2013, p. 1102). For instance, to gain attention and support for the E-cigarette market, actors in the emerging market construct and legitimise the E-cigarette category through its contrast with the established cigarette category (Hsu and Grodal, 2021). By borrowing these concepts and theories from sociology, scholars have examined category emergence in an nascent industry (Hsu and Grodal, 2015; Khaire and Wadhwani, 2010; Zunino et al., 2019) and revealed that collective action and social movement also play a role in the creation of a new market and industry (Lounsbury et al., 2003; Rao et al., 2000; Sine and Lee, 2009; Struben et al., 2020).

New market category formation, implying new market actors, products, and intra-field changes in hierarchies, is central to the institutionalisation of a new industry (Durand and Khaire, 2017). Once constructed and translated into valuation criteria, category meanings act as institutions that provide bases for comparison and valuation in market exchange (Khaire and Wadhwani, 2010). In the bottom-up category emergence, category members make sense of the category; in contrast, in top-down emergence, activists define and control a category with different formation dynamics (Lee et al., 2017). As is shown in Figure 2.5, the co-evolution of technologies and categories is one of the most important mechanisms of industry emergence (Grodal et al., 2015).

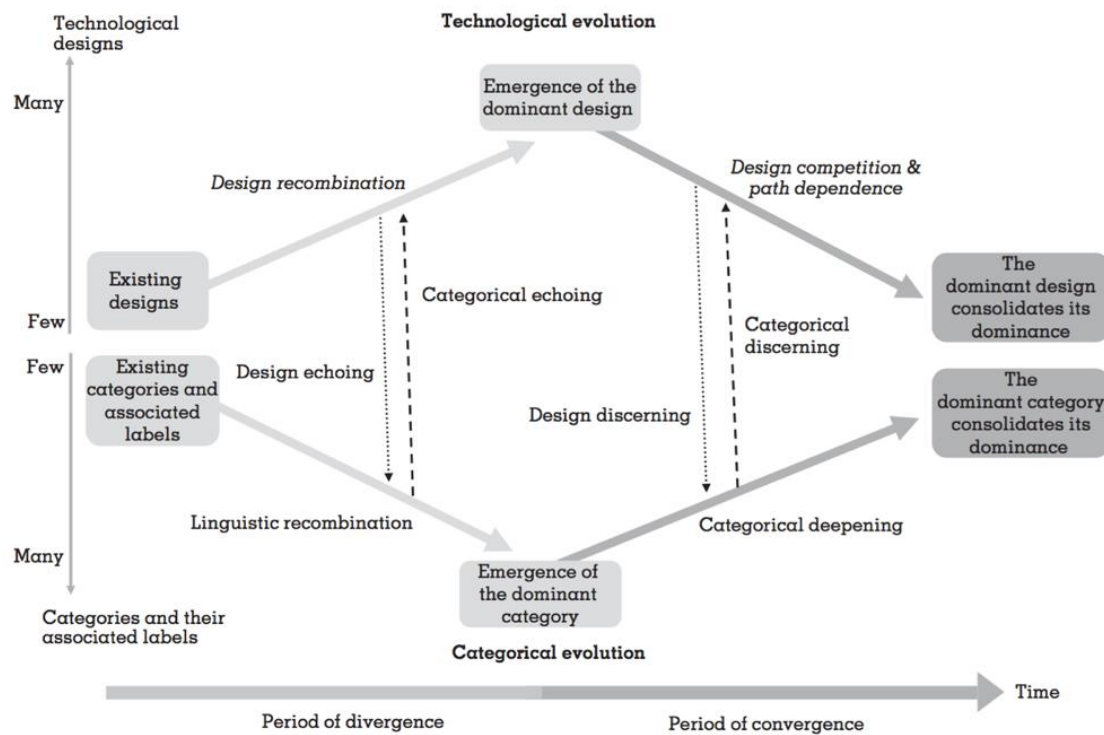


Figure 2.5 The coevolution of technologies and categories (Grodal et al., 2015)

Firms' legitimacy-seeking and building behaviours reshape and co-evolve with emerging industry and institutions (Aldrich and Fiol, 1994). Along with the co-evolution also comes tensions with old institutions and therefore compromises and trade-offs (Lee et al., 2017). The creation of cognitive and socio-political legitimacy requires entrepreneurs' ability to communicate stories of their activities, approaches, and the emerging industry consistently (Aldrich and Fiol 1994). Clegg et al. (2007) find that the interaction between temporal difference and spatial difference enables organisational identity formation in emerging industries and the construction of a legitimate sense of organisational identity. Lee et al. (2017) summarised key legitimacy-seeking behaviours including new member recruitment, downstream engagement, and state authorisation. Before legitimacy is attained, the nascent industry is treated as a whole, whereas, after legitimacy building, the differentiation of firms and products within the nascent industry is paid more attention to (Navis and Glynn, 2010). Companies utilise various means of storytelling (e.g., analogies, templates, and metaphors), publicity (e.g., visible events, press releases, and court press attention), and affiliation (e.g., affiliating with prominent partners and

institutions, building industry associations, and engaging consulting firms) to build legitimacy for the emerging industry, and then for themselves (David et al., 2013; Hill and Levenhagen, 1995; Rindova et al., 2007; Sine et al., 2007; Zuzul and Edmondson, 2017).

During an industry's emergence phase, the institutional environment is of high uncertainty, which is a double-edged sword. Established institutions mean constraining as well as enabling contexts for actors and influence the dynamic interplay between actors and socio-technical systems (Geels, 2005). In nascent industries that lack categorical norms, business precedent and institutionalised expectations, ventures attain legitimacy and resources if their claims are compelling to audiences (McDonald and Gao, 2019). However, actors also face institutional challenges in that a nascent industry is rendered as illegal or legal compliance hinders exchanges, and market challenges of inadequate social acceptance (Moeen et al., 2020).

Some innovation policy scholars have begun to examine the role of state endorsement and policy support in nurturing nascent industries (Boon and Edler, 2018), although the majority of industrial policy literature focuses on assessing the role of government and the impact of industrial policy in mature industries (Adams and Kash, 1994; Dosso et al., 2018; Etzkowitz, 1994; Georgallis et al., 2019). Considering a better position in the future strategic industry is significant to industrial upgrading, economic growth, employment, competition, and sustainability; thus, policymakers have the incentives and abilities to shape the development of emerging technologies into new industries (Hung and Chu, 2006). Favourable regulatory environments can help firms of nascent industries –which are lacking in cognitive acceptance from stakeholders and are threatening entrenched industries – to take root (Georgallis et al., 2019).

In the previous institution, market and policy literature, one of the fundamental assumptions is the industrial boundary, or the regional boundary. For example, Foray and Raffo (2014) suggest that tool industries emerge and evolve as a collection of regional resources such as capital goods and tool inventors and manufacturers. Colombelli et al.

(2014) find that the technological competences accumulated at the local level are likely to shape the future patterns of technological diversification. Sanderson and Simons (2014) emphasise the importance of researchers in local universities, national laboratories, and local firms in the emergence of an industry. However, Aversa et al. (2022) find that certain industries may also emerge away from their birthplace driven by the cyclical process of three forces including centripetal, catalyzing, and centrifugal forces.

In this digital era, the industrial and regional boundaries been further challenged by the "contemporary boundary issues" (Santos and Eisenhardt, 2005, p. 505). The cross-industry and cross-country boundary-spanning phenomenon is salient in the contemporary business landscape, which requires us to view a company "not as a member of a single industry but as part of a business ecosystem that crosses a variety of industries" (Moore, 1993, p. 76); while ecosystem research provides a model across companies, institutions, policy regimes, and industry boundaries for the policymakers and managers nowadays (Ma et al., 2019).

2.1.6 Summary of industry emergence research

As is summarised in Table 2.1, the extant industry emergence studies from different perspectives and disciplines focus on different aspects and concepts of industry emergence. The inconsistency between the different streams hampers the advancement of our understanding of industry emergence and the further development of industry research. The explanations from different disciplines require integration (Moeen et al., 2020).

Table 2.1 Overview of industry emergence literature

Perspective	Discipline	Key concept	Representative studies
Firm	Strategy	Business model design, bottleneck, entry strategy, competitive strategy,	Hannah and Eisenhardt, 2018, SMJ; McDonald and Eisenhardt, 2019, ASQ; Bremner and Eisenhardt,

		collaborative strategy	2022, OS; Santos and Eisenhardt, 2009, OS
	Entrepreneurship	Demand attributes, intra-entrepreneurial regimes, flexibility, knowledge base, resource mobilisation	Agarwal and Bayus, 2002, MS; Moeen and Agarwal, 2017, SMJ; Agarwal et al., 2017, SEJ; Zuzul and Tripsas, 2020, ASQ
Technology/Industry	Technology management	Technical designs, dominant design, technological innovation/discontinuity, technology convergence, product innovation and diffusion	Tushman and Anderson 1986, Utterback and Suarez 1993; Adner and Kapoor 2016; Utterback and Abernathy, 1978, Omega; Anderson and Tushman, 1990, ASQ; Suarez and Utterback, 1996, SMJ; Suarez et al., 2015, SMJ; Eggers, 2014, SMJ
	Industry evolution	Incumbents and entrants, entry and exit, industry leader, creative destruction, market structure	Gort and Klepper 1982; Adner and Levinthal 2001, Agarwal and Bayus 2002; Klepper, 1996, AER; Klepper and Simons, 2000, SMJ; Klepper, 2007, MS; Andersson and Klepper, 2013, ICC
Market/Institution	Organisation theory and marketing	Category emergence, dominant category, organisational identity, organisational inertia/change, adoption, customer segment,	Golder and Tellis 1997; Aldrich and Fiol 1994, Zuckerman, 1999, AJS; Navis and Glynn, 2010, ASQ; Khaire and Wadhwani, 2010, AMJ; Grodal et al., 2015, AMR; Durand and Khaire, 2017, JOM; Sine and Lee 2009; Clegg et al., 2007; Lee et al., 2017, OS
	Institution and policy	Legitimacy seeking/building, regulatory environment, institutional void, policy support, regional resources	McDonald and Gao, 2019, OS; Gao et al., 2017, SMJ; Lechevalier et al., 2014, RP; Krafft et al., 2014, RP; Foray and Raffo, 2014, RP; Georgalli et al., 2019, ASQ; Spencer et al., 2005, AMR

Moreover, although the stages of industry emergence have been examined, transition mechanisms between stages of industry emergence remain to be explored (Gustafsson et al., 2016). The “dynamics and the relationships between various stakeholders building a new industry” remain to be further explored (Zuzul and Edmondson, 2017, p. 318). The emergence process for an industry has typically been viewed as a black box process involving a sophisticated interaction of technological and non-technological factors. The emergence of new industries from evolving technologies is critical to both managers and policymakers, yet has been relatively understudied due to the paucity of available data (Sanderson and Simons, 2014). The existing research about the early formation of the industry does not provide a sufficient explanation of specific transition mechanisms and organisational forms. As an in-depth study, this research will respond to calls for studies into industry emergence, providing insights into how a new industry emerges from both evolutionary and organisational perspectives.

2.2 Ecosystem Research

The following section examines the existing ecosystem literature. After sorting out and distinguishing between different definitions and streams, I identified the research gaps in ecosystem research and tried to establish the concept of industry ecosystem in management research.

2.2.1 Ecosystems with different scopes and disciplines

By using ecological metaphors, Moore (1993) introduced the concept of the business ecosystem into management research. And since then, ecosystem research has grown rapidly with different streams that have different definitions, as summarised in Table 2.2.

Table 2.2 Overview of ecosystem research streams and definitions

Stream	Definition	Source
Business ecosystem	A business community in which companies co-evolve capabilities around a new innovation, and work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations.	Moore, 1993
	Community of organisations, institutions, and individuals that impact the enterprise and the enterprise's customers and supplies, the environment that the firm must monitor and react to.	Teece, 2007
	An ecosystem is composed of the platform innovator(s) and the complementors. Complementarity is the essence of platforms, and platforms help enable ecosystems.	Teece, 2018
	A business ecosystem is a group of interdependent organisations collectively providing valuable goods and services to their customers.	Augier and Teece, 2018
	A business network is formed by large, loosely connected networks of entities that interact with each other in complex ways, and the health and performance of a firm are dependent on the health and performance of the whole.	Iansiti and Levien, 2004
Innovation ecosystem	The collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution.	Adner, 2006
	Alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialise.	Adner, 2017
	A set of actors with varying degrees of multilateral, non-generic complementarities that are not fully hierarchically controlled.	Jacobides et al., 2018
	The ecosystem construct, as a way of making interdependencies more explicit, can be used to analyse the flow of inputs and outputs to distinguish between upstream components that are bundled by the focal firm and downstream complements that are bundled by the firm's customers.	Adner and Kapoor, 2010
	An innovation ecosystem is the evolving set of actors, activities and artefacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors.	Granstrand and Holgersson, 2019
(Industry) ecosystem	Distinct forms of organising economic activities that are linked by specific types of complementarities, new structures of economic relationships.	Jacobides et al., 2018
	Semi-regulated marketplaces require coordination, boundaries, and direction given.	Wareham et al., 2014
	Industry ecosystems are business networks of interconnected firms that depend on one another for their mutual effectiveness and survival.	Ansari et al., 2016

	A community that consists of various levels of interdependent firms which co-evolve in an ongoing cycle and constantly renew themselves.	Rong and Shi, 2014
	Groups of firms that produce products or services that together comprise a coherent solution. Examples include 3D printing (i.e., printers, scanners, feedstock, software) and smartphones (i.e., handsets, apps, operating systems, networks).	Hannah and Eisenhardt, 2018
	Multi-tiered production systems involving heterogeneous agents operating in sectoral value chains and contributing to the capability domains of the ecosystem (and its participants) with close complementary but dissimilar sets of resources and capabilities.	Andreoni, 2018
Entrepreneurial ecosystem	Entrepreneurial ecosystems regulate the direction and quality of entrepreneurial innovation by shaping the direction and potential rewards of alternative courses of technological development and even the types of organisational forms that will be accepted as legitimate.	Autio et al., 2014
	An entrepreneurial ecosystem is a distinct type of cluster that specialises in harnessing technological affordances created by digital technologies and infrastructures and combines them with spatial affordances to support a distinctive cluster dynamic that is expressed through the creation and scale-up of new ventures.	Autio 2018, p. 74
	Entrepreneurial ecosystems are the union of localised cultural outlooks, social networks, investment capital, universities, and active economic policies that create environments supportive of innovation-based ventures. Ecosystems are defined by the connections between the attributes that produce them and the benefits they provide to entrepreneurs.	Spigel, 2017

Business ecosystem theory has its roots in the biological ecosystem. By proposing the business ecosystem, Moore (1996) claims that firms are embedded in a business environment, which is similar to the natural environment where co-evolution exists. Moore (1996, p. 26) defines a business ecosystem as "an economic community supported by a foundation of interacting organisations and individuals – the organisms of the business world. This economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organism also includes suppliers, lead producers, competitors, and other stakeholders". One of the key reasons why Moore (1993) proposed the concept of a business ecosystem is to cross the industry boundaries and provide a new level of analysis in the new competitive environment where the package for customers often requires integrating different actors

from different industries (Baldwin and Clark, 2000). Iansiti and Levien (2004) further illustrate the governance mechanism, firms' strategic positioning, and the capabilities required within the ecosystems. Defining the business ecosystem as "the community of organisations, institutions, and individuals that impact the enterprise and the enterprise's customers and supplies" (Teece, 2007, p. 1325), David Teece's research has brought a great deal of attention to business ecosystem research from the academia.

An innovation ecosystem, "the alignment structure of the multilateral set of partners that need to interact for a focal value proposition to materialize" (Adner, 2017, p. 40), is driven by the complex value proposition and the required multilateral interdependencies between ecosystem actors (Adner, 2017, 2006; Adner and Feiler, 2019; Adner and Kapoor, 2010; Ganco et al., 2020; Kapoor, 2018). Innovation ecosystems are characterised by three elements, "dependencies established among the members", "a common set of goals and objectives", and a "complementary set of knowledge and capabilities" (Nambisan and Baron 2013, p. 1071). Different to the traditional innovation network, triadic or multilateral relationships cannot be decomposed into bilateral relationships (Adner, 2017; Davis, 2016; Hannah and Eisenhardt, 2018). Furthermore, the traditional innovation networks and supply chains mainly address the component challenge, whereas innovation ecosystems focus on the complement challenge and stress the role of complementors in offering peripheral products in the bundle for the end users (Ander and Kapoor, 2010). For example, the innovations of third-party application developers are vital for the platform-based ecosystem of Apple (Gawer and Cusumano, 2014). Complementors that are outside of the traditional value chains of the focal firm are key to innovations and value creation of ecosystems by providing complementary assets and resources (Adner, 2017; Ceccagnoli et al., 2012; Cennamo and Santalo, 2013). And, according to Jacobides et al. (2018), innovation ecosystems are characterised by their non-generic (supermodular and unique) complementarities.

Based on practices in this digital age, many business/innovation ecosystem studies have applied the platform model to capture the characteristics and functions of ecosystems in

these Internet-based businesses (Ceccagnoli et al., 2012; Cennamo and Santalo, 2013; Cennamo and Santaló, 2019; Tiwana, 2015, 2013). For example, Gawer and Cusumano (2014) have studied how the platform changes over time to cope with technological and market disruptions and find that the network effects of the platform lead to positive feedback loops between the adoption of the platform and the rise of complements.

Defined as “the union of localised cultural outlooks, social networks, investment capital, universities, and active economic policies that create environments supportive of innovation-based ventures” (Spigel, 2017, p. 49), the entrepreneurial ecosystem is different to the business or innovation ecosystem in its stress on geographical boundaries and local resources, and the role of various actors including universities and research institutes (Clarysse et al., 2014), local firms (Järvi et al., 2018), regulators (Autio and Thomas, 2013), and intermediaries (Autio et al., 2018) in supporting the entrepreneurial activities in the entrepreneurial ecosystem of the region. Compared with other established spatial concepts such as clusters, industrial districts, and innovation systems, the entrepreneurial ecosystem emphasises the entrepreneurship context and begins with entrepreneurial individuals instead of companies (Stam, 2015). Entrepreneurial ecosystem researchers have studied relational aspects of ecosystems and outcomes of ecosystem activity (Roundy, 2016). Spigel and Harrison (2018) suggest that the entrepreneurial ecosystem can be seen as a strategy for policymakers to develop regional economies by creating a supportive environment for entrepreneurship.

So far, the ecosystems literature has dominantly focused on the focal firms of ecosystems, mainly orchestrators and hubs (Gawer and Cusumano, 2014; Wareham et al., 2014), or examined the impact of ecosystem participation on firm performance for hubs or complementors (e.g. Knockaert et al., 2019). As a new level of analysis in the modern industry setting, ecosystems should be further explored in terms of their multi-actor and multilateral characteristics and in contrast to the established concept of industry.

2.2.2 A structural view of ecosystems: actors and roles

In essence, an ecosystem is an economic community supported by a foundation of interacting organisations and individuals, the organisms of the business world. The structure of the community is shown in Figure 2.6, which is composed of two main building blocks: core business and extended enterprise. The member organisations also include governments, industry associations, suppliers, lead producers, competitors, customers, and other stakeholders. Over time, they co-evolve their capabilities and roles. The function of the ecosystem leader is valued by the community (Moore, 1993; Iansiti and Levien, 2004; Rong et al., 2015).

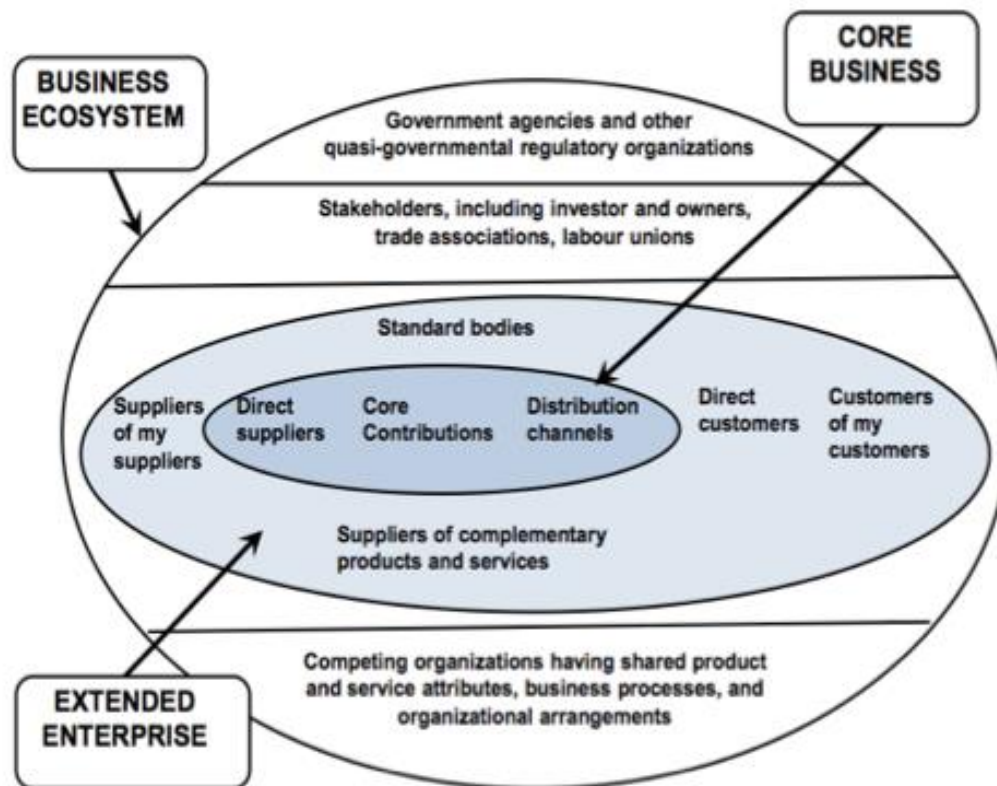


Figure 2.6 Static structure of a business ecosystem (Moore, 1996)

Based on Moore's ecosystem model, Iansiti and Levien (2004) have identified four categories of players:

- 1) The keystone player. The keystone players are the central members of the business ecosystem. They provide a stable set of common assets to allow other ecosystem members to build their offerings on, and to connect organisations in the ecosystems to one another to increase the efficiency of product creation.
- 2) The niche player. Niche players are specialists who are able to develop innovative solutions that add value to the business ecosystem.
- 3) The dominator. The dominators control a large part of the network. They dominate the ecosystem and integrate the ecosystem members both horizontally and vertically.
- 4) The hub landlord. Though not directly controlling the ecosystem, the hub landlords extract as much value as possible from their own network to the ecosystem.

With different roles, firms compete on three foundations of architecture (standards and platforms), integration, and market management. By observing the emergence of network industries, Isanti and Levien (2004) find that the dominated ecosystems largely driven by the efforts of a single firm, could not compete with the combined efforts of the wealth of organisations linked by the PC platform. Dedehayir et al. (2016) collated the roles seminal to ecosystem birth into four groups concerning the activities they carry – leadership roles ('ecosystem leader' and 'dominator'), direct value creation roles ('supplier', 'assembler', 'complementor', and 'user'), value creation support roles ('expert' and 'champion'), and entrepreneurial ecosystem roles ('entrepreneur', 'sponsor', and 'regulator').

Considering the relationship between firm strategy, network governance, and market dynamics, Den Hartigh and Van Asseldonk (2004) suggest three kinds of roles and strategies in a business ecosystem:

- 1) Shaper. The shaper provides the platform or core technology, which encourages other members to participate. Its role is a more flexible one and therefore it could act as the keystone, dominator, or hub landlord.

- 2) Adapter. Similar to the definition of niche players, the adapter is responsible for producing complementary products that are compatible with the shaper's platform. However, the adapter can also directly influence the shaper's strategy in some cases.
- 3) Reserving to play. Those reserving to play will exploit the business opportunities for their respective businesses.

In strategic management studies, the important role of ecosystem orchestrators in ecosystem emergence has been examined and verified by several studies (Dattée et al., 2018; Garud et al., 2020; Gawer and Phillips, 2013; Uzunca, 2018). Ecosystem orchestrators are defined as actors who have particular control over how ecosystems perform and evolve, becoming their intermediary centres of gravity (Ivarsson and Svahn, 2020). Furthermore, the ecosystem orchestrator is not necessarily the dominator or keystone; other kinds of actors in the ecosystem may also play the role of orchestrator. For example, Lingens et al. (2020) find that start-ups can be just as good ecosystem orchestrators as incumbents. Apart from the central coordination by the focal firm, an ecosystem can also be orchestrated through a self-organisation mechanism and interaction among other ecosystems (Thomas and Ritala, 2021).

Most literature has focused on the role of the focal firm as an orchestrator in establishing the value proposition around which the ecosystem is created (Dattée et al., 2018; Hannah and Eisenhardt, 2018); however, the roles of other actors such as complementors, users, and external actors are also vital for ecosystem emergence and growth. Specifically, complementors deliver key complementary offerings for the ecosystem value proposition (Kapoor and Agarwal, 2017; Adner and Kapoor, 2010; Jacobides et al., 2018). Regulators support the ecosystem's birth and growth by developing regional economic development policies and public infrastructure to stimulate entrepreneurship and innovation (Desrochers and Sautet, 2008), or providing the necessary economic and political reform and enacting beneficial regulations (Chang, 2015; Du et al., 2018).

Other external actors, such as the media, financial analysts, competitors, and industry associations, help to form a supportive institutional environment (Thomas and Ritala, 2021). Considering the managerial challenges posed by the increasing complexity of the ecosystem, more attention should be paid to uncovering the underlying dynamics and evolving roles in ecosystems (Wright et al., 2017).

2.2.3 An evolutionary view of ecosystems: dynamic models

From an evolutionary viewpoint, Rong and Shi (2014) regard business ecosystems as a dynamic structure consisting of organisations that co-evolve with their partners and business environment. From a dynamic view, the tornado model of ecosystems was established to demonstrate the interaction mechanisms in an ecosystem (Shang and Shi, 2013; Rong et al., 2018). As is shown in Figure 2.7, the interaction between social networks and value networks is the core of an ecosystem. Shang and Shi (2013) identify the evolutionary process of the electric vehicle industry in Shandong province, China, and examine the matured electric vehicle supply chain, which is transformed from the social network and will give feedback to the social network. The tornado model is developed based on the electric vehicle ecosystem, consisting of four building blocks: social network, value network, interaction mechanisms, and business context. Compared with other ecosystem models, the tornado model (see Figure 2.7) provides a more dynamic view of ecosystems across different levels (Shang and Shi, 2013). It captures the co-evolution between social networks and value networks, which is the key to a new industry formation.

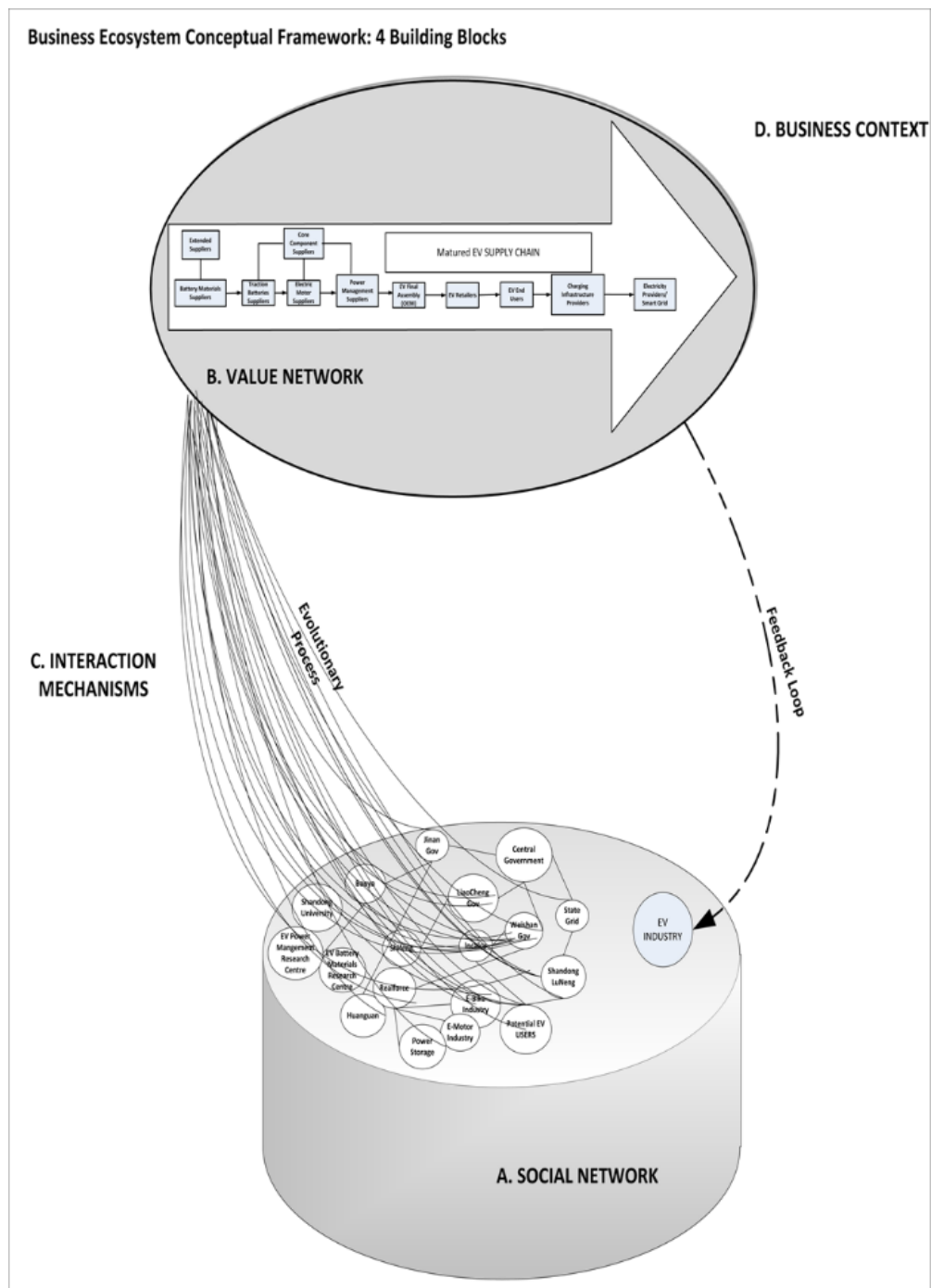


Figure 2.7 Tornado model of the business ecosystem (Shang and Shi, 2013)

Based on the tornado model (Shang and Shi, 2013; Rong et al., 2018), the emergence of a new industry is based on the ecosystem, as is shown in Figure 2.8. From an ecosystem perspective, as the arrow on the left shows, it is a process of transforming the resource pool into a value network, to form a new industrial system. It is assumed that, in the stage of industry emergence, the key is to make an innovative idea become a product/service in the value network and to provide value to customers. When there is a promising idea

and a vision of an emerging industry, ecosystem dynamics make it possible for the ecosystem participants to find the organisations and resources concerned with the emergence in the resource pool. From a dynamic view, this framework follows the tornado model of ecosystems, which demonstrates the interaction between social networks and value networks as the mechanisms of an ecosystem (Shang and Shi, 2013; Rong et al., 2018).

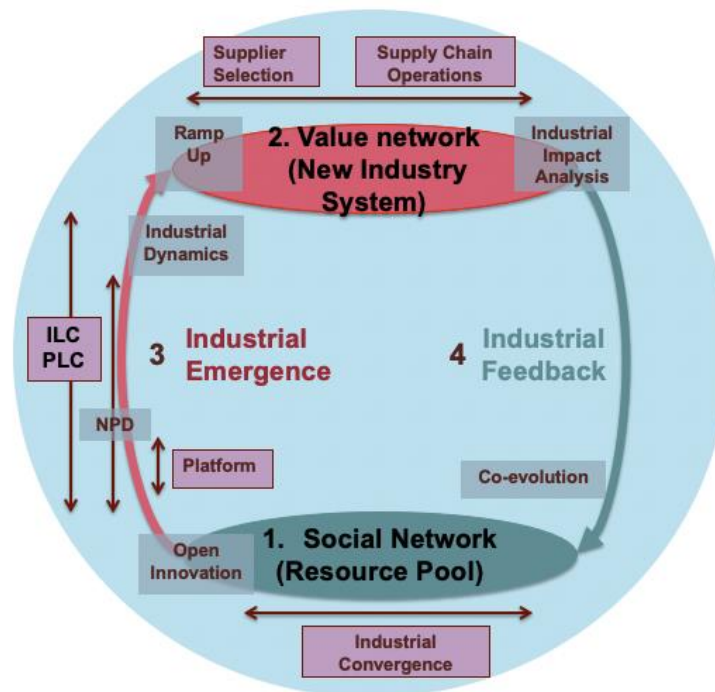


Figure 2.8 Tornado model of the industry ecosystem

How to nurture a new ecosystem is one of the critical questions in ecosystem research, which is also important for understanding how to create and foster a new industry. The processes of ecosystem emergence involve value discovery for designing and establishing an ecosystem value proposition and offering, collective governance for the regulation of participation, platform resourcing for set-up and scale-up, and contextual embedding for legitimation (Thomas et al., 2022). Rong et al. (2015, p. 302) explore the process of how ARM (a leader in microprocessor intellectual property) developed its Chinese market in three sequential stages: "incubating complementary partners, identifying leader partners, and integrating ecosystem partners". In contexts of market failure in the vaccine industry,

Li and Garnsey (2014) propose the ecosystem approach to promoting innovation via policy support so that resource-constrained firms can leverage the policy-driven ecosystems to develop a new vaccine. Dattée et al. (2018) illustrate how focal firms establish dynamic control over the innovation ecosystem creation process to cope with great uncertainties, and call for more research to explore the ecosystem evolution dynamics in a more comprehensive model with more control points.

2.2.4 Establishing the concept of industry ecosystem in management research

The term 'Industry' is traditionally used by economists to define a group of firms competing in a particular product market, especially in a vertically integrated industry with one-dimensional competition (Baldwin, 2021). In the previous innovation studies and management studies, the industry boundary is also a fundamental assumption in classical theories based on the industrial age, such as innovation system, industrial system, and Porter's Diamond Model. As a result of vertical disintegration and industrial reorganisation, the blurring of industry boundaries has caused great challenges to the existing management research, and the industrial ecosystem was proposed to have a better understanding of contemporary technology and innovation (Andreoni, 2018; Best, 2015). Different to systems of innovation that focus mainly on innovation, and much less on industrial production, the ecosystem approach underlines the production-innovation nexus, including the product commercialisation and production organisation following technological innovation (Andreoni, 2018).

To explain the regional growth of diverse sectors, Best (2015) suggests that a large population of technology differentiating enterprises is embedded in a regional industrial ecosystem that facilitates the development of the region's engineering expertise, technology capabilities, and financial resources using the case of Greater Boston. In addition to the traditional emphasis on similarity and economy of scale in regional studies, diversification dynamics are regarded as a mechanism that is more important to the

regional industrial ecosystem by inducing effective recombination and/or integration of capabilities and strengthening interdependencies (Andreoni, 2018). In the regional co-adaptive system, the business enterprises with differentiating capabilities behave as an “entrepreneurial agency in which opportunity discovery and distinctive capability development meet and mutually condition the other” (Best, 2015, p. 4).

It is worth noting that the existing concept of ‘industrial ecosystem’ from the industrial ecology perspective is far away from the concept of ‘industry ecosystem’ proposed in this research from the industry emergence perspective. The industrial ecosystem is concerned with environmental conservation through efficiently reusing materials (Frosch and Gallopoulos, 1989; Korhonen and Snäkin, 2005). Industrial ecosystem studies focus on optimisation, sustainability, and symbiosis by employing energy and/or material flow analysis (Tsujimoto et al., 2018).

Although the ‘regional industrial ecosystem’ from the economic geography perspective provides a foundation for further ecosystem research in terms of industry formation and development, it still differs from the ‘industry ecosystem’ concept of this research in the fundamental aim and mechanism. My definition of industry ecosystem embeds the production system within a broader and precedent ecosystem of interdependent actors contributing to the emergence or transformation of the industrial system. Rather than focusing on the regional industrial development of different sectors, my industry-wide framework focuses on the industry ecosystem for the emergence, transformation, and renewal of the focal industry, although actors from other sectors involved in the cross-industry collaboration are also part of it. According to Moeen et al. (2020), there are various actors in emerging industries including individuals (e.g., academic and corporate scientists, user inventors, user entrepreneurs, ex-employees), for-profit firms (e.g., start-ups, established firms from related sectors), non-profit organisations (e.g., public agencies, foundations), and collaborative forms (e.g., alliances, associations, social movements). The boundary of an industrial ecosystem depends on the value creation processes and the accordingly evolving interdependences linking relevant players of the

focal industry (Andreoni, 2018). All relevant actors are considered beyond the boundaries of a single industry (Jacobides et al., 2018). Moreover, ecosystem actors are not ex-ante, and new actors and existing actors interact and co-evolve during ecosystem and industry emergence (Ansari et al., 2016; Dattée et al., 2018).

To enrich ecosystem research and respond to the call to use ecosystem-level analysis to substitute for the industry-level analysis (Teece, 2012), this research, from an industry-wide ecosystem perspective, seeks to explain how industrial system and industry architecture emerge, which is the nexus of industry emergence. The industry architecture, which refers to the “templates that emerge in a sector and circumscribe the division of labour among a set of co-specialized firms” (Jacobides et al., 2006, p. 1201), is influenced by a diversity of actors in the ecosystem, even a small entrepreneurial venture (Santos and Eisenhardt, 2009). My definition is consistent with but broader than the prior definition of ecosystem by Hannah and Eisenhardt (2018, p. 3164) as “groups of firms that produce products or services that together comprise a coherent solution”, such as the smartphones ecosystem including the firms involved in handsets, apps, operating systems, and networks. Shipilov and Gawer (2020) also stress that the starting point for ecosystem research is the focal offer rather than the focal firm.

In conclusion, the working definition of industry ecosystem is: *the groups of actors that co-evolve capabilities and co-create a new industry, i.e., the emergence of an industrial system and industry architecture around a focal offer.*

2.2.5 Summary

As an emerging research domain, ecosystem research has different streams from different disciplines and units of interest, as is shown in Table 2.3. To resolve the disagreements and inconsistency in ecosystem research, I conducted a comprehensive review of ecosystem literature and distinguished between different streams. From reviewing the literature, a whole picture of existing ecosystem research has been depicted along with

the division of the four streams. For each research stream, the discipline, unit of interest, ecosystem vision, function, behaviour, and representative literature are identified and listed.

Table 2.3 Overview of ecosystem research

Concept	Discipline	Unit of interest	Vision	Function	Behaviour	Representative literature
Business ecosystem	Strategy	Focal firm	Support the business of the focal firm	Value creation and capture	Boundary-spanning and collaboration	Moore, 1996; Teece, 2007; Iansiti, and Levien, 2004
Innovation ecosystem	Innovation studies and strategy	Focal innovation	Creating and commercialise a particular innovation	New value proposition	Product innovation with partners and potential adopters	Adner, 2007; Adner and Kapoor, 2010; Gawer and Cusumano, 2014
Industry ecosystem	Innovation and industry studies	Focal industry	Nurturing a new industry	New industry systems	Resource mobilisation and renewal	Hannah and Eisenhardt, 2018; Best, 2015; Ansari et al., 2016
Entrepreneurial ecosystem	Innovation and entrepreneurship	Focal region	Fostering innovative start-ups	High-growth new ventures	localised resources and knowledge deployment	Autio et al., 2018; Clarysse et al., 2014; Stam, 2015; Spigel, 2017

The existing ecosystem literature has been largely limited to firm-level models for explaining how a firm establishes an ecosystem around its core business to maintain competitive advantage or facilitate innovation; the focal firm view limits the exploitation of dynamics and complexity of the ecosystem, and the multi-actor and evolving characteristics of the ecosystem should be emphasised (Baldwin, 2012; Jacobides et al., 2018). Ecosystem research and models from an industry level are needed to achieve a comprehensive theoretical structure and connect with other levels of ecosystems. To

respond to and emphasise the value of the ecosystem as a new level of analysis to replace industry, as well as to cope with the boundary-crossing trend in this digital era, research is needed to capture and exploit the dynamics and mechanisms of the industry ecosystem in the context of industry emergence.

2.3 Conclusion of Literature Review and Research Question Identification

To sum up, the literature on the topic of industry emergence is disparate and dispersed among several fields of research. However, blind spots in industry emergence research still exist. We find there is a need to improve the understanding of dynamics and transitions involved within industry emergence. Although ecosystem research stresses the importance of the supporting environment for these firms and industries, the organisational forms and roles needed to create a new industry are still unknown. Through reviewing the literature from these two areas, I find it necessary to integrate the existing studies that are directly and indirectly concerned with industry emergence and develop a holistic ecosystem model to explain how a new industry emerges. My research question is: **How does a new industry emerge based on the underlying ecosystems?**

This chapter reviews the literature of two bodies of knowledge, industry emergence and ecosystem research, and identified several research gaps. In summary, the research gaps are: (1) The integration of industry emergence from diverse disciplines (Moeen et al., 2020); (2) Transitions between stages of industry emergence (Gustafsson et al., 2016); (3) The synergy between different levels of ecosystems (Jacobides et al., 2018); (4) The dynamics and mechanisms of the industry ecosystem (Bogers et al., 2017). And thus the specific research questions accordingly are:

(1) How does industry emergence unfold in the digital era?

(2) How do the underlying ecosystems enable the transitions and emergence?

Chapter 3 RESEARCH METHODOLOGY AND DESIGN

This chapter presents the research methodology employed in addressing the proposed research questions and objectives. In the chapter, epistemological positions will be discussed first, followed by selection of the research methods. This research will be a longitudinal qualitative case study. Unit of analysis, data collection, and analysis will be introduced in the third section of this chapter.

3.1 Research Design

My in-depth, inductive, longitudinal research examines the processes and transitions that lead to the emergence of a new industry, with an emphasis on how different actors interact and strategise and how the underlying ecosystems interact and support the industry emergence. In terms of data collection, mainly in Hangzhou and Shenzhen – the two cities leading the development of cloud computing industries in China – I conducted fieldwork and interviews in cloud computing-related firms and organisations, including Alibaba Cloud, Huawei Cloud, Tencent Cloud, China Mobile, Cloud Town, the Economic and Information Technology Commission, and other stakeholders in the Chinese cloud computing industry.

3.1.1 Epistemological positions

There are two major epistemology traditions in social science research, positivism and interpretivism (Johnson and Duberley, 2000). Positivists and interpretivists have different ontological and epistemological positions, search for different kinds of answers, and therefore see data and conduct studies in different ways. To answer the proposed research question, this research had to build up new theories based on up-to-date industrial practices. There are few studies and theories answering the question of how a new industry emerges in the existing literature. Therefore, the appropriate research approach for this research was interpretivism, allowing me to conduct inductive

reasoning and develop new theories to understand the emergence process and mechanism.

Interpretivism entails symbolic interactionism and phenomenology (Weber, 1978). What is distinctive about interpretivism is that it implies that the way people view things determines the nature of things (Goodman, 1978). Positivists believe that social phenomena are objective and not subject to human factors (Bryman, 2012). Practitioners of positivist approaches follow the method of natural sciences research and believe that there must be inherently fixed, universal, reproducible laws in the social world as in the natural world (Taylor et al., 2015). Practitioners of the positivist approach propose theoretical propositions before they go to the field, and then they try to confirm them with observations and test them with analysing tools, which is deductive, while interpretivist approaches derive propositions directly from the case and end here, which is inductive (Gehman et al., 2018). Social scientists seek to understand people's ideas and explain their behaviour and views on society, which requires a different approach to research in the natural sciences (Bryman, 2012). In fact, scientific knowledge cannot simply be deduced from nature without a common cultural background (Kuhn, 1968). Interpretative approaches hold that social science and natural science are fundamentally different (Saunders et al., 2009). It is nearly impossible to fully follow the objectivity of natural science and reveal the laws of social phenomena and social behaviour without value relevance (Goddard, 1973).

Contrary to positivist approaches that posit that everything is objectively independent of human factors, interpretivism has different ontology supporting its research methodology. The interpretivist researcher believes that there is no objective reality in the social world since social customs and rules are human constructs (Easterby-Smith et al., 2002). Practitioners of the positivist approach propose theoretical propositions before they go to the field, and then try to confirm them with case studies, which is deductive; while interpretivist approaches derive propositions directly from the case and end here,

and require a researcher to keep an open mind so that concepts and theories can emerge out of the data, which is inductive (Bryman, 2012).

Interpretative case study research is an evolutionary process in which researchers typically suspend their hypothesis, and the research design can change as the research progresses (Gouldner, 1961). First, in the process of collecting data, the researcher is part of the observation or interview, interacting with the subjects, so that every case is a special experience, which means that the sample number can be small, but details and information should be rich (Easterby-Smith et al., 2002). Second, in the next stage of data analysis, the overall understanding of the situation is deduced from different perspectives of the various stakeholders. The research results are considered to be the interpretative understanding of the social world consisting of everyday reality, and the collective reconstruction by the researchers and subjects together of social reality produced by social actions (Blaikie, 2000). Therefore, interpretivism stresses the environment in which the research is situated and value of qualitative data in the research as a process of knowledge creation (Maxwell, 1996). Standards such as “the maximum exactness in classifying and presenting data” and “the procedure's appropriateness” are also valid in interpretive social science (Flick, 2009, p. 299). For example, grounded theory emphasises in-depth and meticulous investigation of objects, identification of meaningful and native concepts, and theory building from the first-hand data that are collected by researchers themselves (Corbin and Strauss, 2015).

3.1.2 Research method selection

In terms of research strategy, there are two alternative choices: quantitative and qualitative research (Robson, 2002). There is no necessary connection between the research strategy and epistemological position because whether a study is qualitative or quantitative depends on the type of data collected by the methods (Silverman, 2006). The differences between the two contrasting strategies are as shown in Table 3.1. In this research, the data collected will be qualitative because qualitative data could reflect the

rich context of the subjects studied compared to the numeric data in quantitative research. Due to the research question I seek to answer, the information needed is comprehensive, which is hard to obtain through a survey. And the unit I observe is an industry instead of a person, thus making it nearly impossible to conduct an experiment. Considering that industry emergence in the digital era is a new issue that is currently not well documented and lacking in established theory, a qualitative strategy is adopted as it allows me to explore the research area with little theory foundation and to take a holistic approach to the study of phenomena (Corbin and Strauss, 2015).

Table 3.1 Qualitative and quantitative approaches (Creswell, 2014)

	Qualitative	Quantitative
Nature	Emerging methods	Pre-determined
Questions	Open-ended questions	Instrument based questions
Data source	Interview, observation, document, and audiovisual data	Performance, attitude, census, and observational data
Data analysis	Text and image analysis; theme, patterns interpretation	Statistical analysis and interpretation
Methods	e.g., Case study, ethnography	e.g., Survey, experiment
Theory	Propositional	Hypothesis testing

Qualitative research comprises interactive activities which rely on the interaction between researchers and participants and requires efforts from both sides. Research also in turn influences the researchers. In qualitative research, researchers explore the true feelings of the insiders in the organisation studied and gain an interpretative understanding of the organisation through interaction with the research subjects. By figuring out how meanings are formed and transformed through qualitative research, we can build basic theory in this research area not yet thoroughly researched, which will provide relevant variables for later quantitative studies to test (Corbin and Strauss, 2015).

Although the use of validity in qualitative research is often challenged concerning the difference between quantitative and qualitative evidence, validity can still serve as a

useful criterion in qualitative research, but some reformulation of the concept is needed (Cho and Trent, 2006). For example, construct validity is about whether the measure of a concept really reflects it (Kidder and Judd, 1986; Yin, 2009). Maxwell (1996) classified five kinds of validity considerations: descriptive, interpretive, theoretical, generalizability, and evaluative validity. LeCompte and Goetz (1982) introduced internal and external validity into qualitative research; the former relates mainly to what extent researchers' observations match their theory, while the latter defines the degree to which the findings can go beyond the specific setting of the research. This criterion should not be discarded but better adapted to qualitative research and supplemented by other criteria such as reliability, transferability, and credibility.

Concerning specific method, different methods have different ways to implement the research, for example, experimental method or survey methods for quantitative research, ethnography or case studies for qualitative research, and sequential mixed methods or concurrent mixed methods for mixed research (Creswell, 2014). According to Yin (2009), the criteria for choosing a research method comprise the three considerations listed in Table 3.2.

Table 3.2 Relevant situations for different research strategies

Method	Form of Research Question	Requires Control over Behavioural Events	Focuses on Contemporary Events
Experiment	How, Why	Yes	Yes
Survey	Who, What, Where, How Many, How Much	No	Yes
Archival Analysis	Who, What, Where, How Many, How Much	No	Yes/No
History	How, Why	No	No
Case Study	How, Why	No	Yes

For this research, there are three reasons why a case study method is used:

- 1) The form of question is a 'how' type of question. With a richly detailed description of a particular phenomenon, how a new industry has emerged can be unpacked (Hakim, 2000).
- 2) Case studies are flexible, which is appropriate for the explorative purpose of this research. It does not require any control over behavioural events, since case study involves direct observation of events and interviews with people who are involved in these events that are being studied in the research (Yin, 2009).
- 3) Finally, this research is focused on the recent emerging industries. What is most suitable for studying contemporary events will be a case study.

In conclusion, this research used a theory-building case study approach and process research strategies because I aimed to theorise a hitherto under-explored question of industry emergence.

3.1.3 Case study design

This study was a longitudinal case study, considering that the research purpose was to examine the emergence process of a new industry. Process data analysis and multi-case study methods are combined to understand the evolving interactions and dynamics in the digital context (Eisenhardt, 1989; Langley, 1999; Yin, 2009).

During the course of a study, actors, actions, and perspectives can change, and the changes are contextual (Saldaña, 2003). I employed multiple qualitative research methods in analysing the rich text data from a variety of primary and secondary sources to capture the changes and mechanisms in industry emergence. Flick (2009, p. 303) explained the value of text data as follows:

This substantiation of reality in the form of texts is valid in two respects: as a process that opens access to a field and, as a result of this process, as a reconstruction of the reality, which has been transformed into texts. The

construction of a new reality in the text has already begun at the level of the field notes and at the level of the transcript and this is the only (version of) reality available to the researchers during their following interpretations. These constructions should be taken into account in the more or less meticulous handling of the text, which is suggested by each method of interpretation.

Longitudinal research is a powerful tool for collecting rich data of evolution and revealing the underlying generative laws (Van de Ven, 1990; Mills et al., 2010). By conducting a longitudinal case study, this research focuses on recording and analysing the process, transition mechanisms, and dynamics of industry emergence. In longitudinal research, researchers need to get embedded in the setting and context of the research while maintaining their independence, objectivity, and morality as researchers. By keeping an objective recording of the facts and looking at the problem from the perspective of the research subject, researchers produce a process theory that explains the underlying generative mechanism of the observed sequence of events (van de Ven and Huber, 1990).

In the longitudinal research, triangulation, timely follow-up, and respondent validation were conducted to ensure the continuity and validity of each case:

- 1) *Triangulation.* Triangulation means having more than one source of data (Klein and Myers, 1999). This term was first proposed by Webb et al. (1966) as an approach to developing measures of concepts in quantitative studies to increase confidence in the findings. Denzin (1970, p. 310) broadens this term, and his triangulation covers triangulating the perspectives of interviewees with “multiple observers, theoretical perspectives, sources of data, and methodologies”. The idea behind conducting a qualitative interview is to triangulate the perspectives that interviewees offer with various data from different sources. For example, interview data can be triangulated against

secondary sources such as news articles and books about the organisations, and corporates' website and internal publications (Pan et al., 2015).

- 2) *Timely follow-up*. To follow-up the interviewees in a timely manner is a useful skill, which can help keep the interviewers up to date with information about the industries and the firms. Also, it helps the researcher to check whether they might have misunderstood the interviewees' words or to clarify their meaning when some responses are ambiguous. The interviewer should ask for a regular contact to keep in touch after the face-to-face interview. The interviewer may have some confusion or concern after reviewing the interview audio or transcript. In this case, being able to contact the interviewee in a timely way through phone call, email, or instant messaging (e.g., Wechat) can help the interviewer to obtain further corroborating evidence for their interpretation with further informants (Pan and Tan, 2011). Some ideas and concerns of the interviewer, as well as the interviewee's memories, may fade with time, so timely clarifications and follow-up questions are important.
- 3) *Respondent validation*. Respondent validation, also called member validation or member check, means to provide the research participants with an account of the research findings and obtain their feedback to improve the results (Bryman, 2012). The validation materials can vary in form, including the researcher's notes about their impressions and thoughts, their recording of what the participants said or did, and their account of the interview content. This practice can examine whether the interviewees' perspectives corroborate the findings. The researcher tries to confirm that their impressions are congruent with the participants' views. If there is a lack of correspondence, the researcher needs to find out reasons for it and revise the research report with feedback from participants.

If a study is of high reliability, when other researchers conduct their own study according to the same procedures and requirements, they can reach the same results. This requires a specific account of research procedures and process, which is also known as the

research protocol. In a case study, a fully explained protocol will increase the reliability and confidence of the study. Yin (2009) suggests that case study protocol can help to establish the reliability of qualitative research (see Figure 3.1). As shown in Figure 3.1, Yin (2009, p. 57) proposes a case study protocol from replication approach:

- 1) A literature review is conducted in order to identify the research gap and develop theory.
- 2) A preliminary research framework is designed to guide the research.
- 3) The industrial cases are selected and the data collection protocol is finalised.
- 4) For each case study, data is collected, analysed, and recorded, and an individual case report is written.
- 5) When important discovery occurs in individual case study, a redesign is required before proceeding further.
- 6) When all the case studies are finished, cross-case analysis is conducted to synergise the findings to build theories, and a cross-case report is written.

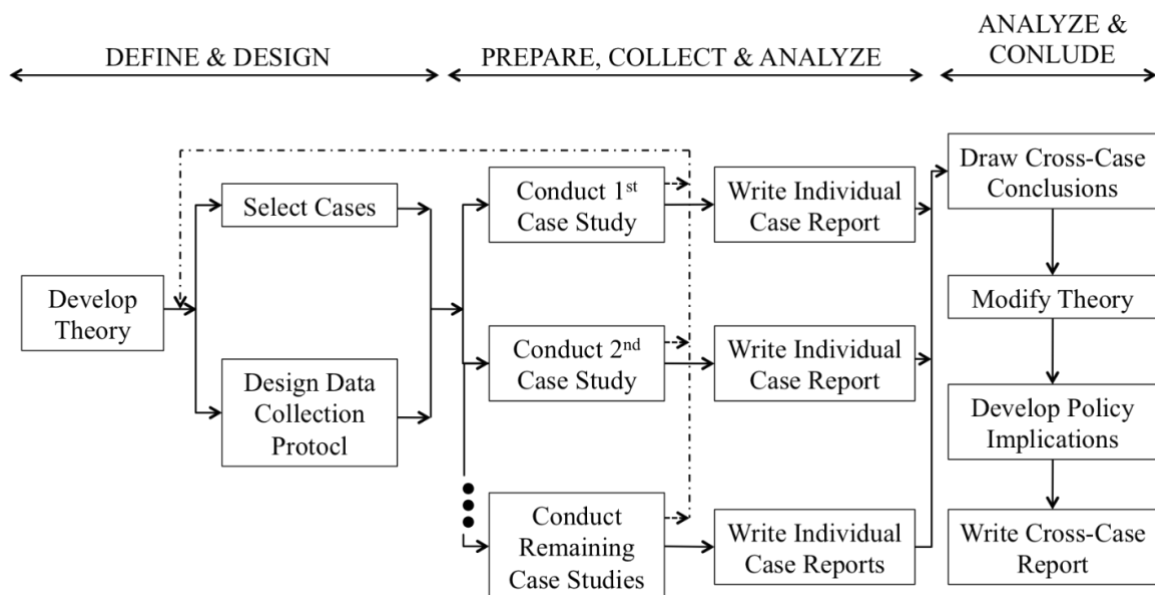


Figure 3.1 Protocol of multiple-case studies (Yin, 2009)

Before choosing the case to be studied and data to be collected, it is important to first define the unit of analysis. Yin (2009) proposes that the identification of the unit of analysis depends on the proposed research question. In this study, the research question

is how a new industry emerges based on the underlying ecosystems, specifically, what are the stages and transitions of emergence, how enterprising actors navigate the emergence, and how the underlying ecosystem supports the emergence. As this is longitudinal research, what the industry or ecosystem is like at the birth is not clear in reality. I aimed at capturing the whole picture of the industry and the ecosystem behind it by integrating the evolutions of the players involved. Therefore, my basic unit of analysis is the evolution process of individual players along with the industry emergence process. In order to capture the industry emergence process, organisational processes of different players and interactions between these players at the ecosystem level and industry level were recorded.

3.1.4 Pilot study

The implementation of pilot case studies is a useful methodology in ensuring the appropriateness of the research design and can be viewed as a 'dress-rehearsal' for the main empirical collection (Yin, 2009; Atkins and Sampson 2002). There are two reasons why case studies at this stage of the research are needed. One is to gain a better understanding of the general picture of the industrial emergence. The other is to test and improve the preliminary research design including the selection of case firms. The focus here is the method of approaching the case firms as well as the method of data collection used in order to obtain a more refined research design for the main data collection. For the purpose of improving the research design and the understanding of industrial challenges – the pilot case study – this chapter reviews the emergence of Zhejiang's computing industry. The findings will reveal the mechanism of how this industry has emerged and serve as a guide for our future research.

As stated in the research design, the first stage of research preparation was performed through the gathering of secondary data sources using documentation and archival data. Currently, the cloud computing industry is most successful in Zhejiang province. Also, the earliest cloud computing businesses and firms were born in this region. In the first

quarter in 2018, Alibaba Cloud, the leading cloud computing firm in Zhejiang province, ranked first in enterprise public cloud adoption in China and occupied 43% of the Chinese market (see Figure 3.2). Concerning the emergence of the cloud computing industry, Zhejiang province has seen the creation and growth of this industry and developed its own industry structure.

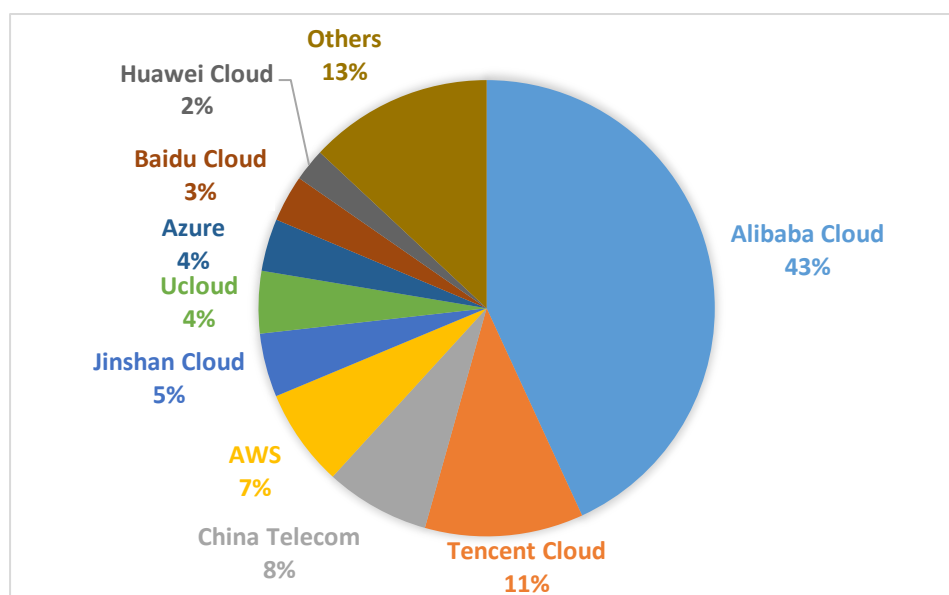


Figure 3.2 Enterprise public cloud adoption in China 2018 H1

Then, a pilot case study was carried out through the implementation of semi-structured interviews as well as on-site plant visits with industrial players and policymakers. This exploratory work consists of interviews with three cloud service providers (Alibaba Cloud, Huber Cloud, DT Dream), two service receivers (Hanbo, Geely), one related hardware manufacturer (SUPCON), a local university (Zhejiang University), and a government-affiliated institute (Zhejiang Institute of Industry and Information Technology).

As cloud computing gains increasing legitimacy as a new market category, the vendor develops a portfolio of strategies and leverages a political toolkit to respond to and shape the emergence and evolution of the market (Su, 2011). The research results answering the proposed research question are displayed in Table 3.3.

Table 3.3 Pilot study results

Proposed research question	Pilot case study results
Who are the key players in the business ecosystem? What roles do they play?	Alibaba is the core of the ecosystem. It initiated the new industry at first quite unintentionally and then the government facilitated it purposely.
How do they interact with each other?	Alibaba spins off and invests in start-ups and then they cooperate on government projects.
What resources and capabilities are needed to create a new industry?	Government policy supports, firms' R&D capability.
How do they leverage the resources in the ecosystem?	Firms' ability to leverage social and governmental resources as well as government planning.

Through the case study, for one thing, experiences accumulated from fieldwork and data analysis helped me refine and improve the research design. For another thing, the preliminary fieldwork about the cloud computing industry in Zhejiang province provided an excellent opportunity for me to understand not only practical management backgrounds but also theoretical frontier solutions.

In this case, the Alibaba group is the key player in the emergence of the cloud computing industry. It started the R&D of cloud computing technology from the very early stage, as one of the earliest cloud computing service providers in China. The first-mover advantage also contributes to its leading role in the enterprise public cloud market. However, initially, Alibaba developed cloud computing technology not for a cloud computing service business, but for its inner use, especially during the 11-11 festival, which requires huge computing capacity. This case illustrates that the emergence of a new industry is not necessarily created on purpose, which provides an important insight for industry emergence theory. Moreover, a big high-tech company leads the industry emergence in this case, leaving more dynamics and patterns to be explored in the following research.

3.2 Case Selection and Data Collection

To investigate industry emergence in the digital age, the case industry should be a representative emerging industry based on digital technologies, and, moreover, it has emerged but the emergence is not too long ago to trace back. Considering the criteria and the practical backgrounds, I chose the emerging cloud computing industry in China as the research context, because it emerged in 2008 and was in the fast-growing period, which made it suitable for a longitudinal study to collect data. Furthermore, samples cover important players in the industry according to the principle of theoretical sampling (Eisenhardt, 1989). With the aim of addressing the research question through the implementation of case studies, the case entities were chosen with reference to the following conditions within the emerging industry:

- 1) The case entities must represent different stakeholders in an industry or ecosystem, including core firms, extended enterprises, industrial supporting organisations, and policy-making bodies.
- 2) The case entities must have experienced or be experiencing the emergence stage of the industry.
- 3) The case entities must have great potential to survive the emergence stage, which can reduce the risks of the case studies.

Three main rounds of data collection were taken as an interactive process. Firstly, I collected second-hand data before the fieldwork to become familiar with the basic information about the industry and organisations, and I then conducted fieldwork-based interviews, followed by preliminary analysis. I also collected more second-hand data for triangulation. With the more nuanced enquiry and gaps or contradictions from the preliminary analysis, I conducted a second round of fieldwork and data collection. This second round of data collection and analysis produced main findings and frameworks, for which I conducted a third round of data collection and analysis to refine them until theoretical saturation.

As the main data source, semi-structured interviews were conducted because they are less structured and more flexible, meaning the interviewer can change the order and focus or add follow-up questions to cultivate interviewees' insights better (Myers and Newman, 2007). The timeframe that I focused on in the data collection was January 2008 to July 2022. I also collected data from various sources including documentation, archival records, and direct observations. As the data sources have their own strengths and weaknesses, they are complementary to one another and none of them are superior to the others. Therefore, a combination of several data sources is used in this research to generate a more robust and reliable set of data.

I conducted 84 semi-structured interviews between April 2018 and July 2022, and Table 3.4 lists the number of interviews conducted from each firm in the sample. Furthermore, I collected secondary data from documentation and archival records including internal reports, press releases, newspaper articles, and research reports (Yin, 2009). I triangulated the interview data against secondary sources such as news articles and books about the organisations, and corporate websites and internal publications (Pan et al., 2015), especially when I mapped out the timeline concerning the occurrence and dates of certain events. The interviews were conducted in Mandarin, and most of the secondary data was Chinese, so all the textual data was retained and analysed in the original language and only translated at the time of writing.

Table 3.4 Overview of interviews conducted

Role	Type	Number	Organisation	Interview
Focal firm	IaaS vendor	6	Alibaba Cloud	Director of Alibaba cloud research institute, 27/05/2019; marketing manager, 27/05/2019; IIoT manager, 27/05/2019; technology manager, 06/11/2020; IIoT manager, 01/03/2021; project manager, 18/05/2021

		6	Tencent Cloud	Financial cloud manager, 13/06/2019; PR manager, 05/02/2021; overseas business manager, 20/04/2021; ecosystem office manager, 22/04/2021; Qianfan project manager, 22/04/2021; PR manager, 23/04/2021
		6	Huawei Cloud	IIoT manager, 23/07/2018; Cloud BU strategy manager, 20/04/2021; Cloud BU technology manager, 20/04/2021; 2012 lab manager, 21/04/2021; strategy manager, 14/04/2022; computing product manager, 01/06/2022;
		2	China Mobile Cloud	Cloud support manager, 03/11/2020; IIoT manager, 30/07/2021
Complementor	SaaS/PaaS vendor	3	DT Dream	Marketing manager, 27/05/2019; technology manager, 27/05/2019; co-founder, 13/08/2020
		5	CityDO	Founder, 12/08/2020; technology manager, 12/08/2020; project manager, 12/08/2020; founder, 01/06/2021; project manager, 01/06/2021
		2	Blacklake	Technology manager, 11/09/2019; marketing manager, 23/09/2020
		1	Chinasoft international	Marketing manager, 24/09/2020
		2	Brand New Data	Co-founder, 11/08/2020; chief technology officer, 11/08/2020
		2	Huber Cloud	Co-founder, 29/05/2019; 10/06/2021, co-founder, 18/11/2020
		1	Cosmo Plat	Head of Cosmos Institute, 02/09/2020
		2	Hudsun Technology	Technology manager, 28/10/2020; project manager, 28/10/2020
		2	DAS Security	Vice-president, 22/10/2020; technology manager, 22/10/2020

		2	Kingdee	Marketing manager, 23/09/2020; project manager, 24/03/2021
		1	Sinoiov	Technology manager, 06/12/2021
Supplier		2	SUPCON	Technology manager, 31/05/2019; marketing manager, 31/05/2019
		2	Huawei	Design manager 23/07/2018; supply chain manager, 23/07/2018
		2	China Mobile	Head office manager, 12/04/2021; technology manager, 12/04/2021
Client		2	Ant Group	Technology manager, 06/11/2020; Oceanbase manager, 06/11/2020
		2	Eifini	CEO, 13/11/2020; chief technology officer, 26/12/2020
		3	Haier	IoT manager 01/09/2020; factory director, 02/09/2020; strategy manager, 03/09/2020
		2	Wynca	Project manager, 12/10/2020; technology manager, 12/10/2020
		2	Hangzhou Government	Transportation secretary, 10/04/2021; health commission secretary, 12/04/2021
		2	Mindray	Technology manager, 23/04/2021; marketing manager, 23/04/2021
		1	Mogu	E-commerce manager, 11/05/2021
Regulator	governme nt	2	Ministry of Industry and Information Technology	Digitalisation office secretary, 10/02/2020; network office secretary, 10/02/2020
		2	China Academy of Information and Communications Technology	Policy office director and secretary, 13/07/2022; policy office director, 20/07/2022

	3	Cloud Town Officer, Administrative Commission	15/12/2019; head, 22/10/2020; officer, 22/10/2020
	2	Hangzhou Commission of Economy and Information	Deputy head, 30/05/2019; deputy head, 17/09/2020
	3	Shenzhen Administrative Commission	District head, 20/07/2018; ex-deputy mayor, 21/07/2018; secretary for the commerce department, 22/07/2018
	2	Zhejiang Institute of Industry and Information Technology	Head, 30/05/2019; analyst, 30/05/2019
Intermediary	2	Big Data and Cloud Computing Association	Secretary, 10/12/2020; secretary, 10/01/2021
	1	SZ Venture Capital	Associate, 04/09/2019
Research institute	2	Cloud Academy of Engineering	Rotating chair, 22/10/2020; fellow, 22/10/2020
	2	Zhejiang University	Researcher, 30/05/2019; researcher, 03/04/2022
Total	84		

Notably, I also collected rich field data for uncovering mechanisms and tracing emergence processes (Small, 2009), and attended events hosted by relevant organisations to observe interactions (Lampel and Meyer, 2008). As is shown in Figure 3.2, the annual conferences hosted by IaaS vendors invited their partners and clients to present the latest practices. I went to the HUAWEI CONNECT 2020 Conference in Shanghai, the 2020 Tencent Ecosystem conference in Shenzhen, and the 2021 World Internet Conference in Wuzhen, Zhejiang. After Covid-19, many of the cloud vendors organised regular online sessions and gave online presentation to promote cloud services and update with their use cases, such as the Kingdee forums on digital transformation, Huawei Cloud Native sessions, and Tencent Cloud developer workshops. I watched many live-streaming promotion activities and also obtained some of their presentation slides and contacts as updated data sources.

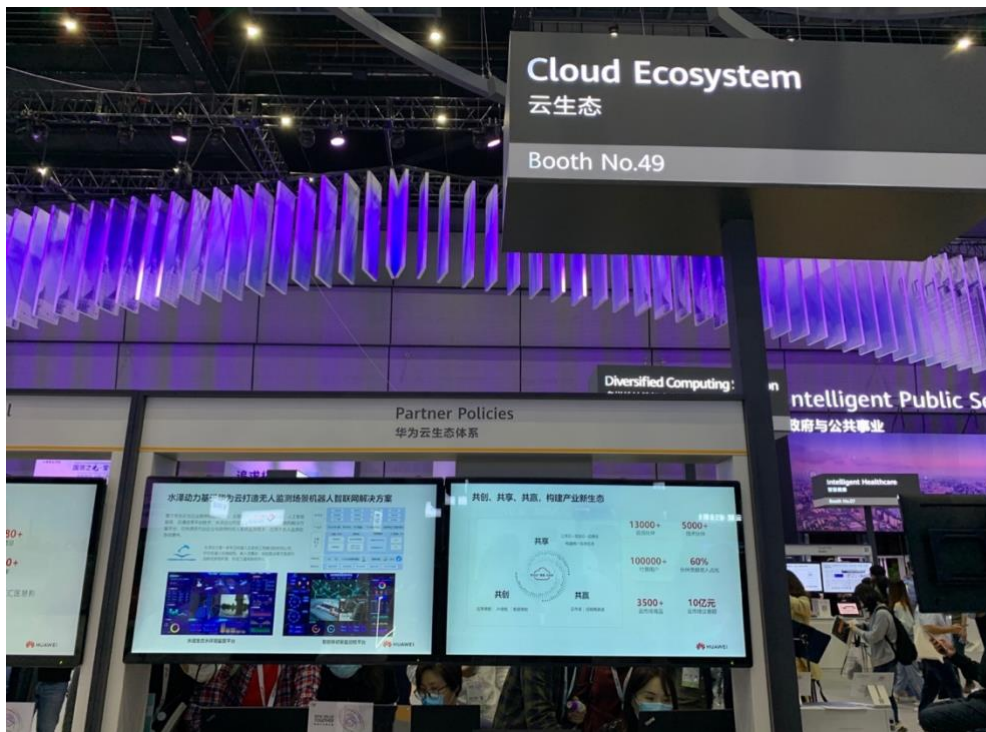


Figure 3.3 Picture taken at the HUAWEI CONNECT 2020 Conference

3.3 Data Analysis

As is shown in Figure 3.4, my data analysis protocol comprised four steps: (1) documenting key events and milestones of each organisation and the main business ecosystems through road mapping and temporal bracketing (Langley, 1999); (2) conducting within- and cross-case analysis of the organisational processes (Eisenhardt, 1989); (3) developing the theoretical framework for emergence stages and transitions by comparing the organisational processes; (4) conducting thematic analysis of the interviews and documents and comparing the analysis results with literature to explore the dynamics and mechanisms (Gioia et al., 2013).

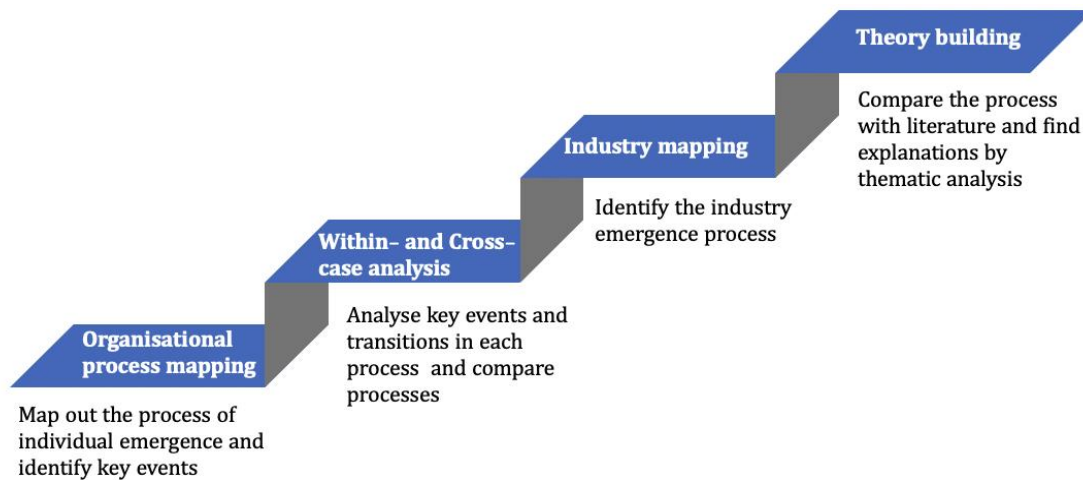


Figure 3.4 Data analysis protocol

Langley (1999) summarised seven strategies for theorising from process data. I used different strategies for the two sub-questions according to the unit of analysis, key anchor point, and form of sensemaking of each research question (see Table 3.5).

Table 3.5 Overview of research questions and design

Research question	Theory	Unit of analysis	Methods	Deliverables	Implications
How does a new industry emerge?	Industry emergence, dominant design	Industry	Visual mapping strategy & temporal bracketing	Industry emergence model	New pattern in digital era, transactions, dynamics of dominant design
How do the underlying ecosystems support industry emergence?	Ecosystem, cross-industry innovation	Ecosystem	Grounded theory strategy	Industry ecosystem model	Mechanism of transitions, actor and activity models of industry ecosystem

First, I used the temporal bracketing and roadmapping techniques of Langley's method to derive the process model of industry emergence and transition mechanisms. After identifying the stages, I focused on and labelled the common activities pursued by different actors and key tasks completed in each phase, searched literature to refine the

labels as concepts, and compared the findings with literature to find explanations for the change, especially for how what happened in the last phase led to the next phase (Denis et al., 1996).

For the second sub-question, using thematic analysis (Charmaz, 2014; Braun and Clarke, 2006), I exploited extensive data with a focus on ecosystems to add depth and nuance following the traditions of inductive case study (Doz, 1996). To reveal the theoretical dynamics surrounding the “emergence and evolution through multi-level interaction” in ecosystems (Langley et al., 2013, p. 9), I theorised from process data through grounded-theory strategy (Langley, 1999; Strauss and Corbin, 1990). The multi-centric structure and multi-level interaction of the ecosystem challenge the traditional case study methods that centre on a focal firm, so as yet there is no comprehensive approach to analyse a dynamic ecosystem (Talmar et al., 2020). This research developed an innovation analysis protocol that can capture the dynamics of ecosystems by utilising road-mapping methods, as well as can depict multi-centric nature of ecosystems by within- and cross-organisation analyses (see Figure 3.4). After mapping the development process of the new market and identifying key events in the earlier steps, I developed the ecosystem model with emergent themes from coding.

As mentioned above, my data collection and data analysis were iterative to ensure that the analysis process and results were tightly linked to the data (Eisenhardt, 1989). The preliminary conclusions that emerged from the first round of data analysis of fieldnotes were used to generate the guide for the subsequent interviews (Klein and Myers, 1999). The preliminary model was validated by the informants in the additional interviews, and refined with the additional data (Neuman, 2011). This process continued until no new insights occur and theoretical saturation was achieved (Corbin and Strauss, 2015).

Chapter 4 CASE STUDIES

This chapter presents the case studies implemented according to my research question and research design in the above chapters. The empirical setting of this case study is the cloud computing industry. Enabled by the foundational technology of distributed computation over the cloud, the emerging cloud market has developed rapidly and brought unprecedented changes to today's business world and society.

Cloud computing is defined as "both the applications delivered as services over the Internet and the hardware and systems software in the data centres that provide those services" (Armbrust et al., 2010, p. 50). Services delivered in this pattern have long been referred to as software as a service (SaaS), exemplified by the salesforce. In terms of the architecture, the cloud-based services can be divided into cloud-based IaaS (infrastructure as a service), cloud-based PaaS (platform as a service) and cloud-based SaaS (software as a service) (Kavis, 2014). In the cloud market, cloud vendors share and monetise computing as a utility. This disruptive mode is becoming widespread and transforming a large part of the IT industry by shaping the way that IT products and services are designed and purchased (Armbrust et al., 2010).

4.1 Alibaba Cloud Ecosystem

4.1.1 Overview of Alibaba Group and Alibaba Cloud

Alibaba Cloud, established in September 2009, is the cloud computing arm of the Alibaba Group. Initially, it was named Aliyun, aimed at providing technological infrastructure for Alibaba's e-commerce business. Alibaba Cloud powers Alibaba's vast online and mobile commerce ecosystem, especially during transaction 'rush hours' when high concurrency issues occur. During the 2017 Singles' Day (11-11) festival, a global shopping extravaganza that tests Alibaba's cloud computing processing, Alibaba Cloud processed over 325,000 orders per second at the peak, and 1.5 billion Alipay transactions in total,

achieving over \$25BN of gross merchandise volume (GMV) for retailers (Alibaba Group, 2017). At low points of computing tasks, cloud computing capacities become idle resources that can be shared with other users, which is the basic logic of the Infrastructure-as-a-Service (IaaS) model. With the advancements of cloud and other digital technologies, the e-commerce vendor and its partners are also equipped with increasingly comprehensive cloud-based, intelligent-driven capabilities, and start to provide Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS) for enterprises and developers.

As China's largest provider of public cloud services, Alibaba Cloud also became the world's third-largest IaaS service provider by revenue in 2017 with more than 1 million paying customers, according to Gartner (2017). By 2022, Alibaba Cloud had more than 3 million customers in more than 200 countries and regions and was able to keep upgrading its cloud services with advanced intelligence technologies and numerous cross-industry solutions (Alibaba Cloud, 2022). Alibaba Cloud offers a complete suite of cloud services, including elastic computing, database, storage, security, network & content distribution network (CDN), enterprise applications, big data analytics, hybrid cloud, and IoT services (Alibaba Group, 2018, p. 64). Driven by Alibaba's vision to make it easier to do business anywhere, with anyone, Alibaba Cloud keeps harnessing, improving, and fostering the latest cloud and intelligent technologies to enable large and small businesses, private and public sectors, and individual developers (Alibaba Cloud, 2019).

Alibaba Cloud is a business unit of Alibaba Group, which is a Chinese multinational Internet company specialising in e-commerce, retail, and technology. Founded on 28 June 1999 in Hangzhou, Zhejiang, the company was first incorporated as 1688.com to provide business-to-business (B2B) sales services via web portals, which boomed during the SARS pandemic by connecting buyers and sellers. After that, Alibaba launched Taobao.com in May of 2003 as a consumer-to-consumer (C2C) platform for individual sellers and later some small businesses. And, with the increasing influence of Taobao, more enterprise users joined and transacted via the e-commerce platform. In 2008, the company set up

Tmall.com as a business-to-consumer (B2C) platform for established companies to open online retail chains and flagship stores. At this point, Alibaba Group became the largest e-commerce company in China that offers B2B, C2C, and B2C sales services, and gradually transformed into a technology company owning and operating a comprehensive portfolio of companies in various business sectors globally, along with its relentless pursuit of enabling businesses and transactions to be conducted in a better way and keeping up with the pulse of digitalisation. As is shown in Figure 4.1 from Alibaba's 2020 annual report, Alibaba Cloud is the technology foundation of other business units.



Figure 4.1 Alibaba business structure

The booming users and transactions as well as the increasing diversity and complexity of services required Alibaba to develop new capabilities, thus driving the growth of its ecosystem. To support e-commerce on its platforms, Alibaba launched Alipay for electronic payment security, Alibaba Cloud for cloud computing capacity, and Cainiao for third-party logistics. These capabilities were initially for internal use and then turned into commercial products and services as new business units. As a representative example, Alibaba Cloud serves both Alibaba Group's own e-commerce ecosystem and international customers in numerous sectors.

In the journey of digital transformation and the successful launch of Alibaba Cloud, Alibaba Group has placed great emphasis on and investments into the continued development of its ecosystem and the interests of the ecosystem members, and attributed much of its success to the sustained and healthy growth of its ecosystem, as is stressed in its annual report in 2018:

An ecosystem has developed around our platforms and businesses that consists of consumers, merchants, brands, retailers, other businesses, third-party service providers and strategic alliance partners. At the nexus of this ecosystem are our technology platform, our marketplace rules and the role we play in connecting these participants to make it possible for them to discover, engage and transact with each other and manage their businesses anytime and anywhere...(Alibaba Group, 2018, p. 65). (Q4.1.1)

Alibaba Cloud and Alibaba Group have been pushing their boundaries through continuous innovation at all levels of business and spanning into emerging industries and markets. Ecosystem growth is intertwined with digital and business model innovation in a virtuous circle, in which the other participants of the Alibaba ecosystem are also helpful and indispensable.

4.1.2 Alibaba cloud ecosystem and its members

The key participants of the Alibaba Cloud ecosystem include SaaS/PaaS vendors as complementors, network and hardware suppliers, and important customers. As highlighted in the annual report, ecosystem members benefit from as well as contribute to the ecosystem.

Our ecosystem has strong self-reinforcing network effects benefitting its various participants, who are in turn invested in our ecosystem's growth and success (Alibaba Group, 2018, p. 65). (Q4.1.2)

The overview of representative members of each type I visited and interviewed is provided in Table 4.1.

Table 4.1 Overview of Alibaba Cloud ecosystem members

Type	Organisation	Description
IaaS/ PaaS vendor	Alibaba Cloud	Founded in 2009 in Hangzhou, Alibaba Cloud is a global leader in cloud computing and artificial intelligence, providing services to thousands of enterprises, developers, and governments in more than 200 countries and regions. It provides reliable and secure cloud computing and data processing capabilities as a part of its online solutions.
	DT Dream	Founded in 2015 in Hangzhou, DT Dream is a cloud computing and big data solutions provider and a strategic partner of Alibaba Cloud, and a founder member of Hangzhou City Brain since 2016. It has extensive experience in government, urban, and industrial internet applications.
	CityDO	Founded in 2017 in Hangzhou, CityDO is a big data service provider that aims at building smart cities through data operation and ecosystems as a promotor of urban digital transformation, enabler of urban data intelligent operation, and practitioner of smart city construction in the new era.
	Brand New Data	Founded in 2014 in Hangzhou, Brand New Data is a data management company that enables customers to transform data into a digital resource and then create value from digital assets to improve government governance and digital society.
	Hundson	Founded in 1995 in Hangzhou, Hundson is a financial technology company with the mission to "Make Finance Easy". It focuses on the financial industry and devotes itself to offering integrated solutions and services to the institutions of securities, futures, funds, trust, insurance, banking, exchange, and private placement.
	DAS	Founded in 2007 in Hangzhou, DAS-Security is a cybersecurity enterprise that developed against the backdrop of Zhejiang and Hangzhou's endeavour to play a leading role in the digital economy. It strives to provide Internet security for the development of the digital economy and society with the mission of building a safe and trusted digital world.
Supplier	SUPCON	Founded in 1993 in Hangzhou, SUPCON is a leading product and technology, solution and service provider of process automation for various process industries such as oil & gas, chemical, power, building material, pulp & paper, metallurgy, food & beverage, public utilities, etc. SUPCON is creating new values for clients by combining its automation

		know-how with advanced digitalisation technology such as IIoT, big data, and AI technology.
	Huawei	Founded in 1987 in Shenzhen, Huawei is a leading global provider of information and communications technology (ICT) infrastructure and smart devices. Under the guiding principle of Business-Driven ICT Infrastructure (BDII), Huawei is setting the pace for IT systems based on cloud architecture to lead the transformation of enterprise IT towards cloud architecture.
	China Mobile	Formally established in 2000 in Beijing, China Mobile is the leading ICT services provider in China and boasts a world-class telecommunications and information operator with the world's largest network and customer base. Its businesses primarily consist of mobile voice and data business, broadband, and other services.
Customer	Ant Group	Tracing its roots back to Alipay established in 2004, Ant Group is a world-leading Internet open platform that supports its partners to enable an inclusive, convenient digital life, and digital financial services for consumers and SMEs (small and micro-sized enterprises).
	Eifini	Founded in 2001 in Hangzhou, Eifini Group is a multi-brand lifestyle retail group, which owns multiple famous brands targeting differentiated market segments. It is committed to digital transformation to improve operational efficiency and organisational capabilities and strives to create sustainable value in the field of fashion and lifestyle consumption.
	Hangzhou city government	Hangzhou is the capital and most populous city of Zhejiang, People's Republic of China. It has a leading digital economy that contributed an added value of 429 billion yuan in 2020. Hangzhou city government constantly improves its governance by iteratively and cooperatively upgrading the City Brain to make the city a happier place to live and work.
	Wynca	Founded in 1965 in Hangzhou, Wynca is one of the top 500 chemical enterprises in China and one of the top 20 agrochemical sales enterprises in the world. It is transforming into a modern service-oriented enterprise of "manufacturing + platform + service" through the implementation of the green, intelligent, terminal, platform, and globalisation strategy.

DT Dream Technology Co Ltd, founded in March 2015, is headquartered in Yunqi Town, Hangzhou. Its founding team members have sufficient experience in the traditional ICT industry. As one of the key complementor in the Alibaba Cloud ecosystem, it has received investments from Alibaba Group and become the unicorn of the new Internet platform development and service sector. DT Dream's main businesses include new Internet

architecture, cloud computing, big data, security, and other internet-based fields. As an Internet-based business start-up leader, it is committed to providing cloud computing services for government, cities, and industries, and empowering them with digital capabilities. Based on the data stored on the cloud platform, DT Dream can also help customers to analyse and capitalise on the data, which is a pattern of Data-as-a-Service (DaaS). As a co-founder claimed, *"the mission of DT Dream is to enable digital transformation in government, city and industry"*. After moving the data storage and computing over to the cloud, Alibaba Cloud's complementors develop additional services based on the data and cloud computing platform for the customers. One technology manager explained:

Alibaba has no incentive to handle specific services tailored for the end customer from business logic because they mainly look at the infrastructure revenues and general services. Some industry insiders called us the construction team for Alibaba Cloud because we develop and maintain customised services based on its design and technological framework, focusing on PaaS and DaaS. Typically we work with Alibaba Cloud under a big project such as Hangzhou City Brain, and we get access to its business and digital ecosystem. (Q4.1.3)

Founded in 2017 in Hangzhou, CityDO provides cloud and big data-based services specialising in smart city and urban digital transformation. The smart food market where all food can be traced from the farm to the market, the smart community featuring smart safety monitoring and cultural diversity, and the smart village with convenient recycling and dynamic management are all exemplary projects accomplished by CityDO. They dive into every detail and aspect of the smart city to create convenience that citizens can actually experience. Urban digital transformation and smart city construction have become the keynote of urban development, and cloud resources are the foundation of this new infrastructure. However, with the rapid developments of cloud computing, the incompatibleness between different vendors and technologies caused difficulty in

integration in terms of management, and resulted in low efficiency overall. This was illustrated by a CityDO's project manager:

We independently developed a cloud resource management system, as the foundation of CityDO's city operating system, to improve and optimise the application, approval, and deployment of cloud resources through integrating the cloud resources from different vendors. Our systems provide can boost efficiency in the use of resources, strengthen scientific management, utilise cloud resources, and realise the city's one cloud management. (Q4.1.4)

In addition to entrepreneurs from traditional ICT industries, many SaaS/PaaS new ventures in Hangzhou were founded by ex-employees of Alibaba Cloud, and actively participate in the Alibaba Cloud ecosystem. For example, Brand New Data was founded by ex-employees of Alibaba Cloud in 2014 in Hangzhou. The founding members are from the City Brain team, which was the first team to explore urban digital transformation, city brain and industrial brain in China. The start-up is positioned as a data management company that helps customers to manage data over the cloud and utilise the data to create value and improve efficiency and governance. Different to the other established Internet companies, Brand New Data has an advantage in the niche market of the 'digital village', which represents the information infrastructure construction for villages, the development of rural digital economy, and the digital model of rural governance. In Jinhua, Tonglu, Jiande of Zhejiang province, Tongchuan of Shanxi province, and Chengde of Hubei province, Brand New Data has successfully utilised cloud computing and big data technologies to enhance primary-level governance and integrated development of urban and rural areas.

Both DT Dream and Brand New Data were established in Yunki Town, a cloud-based industrial cluster in Hangzhou, Zhejiang province. On 24 December 2012, the Xihu District Government issued the "Policy Support for Promoting the Development of Hangzhou Cloud Computing Industrial Park (Trial)", including a series of supporting policies such as

rent reduction, bandwidth subsidy, and financing subsidy. In addition to industrial policy encouragement and one-stop registration services, Yunqi Town has also established the Cloud Computing Technology Training Institute 'Yunqi College'. The goal of Xihu District is to develop thousands of cloud-related enterprises through three to five years of development, covering cloud computing applications, games, Internet finance, mobile Internet, data mining, etc., to form a complete industrial system of the cloud computing industry. As one entrepreneur in Yunqi Town described:

The year of 2015 saw a start-up trend and many leading new ventures emerged. And, you know, many of the entrepreneurs are those who left Alibaba and started up here in Yunqi Town. We got good prices in land, and quota of electricity consumption – which is crucial for cloud computing vendors – and, more importantly, [there are] many cloud-related enterprises here that achieve economies of scale and create convenience. (Q4.1.5)

Other than new ventures, traditional software vendors that transform into cloud-based SaaS vendors are also important complementors contributing valuable industry experience and knowledge, and a loyal customer base. Hundson is one of the most vital players that significantly promoted cloud adoption with its dominant position in the financial software market. The company is a leading provider of financial technology products and services in China. This is illustrated in a description of the company's genesis on their website, the company has "*continuously explored the intelligent application of financial technology, using advanced technologies such as cloud-native, high performance, big data, artificial intelligence and blockchain*". Based on their strong R&D team and sufficient resources in the financial industry, Hundson's moving over to the cloud has promoted the digital transformation of the financial industry in China. After being acquired by Jack Ma, the founder of Alibaba Group, in 2014, Hundson accelerated digital transformation to cloud-based SaaS and set up a joint venture, Yun Rong Fintech.

In the Alibaba cloud ecosystem, hardware and network suppliers include Huawei supplying system hardware, China Mobile supplying network support, and SUPCON supplying sensors for IoT. Founded in 1993, SUPCON is one of China's leading providers of automation and information technology, products, and solutions. Its business covers process automation, utility engineering, and equipment industry automation. With its cutting-edge systems designed for the development of innovative technology products, SUPCON has grown rapidly, and to date has delivered over 30,000 control systems to a wide range of process industries (SUPCON, 2018). Based on its cutting-edge technologies and manufacturing system, it supplies sensors to the IoT platform of Zhejiang province, SupET.

Customers also contribute to the improvement of Alibaba cloud services and the healthy growth of the Alibaba cloud ecosystem. The Ant Group, originally known as Alibaba Finance, was the first client and its Shepherd project was the first test land for the early Alibaba Cloud. The Hangzhou City Brain for Hangzhou's city government was a milestone that set an example and model for the application of digital technologies in a smart city, which became one of the most important market segments for cloud vendors in China. With the support of the local government, the cooperation with Eifini – the leading women's wear and lifestyle retail group China– and Wynca – the leading chemical enterprise in China – helped Alibaba Cloud explore new applications in manufacturing industries.

4.1.3 Incubation stage: 2008-2013

After sorting out and triangulating the first-hand and secondary data about key events and milestones of Alibaba Cloud history, the roadmapping result is shown in Figure 4.2. Based on the milestones that led significant progresses and changes, using the temporal bracketing method to identifying discontinuity, four stages are identified. The milestones are highlighted by a heavy back box in the figure.

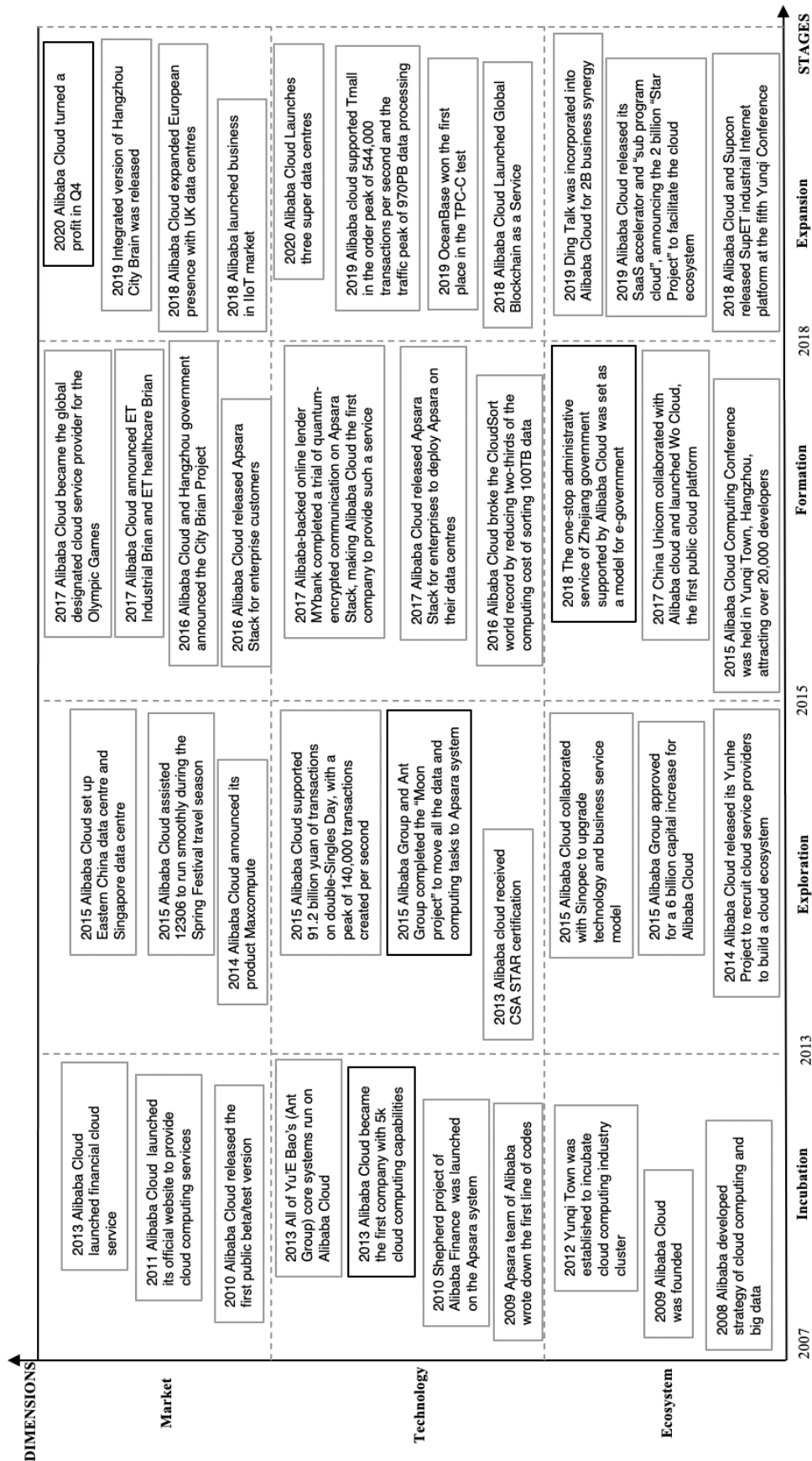


Figure 4.2 Roadmapping of the Alibaba cloud ecosystem

The first stage is the incubation stage starting from 2008 and ending in 2013. At the founding stage of Alibaba Cloud, instead of using an open community platform such as Openstack, the team decided to develop its own cloud computing operating system, Apsara, which is a proprietary general purpose distributed computing system. It was initially aimed at supporting the dramatic growth of Taobao and other Alibaba businesses, and gradually began to provide enhanced computing power to wider enterprises and individual customers.

Since it developed a cloud computing and big data strategy in 2008, Alibaba Group mobilised internal and external resources to stimulate the technology development and its commercialisation. Its determination in terms of cloud computing resulted from the IT challenges brought by the booming e-commerce business. At the beginning, just like other companies, Alibaba Group relied on the international mainstream 'IOE' solutions: I represents IBM, which provides servers, O represents Oracle, which provides databases, and E represents EMC, which provides storage equipment. As Alibaba's Taobao, Alipay, and B2B businesses exploded in both user and business scales, the processor usage of servers exceeded 98% of the time each day and IT costs made up most of their revenues. More importantly, it was feared that the IOE solutions might not be able to support the fast-growing transactions with unlimited growth potential in the future. Only cloud computing had nearly unlimited storage and resources that could ensure that Alibaba could grow without worry. Alibaba's top management team decided to invite Dr. Jian Wang – previously the head of Microsoft Research Asia – to join Alibaba and lead the cloud computing research and development. From science to technology and then to application, from Zhejiang University to a research institute and then to a company, Dr Wang transferred his prior experiences in digital technologies and his vision for cloud computing into the founding of the Apsara team and Alibaba Cloud. In February of 2009, the Apsara team with new recruits wrote down the first line of codes in Beijing. In September of 2009, Alibaba Cloud was founded in Beijing. Through great investments and efforts devoted to R&D, in 2010 Alibaba Cloud released the first public beta/test version. In 2011, Alibaba Cloud launched its official website to provide cloud computing services,

and its first large-scale cloud computing customised data centre was established and delivered.

To accelerate the development and improvement of its own cloud platform, the Apsara platform, the Alibaba Group's top management team decided to run the new business of Alibaba Finance on the platform. Alibaba Finance's initial mission was to provide micro-finance services to Taobao sellers. As a key element of Alibaba Finance's microcredit business, the 'Shepherd project' was set up to leverage the cutting-edge data and computing technologies to solve the financing problems for small and medium-sized enterprises, especially the sellers on Taobao. In 2010, the Shepherd project was launched on the Apsara platform as an internal application. Through trial and error, the safety and reliability of the Apsara platform as well as the efficiency and accuracy of the loan approval for Alibaba Finance improved significantly. Alibaba Finance, later known as Webank under the Ant Group, became one of the earliest client of the Apsara platform and Alibaba Cloud, and also the first bank hosted on the cloud in China. Based on the experience of internal application, in 2013, Alibaba Cloud officially launched a financial cloud service for commercialisation. The internal application was meaningful for Alibaba Cloud from both the technology capability and commercial exploration.

Since 2010, two teams with two designs and plans in the Alibaba Group had been striving for the 5k challenge, which means a single cloud computing cluster can provide the capability of 5000 servers. Team 1 was based on the open source software Hadoop, and team 2 was based on the company's own design, the Apsara system. To support the development of the Apsara platform, Alibaba Group mobilised the technological talents and resources of the whole group for the 5k challenge. In 2012, Alibaba Cloud moved from Beijing to Hangzhou so that more software engineers from Taobao could join the cloud team and more application scenarios in Hangzhou could be leveraged. In 2012, the Hangzhou government established Yunqi Town to incubate the cloud computing industry cluster, which also facilitated the development of Alibaba Cloud and paved the way for its cloud ecosystem formation. With the joint efforts, in June of 2013, the Apsara team

successfully completed the 5k challenge and Alibaba Cloud became the first company in the world to provide 5k cloud computing capabilities, which highlighted that the fundamental cloud technology was now mature for further application and commercialisation. And, later in 2013, Alibaba Group announced that all of Yu'E Bao's (Ant Group) core systems would run on Alibaba Cloud, which was also a promotion for its cloud service in terms of further commercialisation. A senior manager detailed the founding stage of Alibaba Cloud:

In 2008, the plan to do cloud computing was proposed, but many opponents appeared internally. Dr. Jian Wang was very insistent, and founded the early team of Alibaba Cloud. However, the biggest difficulty was to find the first wave of seed users. Jack Ma decided we should apply it ourselves in the first place, and Ant Group – of course, it was only the Alibaba microcredit unit – should be a pilot. This internal application was actually very difficult because the Alibaba microcredit was also a new project. And there were many times when the two teams thought that they would not be able to go on, but they knew that they must because cloud computing is the future. (Q4.1.6)

Through applying internally and promoting the category and vision of cloud computing externally, the pioneers sparked the commercialisation and business activities and communities in the next stage of exploration. The manager described their early efforts to promote the commercialisation of cloud technologies:

The second milestone was the Yunqi Conference, because to launch a new business and shape the new industry, what you need is not only the users but also an ecosystem with complementors. But how? We came up with the idea of a cloud computing-themed conference to tell the story of cloud computing to a larger audience. I still remember Dr. Wang often told the story of how the cloud computing was used in a remote mountainous area to store and connect

the railway data, and even people in the remote mountainous area can use cloud computing, [so] why not you? (Q4.1.7)

4.1.4 Exploration stage: 2013-2015

Based on its cloud technology and platform, as big steps towards commercialisation, Alibaba Cloud published its product Maxcompute and released its Yunhe Project to recruit cloud service providers to build a cloud ecosystem. In 2015, Alibaba Group approved RMB 6 billion capital increase for Alibaba Cloud. The aim of cloud development was not only for the IT support for Alibaba businesses, but also for the commercialisation of the cloud services to enable other companies and create a new engine for Alibaba Group in the future. The group positioned itself not only as an e-commerce company, but also as a high-tech enterprise that promoted digital transformation.

In order to facilitate commercialisation, Alibaba Cloud also sought the legitimacy of cloud service as a new category in the market. In December of 2013, Alibaba Cloud received CSA STAR certification, as an endorsement for its cloud service. In October of 2015, Alibaba Cloud won the '2015 Telecom World Excellence Enterprise Award' based on the criterion of real technological capability and social impact, becoming the only Chinese enterprise to win the award. The endorsement from technology alliances and government contributed to the company's legitimacy and acceptance.

More importantly, the successful projects Alibaba Cloud accomplished greatly promoted its cloud services as well as the awareness and acceptance of cloud transformation. Internally, Alibaba Cloud supported 91.2 billion yuan of transactions on the 2015 Singles' Day, with a peak of 140,000 transactions created per second. In May of 2015, Alibaba Group and Ant Group completed the 'Moon project' to move all the data and computing tasks to the Apsara system, which showed Alibaba Cloud's great capability and marked the success of cloud computing application in the second stage.

Externally, in 2015, Alibaba Cloud collaborated with Sinopec to upgrade its technology and business service model. In January of 2015, Alibaba Cloud assisted 12306 to run smoothly on the Apsara platform during the Spring Festival travel season, during which millions of Chinese passengers booked tickets to go home and the booking website 12306 often crashed when the tickets came out. Alibaba Cloud diverted 75% of the peak traffic this year and helped solve the long-standing website problem of a ticket booking rush in the Spring Festival travel season. This became a famous case for Alibaba Cloud for the growth and expansion of its business.

4.1.5 Formation stage: 2015-2018

At stage 3, from 2015 to 2018, Alibaba Cloud successfully commercialised cloud services in several leading markets. As a senior manager of Alibaba Cloud expressed,

The idea of [the] cloud is to leave the difficulty to ourselves, such as how to clear up the network and how to design the bandwidth, and give the convenience to our customers. In every project, we together with our partners work out a complete solution for the client. (Q4.1.8)

For one thing, a portfolio of cloud products and services was introduced to the market to provide the full experience of cloud computing for users. In April of 2016, Alibaba Cloud released Apsara Stack, a private cloud service for enterprise customers who had higher security and confidentiality requirements to deploy the Apsara platform on their own data centres. Various public and hybrid cloud services were also launched in a diversity of markets and scenarios. In March of 2017, Alibaba Cloud announced ET Industrial Brain and ET Healthcare Brian to empower enterprises in manufacturing and healthcare industries. Continuing its accumulation in the financial cloud, Alibaba Cloud made another breakthrough in the application of cloud computing with cross-industry innovation. In March of 2017, Alibaba Cloud supported the online lender Webank to complete a trial of quantum-encrypted communication on Apsara Stack, making Alibaba Cloud the first

company to provide such a service. Other than the Taobao sellers and related SMEs as the users sharing public cloud services, Alibaba Cloud also attracted government and financial institutions as big clients of its hybrid or private cloud services.

For another thing, the Alibaba cloud ecosystem also gradually formed in this stage. As was described in the company's annual report of 2018,

...Our technology infrastructure and services, including our cloud product and service offerings, incorporate third-party-developed software, systems and technologies, as well as hardware purchased or commissioned from outside and overseas suppliers (Alibaba Group, 2018, p. 21). (Q4.1.9)

Multiple approaches enabled the formation and nurturing of the Alibaba cloud ecosystem. For one thing, regular exhibitions and conferences helped to demonstrate the new applications of cloud computing to attract users and partners. For example, Yunqi Conference is a cloud computing conference organised by Alibaba Cloud every year. The name Yunqi comes from Yunqi Town in Hangzhou, originally as the name of a district with a meaning of 'living in the cloud'. The 2016 Yunqi conference was held in Yunqi Town, Hangzhou, between 13 and 16 October, with over 40,000 professionals attending the conference and more than 7 million people watching the conference proceedings live online. Compared with the first year of this conference with only 400 attendees, the great attention and unprecedented influence of this year's conference reflected not only the growing impact of Alibaba Cloud and its emerging ecosystem, but also the advancements in cloud computing and digital economy in China. For another thing, Alibaba Cloud set up collaboration projects with other companies who could provide complementary resources and knowledge. For instance, in December of 2017, China Unicom collaborated with Alibaba Cloud and launched Wo Cloud, the first public cloud platform. In terms of hardware suppliers, a senior manager from Alibaba Cloud I interviewed explained how the alignment formed and changed,

Concerning core hardware, we basically purchase from upstream electronics manufacturers. In the past, we [bought a] standard server, and then we [did the] design [on] our own and get OEM [original equipment manufacturer]; later we [began] to design electronic components and get ODM [original design manufacturer]. To ensure a good integration of software and hardware, we must minimise the internal costs of virtualising hardware. So it is imperative for us IaaS vendors to design hardware. We also invested a lot in R&D of chips and radiators that are especially for the use of cloud computing data centres [and have] high cooling performance. (Q4.1.10)

With the endorsement from government and the technology community, the legitimacy of cloud computing was gradually established. In November of 2016, Alibaba Cloud broke the CloudSort world record by reducing two-thirds of the computing costs of sorting 100TB data. In January of 2017, Alibaba Cloud officially became the global designated cloud service provider for the Olympic Games. In October of 2016, Alibaba Cloud and the Hangzhou government announced the Hangzhou ET City Brain Project. At the 2018 World Internet Conference held in Wuzhen, Zhejiang province, ET Brain won the World Internet Leading Scientific and Technological Achievement Award. In 2016, Zhejiang province started the “At Most One Visit” reform “to streamline administrative procedures and reduce red tape for both individuals and businesses” and ensure that “administrative services can be accessed by personal visit or by digital channels, such as government websites and mobile apps” (Ezhejiang, 2020). Complex procedures and paperwork were waived and the previously isolated data from different departments were moved to a cloud platform and connected in an integrated resources system. On the technology side, Alibaba Cloud provided technological foundation and cloud services for the one-stop administrative service. In 2018, the “At Most One Visit” reform of Zhejiang government backed by Alibaba Cloud was set as a model for e-government and acknowledged by the central government’s annual report.

4.1.6 Expansion stage: 2018-2020

In 2018, Alibaba launched its new business in the IIoT market. Later, Alibaba Cloud and SUPCON released the SupET industrial Internet platform at the Yunqi Conference. The applications of cloud computing technologies and the services Alibaba Cloud could offer expanded to more sectors by combining cross-industry knowledge and other emerging technologies. In 2018, Alibaba Cloud launched Global Blockchain as a Service. In 2019, the integrated version of Hangzhou City Brain was released. As is stated in the company's 2019 annual report,

Members of our research and development team play key roles in various international standardization organizations in areas such as e-commerce, security and IoT. In addition, we are also active in open source communities. In October 2017, we established DAMO Academy, a global research program in cutting-edge technology that aims to integrate science with industry and speed up information exchange between them. It encourages a collaborative environment where scientific discoveries can be more quickly applied to real-life problems (Alibaba Group, 2019). (Q4.1.11)

Enabled by the accumulation and optimisation after various projects in various scenarios, Alibaba improved its service quality and process. This stage witnessed further increases in efficiency. In 2020 Alibaba Cloud launched three super data centres. In October of 2019, as China's self-developed database product, Alibaba Cloud's OceanBase won first place in the TPC-C test, which is known as the 'World Cup in the Database Domain', surpassing traditional IT service providers at home and abroad. During the 11-11 festival of 2019, Alibaba Cloud supported Tmall in the order peak of 544,000 transactions per second and the world record traffic peak of 970PB data processing per day.

The growth and competitiveness of the Alibaba ecosystem was still the strategic focus at this stage. With its long-term strategy "to serve two billion consumers around the world

and support ten million businesses to operate profitably on our platforms”, Alibaba “embarked on three key initiatives to achieve this strategic goal – globalisation, rural expansion and big data and cloud computing” (Alibaba Group, 2018, p. 67). In March of 2019, Alibaba Cloud released its SaaS accelerator and ‘sub-program cloud’, announcing the 2 billion ‘Star Project’ to facilitate the cloud ecosystem. In June of 2019, Ding Talk –an intelligent working platform under Alibaba Group to support enterprises to enhance remote working efficiency with the new digitalised working mode – was incorporated into Alibaba Cloud for 2B (to business) business synergy. Alibaba Cloud supported the smooth and stable HD video meeting of Ding Talk from both mobile and desktop devices. And Ding Talk’s new enterprise users could be potential users for Alibaba Cloud. This adjustment of internal organisation design contributed to the development of the 2B business and the competitive advantage of the Alibaba ecosystem. As noted in the annual report, resources were mobilised and integrated to provide a solid digital transformation solution:

Our diverse commerce platforms and extensive consumer insights, combined with our cloud computing technologies, New Retail supply chain management and sales and marketing systems, form a critical foundation that facilitates digital transformation for businesses (Alibaba Group, 2020, p. 29). (Q4.1.12)

At the fourth stage, the Alibaba cloud ecosystem was mature and comprehensive with diverse services and complementors. Its mature technology capabilities were able to support its own business and empower thousands of enterprises in various sectors. As one of the Alibaba Cloud senior managers expressed,

We made the strategy about building an open, collaborative and prosperous e-commerce ecosystem driven by data in the strategy meeting in Ningbo. In 2015, the so-called ‘Moon project’ [saw] great progress. We successfully moved the data to the cloud and then completed computing tasks through

ODPS [Open Data Processing Service], which is our Maxcompute service, now called OSS [Object Storage Service]. This is a relational database RDS [Relation Data System], with our own developed Pangu system as the basis. We would like to see if the basic capabilities of the cloud can support our business. In 2019, we finally achieved the mission of [the] 'Moon project' and [ran] all of our business on [the] cloud and replaced IOE totally. (Q4.1.13)

This breakthrough was also evidenced in the annual report of 2020,

This year's shopping festival showcased the strength of our leading cybersecurity technology in the public cloud environment, which is a key priority of many of our public sector and industry customers. We believe the migration of the core systems of Alibaba's e-commerce businesses onto the public cloud is a major milestone that not only generates greater operating efficiencies for Alibaba but also will encourage more customers to adopt our public cloud infrastructure" (Alibaba Group, 2020). (Q4.1.14)

At expansion stage, Alibaba Cloud's products and services were enriched and expanded. The development and consolidation of its main products represent the maturity of Alibaba Cloud's offerings and business models, as well as the maturity of the Alibaba cloud ecosystem. As the CEO of Alibaba Cloud said at the 2019 Alibaba Cloud Summit in Shanghai,

There are four milestones of [the] 'All-in-Cloud' process of enterprises and governments, migrating IT infrastructure to cloud, migrating big data to cloud, middle offices on cloud, and intelligence on cloud. 'All-in-Cloud' is the corollary of this digital era. After the efforts over 10 years, now we have four best cards, Apsara operating system, Apsara big data platform, Alibaba middle offices, and smart internet of things – AIoT – to enable the technology and business of our clients to grow exponentially. With these big four key

services, Alibaba Cloud will help our government and business clients to embrace 'All-in-Cloud'. (Q4.1.15)

In 2020, cloud computing revenue achieved 62% growth year-on-year (YoY), which also showed the fast-growing trend of the cloud computing market in China.

4.2 Tencent Cloud Ecosystem

4.2.1 Overview of Tencent and Tencent Cloud

Tencent Cloud is a business unit of Tencent Holdings Limited under the Cloud & Smart Industries Group (CSIG), as is shown in Figure 4.3. On 21 October 2010, Tencent Cloud Computing Company Limited was founded in Beijing. It is characterised by Tencent's cloud infrastructure capabilities with the advantages of its platform and ecosystem centred around QQ and Weixin with a massive number of users over the globe.

Figure 4.3 Tencent company structure



In November 1998, Tencent was founded in Shenzhen. Its earliest business was mobile email and instant messaging service QQ, launched in 1999. Then in 2011, Weixin was launched and later became the most popular social network platform in China. The combined monthly active user (MAU) figure for Weixin and WeChat (the global version of Weixin) was 1,268.2 million as of 31 December 2021 (Tencent, 2021). As strategic actions in FinTech, Tencent launched Weixin Pay in 2013 and co-founded WeBank in 2014. In addition to the social network business, in August 2003, Tencent launched the online

game platform QQ Games, which became another major business for Tencent afterwards. Tencent Games became the largest online game platform in China in 2009, and became the world's largest online game developer and publisher by revenue in 2013. The value-added service (VAS) revenue and online advertising revenue mainly based on the game, social network, and entertainment business make up the two main revenue sources of Tencent, as is shown in Table 4.2. FinTech and Business Services is the biggest revenue source driven by commercial payment and wealth management. Revenues from cloud services are also included in this revenue category and the growth of cloud business also contributed to the sustainable increase of this category (Tencent, 2019).

Table 4.2 Revenue structure of Tencent

	2018	2019	2020	2021
VAS	176,646	199,991	264,212	291,572
	56%	53%	55%	52%
FinTech and Business Services	73,138	101,355	82,271	88,666
	23%	27%	17%	16%
Online Advertising	58,079	68,377	128,086	172,195
	19%	18%	27%	31%
Others	4,831	7,566	7,495	7,685
	2%	2%	1%	1%
Total revenues (RMB in millions)	312,694	377,289	482,064	560,118

Creating a diverse and competitive business ecosystem has long been the strategic focus of Tencent. Early in the its annual report of 2013, Tencent mentioned building an ecosystem: *“The strategic transactions with Sogou, JD.com and other partners...reinforce our ‘open, win-win’ philosophy of working with leading teams to create innovative products for users, and to build a healthy, diversified ecosystem for the Internet industry”* (Tencent, 2013, p. 6). Tencent is the strategic shareholder of many other leading internet companies; for example, it invested in Jingdong and Sougou in 2013, and invested in Meituan Dianping in 2014. Through equity stakes, Tencent can benefit from the external resources and growth of ecosystem members in other industries, while focusing its internal resources and efforts on its own platforms. Through various approaches to building an ecosystem such as strategic investment, mergers and acquisitions (M&A), spinoff, incubation, and

collaboration with business partners, Tencent strives to “build a sustainable ecosystem in the Consumer Internet and Industrial Internet sectors and create value for our users with our products and services” (Tencent, 2020, p. 9).

4.2.2 Tencent cloud ecosystem and its members

The key participants of the Tencent Cloud ecosystem include SaaS/PaaS vendors as complementors, network and hardware suppliers, and important customers. The overview of representative members of each type I visited and interviewed is provided in Table 4.3.

Table 4.3 Overview of Tencent cloud ecosystem members

Type	Organisation	Description
IaaS vendor	Tencent Cloud	Founded in 2010 in Beijing, Tencent Cloud is a secure, reliable, and high-performance cloud computing service provider. Tencent is now the largest Internet company in China and provides services for hundreds of millions of people via its flagship products like QQ and Weixin
SaaS/PaaS vendor	Kingdee	Founded in 1993 in Shenzhen, Kingdee has retained the largest share in the enterprise application software sector for fast-growing enterprises for 16 consecutive years, and has twice grasped the biggest share in the enterprise-grade SaaS Cloud services industry.
	DAS	Founded in 2007 in Hangzhou, DAS-Security is a cybersecurity enterprise that developed against the backdrop of Zhejiang and Hangzhou's endeavour to play a leading role in the digital economy. It strives to provide internet security for the development of the digital economy and society with the mission of building a safe and trusted digital world.
Supplier	China Unicom	Formally established in 2000 in Beijing, China Unicom is a provider of basic communication services. It resolutely fulfils national missions to establish an unblocked information artery and a new digital base for economic and social development, through comprehensive approaches to building industry-leading intelligent and comprehensive digital information infrastructure in greater breadth and depth
	Huawei	Founded in 1987 in Shenzhen, Huawei is a leading global provider of information and communications technology (ICT) infrastructure and smart devices. Under the guiding principle of Business-Driven ICT Infrastructure (BDII), Huawei is setting the pace for IT systems based on

		cloud architecture to lead the transformation of enterprise IT towards cloud architecture.
	China Mobile	Founded in 2000 in Beijing, China Mobile is the leading ICT services provider in China and boasts a world-class telecommunications and information operator with the world's largest network and customer base. Its businesses primarily consist of mobile voice and data business, broadband and other services.
Customer	Mogu	Founded in 2011 in Hangzhou, Mogu was launched as a consumer sharing community that accumulated millions of seed users rapidly and later built up KOL workstation and a socialised fashion shopping guide ecosystem. Its mission is to make fashion accessible to everyone.
	Mindray	Founded in 1991 in Shenzhen, Mindray offers integrated solutions that adapt to different departments to help healthcare providers boost efficiency and optimise management. In the era of medical transformation, it empowers healthcare professionals to deliver better care to patients with ease.

Kingdee, a leading Chinese software provider and IT integrated solutions supplier that is also based in Shenzhen, is one of the key partners of Tencent Cloud. Kingdee has retained the largest share in the enterprise application software sector for fast-growing enterprises for 16 consecutive years (Kingdee, 2020). With the mission of building "the cloud for enterprise management", Kingdee is committed to becoming "the most trusted corporate service platform" with the mission of "serving enterprises wholeheartedly and letting each of them shine". As one of the leading SaaS vendors in China, Kingdee focuses on and specialises in IT systems software integration, middleware business, online management and e-business service platform for small and medium-sized enterprises, online public management, and e-Government service platform for government and other public organisations. Through its devotion to the cloud computing industry for over a decade, Kingdee has accumulated more than 6.8 million clients covering enterprises, government agencies, and other organisations around the world (Kingdee, 2020). Its main cloud services and products include "Kingdee Cloud Cosmic" (digitalisation and ecosystem platform for large enterprises), "Kingdee Cloud Galaxy" (intelligent growth service platform for medium-sized enterprises), "Kingdee Cloud Stellar" (intelligent growth service platform for micro and small-sized enterprises), "Cloud-Hub" (intelligent

Cloud office), “Guanyi Cloud” (Cloud services for E-commerce operators), “Cargeer” (Cloud services for auto dealers), and “Wojia Cloud” (Cloud services for Property Industry).

Founded in 1993, it was originally a traditional software vendor specialising in Enterprise Resource Planning (ERP), and the software was hosted on local servers. To embrace the cloud trend, Kingdee began its transformation to cloud-based SaaS in 2010, and contributed to the emergence of the cloud computing industry with its leading position and influence in the enterprise software market. This was illustrated in its annual report:

To tap and seize the business opportunities of the emerging cloud computing industry, Kingdee launched the “Terminal product + Cloud services” initiative in 2011. The Group continued to promote and differentiate its service packages based on products in order to build a standardized cloud computing service platform; consequently integrating its online service network, optimizing its desktop system by cloud computing and integrating available resources. This enabled the Group to provide convenient and prompt cloud computing services to customers (Kingdee, 2011, p. 15). (Q4.2.1)

For its partners like Tencent, which has specialised in 2C (to customer) business and tried to outgrow enterprise cloud services, Kingdee's broad client base and abundant 2B experiences in diversified sectors are valuable resources. Similarly, the security specialisation and 2B service capability of DAS also serve as complementary assets in the Tencent cloud ecosystem. As is introduced in section 4.1, Tencent's suppliers also include network infrastructure suppliers like China Mobile and China Unicom, and hardware and system suppliers like Huawei.

Tencent Cloud's early and important clients are mainly from the sectors that Tencent is involved in and familiar with, such as online games, online video, entertainment, and E-finance companies. For example, MOGU, one of the earliest lifestyle-sharing social media platforms in which users can showcase their photos and notes from clothing and fashion

to cosmetics and beauty, was invested in by Tencent and is also an ecosystem partner of Tencent Cloud. MOGU launched as a consumer sharing community that accumulated millions of seed users rapidly. The format of sharing evolved from photos and text, to videos and live streaming. Tencent cloud services ensure the storage and network supports for MOGU's platform. In 2017, the MOGU WeChat mini program matrix was launched and MOGU became an important creator of E-commerce on WeChat. A senior manager from MOGU indicated that,

MOGU was possibly the earliest platform that started using live streaming to sell clothes. We have KOLs as fashion shopping guides and our own e-commerce system in the female fashion industry. It was natural for us to invent the live streaming shopping in 2016, and this required huge computing capacity. We got support from Tencent. Nowadays, live streaming-based marketing and commerce have become our main business. (Q4.2.2)

Considering the regional connection, Tencent Cloud also provides cloud services to many enterprises and public organisations in Shenzhen, and the southern China area. For example, Mindray is also based in Nanshan District, Shenzhen, and is less than 10 minutes away from Tencent's headquarters. Mindray is a leading medical device manufacturer and healthcare solution provider in China. Tencent collaborated with Mindray to explore the application of cloud computing and AI in healthcare scenarios.

4.2.3 Incubation stage: 2008-2013

Similarly, after sorting out the key events and milestones of Tencent Cloud history, the roadmapping result is shown in Figure 4.4. Based on the milestones that led to significant developments and changes recognised by informants and other secondary documents, using the temporal bracketing method to identify discontinuity, four stages are identified.

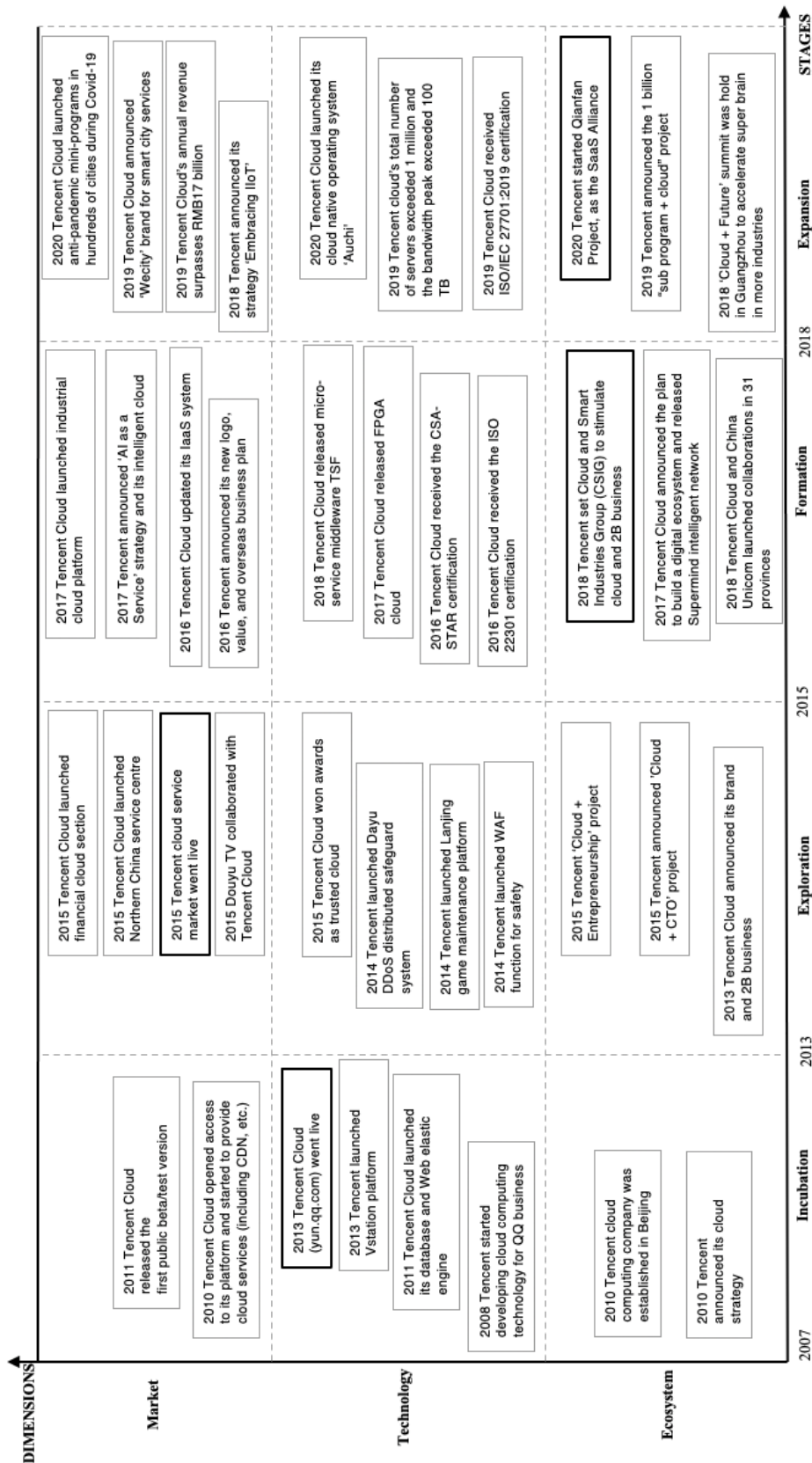


Figure 4.4 Roadmapping of Tencent cloud ecosystem

The first stage is the incubation stage starting in 2008 and ending in 2013. In 2008, Tencent started R&D into cloud computing technology for the QQ business. An informant from Tencent described how the company started R&D in cloud computing,

You know there was a time a QQ game called Toucai was so popular that many users logged in and played even at night to win. This game brought us the problem of high concurrency, for which distributed and shared cloud computing is the best choice. Moreover, you know QQ provides every user with big folder storage space. This also brought a great challenge for our servers. Driven by the specific needs of the existing business, and the advancement of cloud computing research, different teams within our company began R&D of cloud computing, but sparsely. (Q4.2.3)

In 2010, Tencent cloud computing company was established in Beijing to integrate the cloud computing talents and strategise for further development in cloud computing. In 2010, Tencent announced its cloud strategy and opened access to its platform to provide cloud services (including CDN, etc.) for external users. In 2011, Tencent Cloud released the first public beta/test version and launched its database and Web elastic engine. However, at that time, the exploration was only limited to R&D because they assumed that the real application and commercialisation of cloud computing was still too far into the future to imagine. The CEO of Tencent indicated at a conference during that time, *"So far it is still too early to talk about the cloud computing industry, maybe the industry will become possible many years later."* In September of 2013, Tencent officially launched Tencent Cloud services. After witnessing the rapid progress of cloud computing in global and Chinese markets, Tencent changed its mind and spared no efforts to catch up in the emerging cloud computing industry.

4.2.4 Exploration stage: 2013-2015

In October 2013, Tencent Cloud announced its brand and 2B business, and blew the horn for the exploration of the cloud computing industry. In its annual report of 2013, Tencent emphasised “cloud-based infrastructure support” for the first time,

In 2013, our open platforms continued to create value for the Internet industry, and enjoyed significant growth in users and revenues as a result. We believe we have become the partner of choice for application developers in China, offering access to our large logged-in user base, the network effect of our leading social platforms, our targeted advertising solutions, and our proprietary cloud-based infrastructure support. We are extending our open platforms to mobile and targeting to build a cross-platform ecosystem (Tencent, 2013, p. 7). (Q4.2.4)

In 2013, Tencent Cloud also launched the Vstation platform and Tencent Cloud (yun.qq.com) was live and fully opened to society. Individuals and external organisations can access to its "proprietary cloud-based infrastructure support" (Tencent, 2013, p. 7), and open platform API and cloud services. In November 2013, Tencent unveiled the 'Connection' and 'Internet +' strategies, and Tencent Cloud is an important strategic focus in it as cloud computing serves as a foundation for better digital connectivity and a digital infrastructure for the internet economy.

With the development of cloud computing technology becoming remarkable and taken seriously by the top management team, Tencent Cloud launched a series of experiments with cloud computing technology in 2014 and 2015. For example, as is shown in the roadmapping figure, the Lanjing game maintenance platform and Dayu DDoS distributed safeguard system were launched in 2014, and the Tencent cloud service market, Northern China service centre, and financial cloud section were successively launched in 2015.

In 2015, Tencent also engaged in the application and promotion of cloud technologies. Tencent announced 'Cloud + CTO' to improve the awareness of cloud transformation in enterprises' IT construction and set the 'Cloud + Entrepreneurship' project to foster start-ups aimed at the emerging cloud computing industry. As a milestone for Tencent Cloud, the project with Douyu was one of the earliest application cases of their cloud computing capability. In October 2015, Douyu TV started a collaboration with Tencent Cloud and began to run their live streaming on Tencent Cloud. A manager and an early team member of Tencent Cloud explained,

We were responsible for the cloud services for Douyu; during the early stage we often need[ed] to work overtime to expand the bandwidth to deal with any crashes. But the early efforts worked, our cloud services had a good reputation on gaming and live-streaming markets. Our collaboration also continued and we now launched cloud gaming on Douyu. (Q4.2.5)

The difficulties overcome during the exploration stage offered valuable experiences and lessons for the formation of a cloud computing service system.

4.2.5 Formation stage: 2015-2018

Through continued investments and broad deployments in cloud services, Tencent Cloud developed products and services based on its fast-developing cloud computing technology capability for its corporate clients and partners. Its technology received several certifications such as ISO 22301 and CSA-STAR certification. With its specialisation in the game and video industry, it established leadership in those early markets. Leveraging Tencent's broad ecosystem and strong partnerships, Tencent Cloud also strengthened the company's position in providing offline-to-offline (O2O) and financial services solutions.

The statements about cloud business during this stage reflect that Tencent cloud was gradually establishing its product portfolio, competitive advantage, and business ecosystem.

Our cloud service business achieved over 100% year-on-year revenue growth as we promoted our services to key enterprise customers from a range of verticals such as eCommerce, O2O services, online games, online video and Internet finance. We will continue investing in enhancing our cloud services, supporting our private and public sector partners in fulfilling their “Internet-Plus” related initiatives (Tencent, 2015, p. 7). (Q4.2.6)

During the year, we made continued investments in technology and infrastructure, grew our sales force and channel partners to drive adoption by more small-scale application developers, and strengthened our overseas capability to help Chinese enterprises to deploy their services globally. Our cloud services revenue more than tripled year-on-year in 2016 as both the number of enterprise accounts and usage of existing accounts increased substantially (Tencent, 2016, p.6). (Q4.2.7)

Tencent Cloud continued to grow rapidly during the year. We maintained our leading market position in cloud services verticals including online games and video cloud services. We deepened our penetration among the leading Internet industries with more key clients, and expanded our client base in cloud services for financial services and government sectors. Our sales, channel and big data capabilities enabled us to offer smart retail solutions targeted at supermarkets, department stores, and fast moving consumer goods companies (Tencent, 2017, p. 7). (Q4.2.8)

During 2018, Tencent Cloud maintained market leadership in verticals such as online games and streaming video, leveraging our industry know-how and solid infrastructure. We now serve over half of the China-based game

companies and are expanding overseas. We expanded our customer base rapidly for Internet services via strategic partnerships in verticals. Key categories include eCommerce, social media and community, handset manufacturer app stores and smart transportation. We have further expanded our presence in other key industries such as the financial and retail sectors (Tencent, 2018, p. 7). (Q4.2.9)

At this stage, its commercial activities brought increasing revenue for Tencent although the investments were also huge. In 2016, Tencent announced its new logo, value, and overseas business plan, and updated its IaaS system. In 2017, Tencent announced the "AI as a Service" strategy and its intelligent cloud and launched an industrial cloud platform. In 2018, Tencent Cloud and China Unicom launched collaborations in 31 provinces to build its cloud ecosystem. In addition to the prosperous business in the game and video industry, Tencent's financial cloud and retail cloud were also formed and widely accepted. The financial clients included top banks such as BOC, CCB, and CMB, and many top online finance companies and insurance firms. Its retail cloud solutions were also popular by leveraging the Official Accounts and Mini Programs of Weixin to enhance retailers' consumer engagement and marketing efficiency.

The most important milestone for the evolution of Tencent Cloud happened in 2018. On 30 September 2018, Tencent set up the Cloud and Smart Industries Group (CSIG) to stimulate cloud and 2B business, which was referred to as "930 reform". This also announced a strategic upgrade and restructuring to embrace the industrial internet, while maintaining the company's roots in the Consumer Internet. A senior manager from Tencent explained the importance of this reform:

We have mature organisation design for our established 2C business. But in terms of 2B business, especially the solutions based on cloud computing, AI, and industrial internet, we have strong teams but they are from different departments and lack collaboration. To deliver a complex solution for

business or government clients, and to increase our competitive advantage, we need a better synergy to integrate our talents and capabilities. (Q4.2.10)

CSIG is responsible for the company's cloud and industrial internet businesses that are aimed at creating innovative solutions for smart industries via technological advancements such as cloud, AI, and network security. By integrating and structuring the internal resources of cloud computing and industrial internet, Tencent strives to build a new ecosystem of intelligent industries that connect users and businesses in retail, medical, education, transportation, and other industries.

4.2.6 Expansion stage: 2018-2020

Since 2018, Tencent cloud has expanded its cloud services to more scenarios and put more emphasis on the combination of cloud computing and other digital technologies such as AI, big data, and the Industrial Internet of Things. In February 2018, Tencent announced its strategy 'Embracing IIoT'. In May 2018, the 'Cloud + Future' summit was held in Guangzhou to accelerate the super brain in more industries. As is elaborated in its annual report, Tencent "*keeps up with the technological development through innovation in frontier technology and explores application of technologies in new scenarios*" (Tencent, 2020, p. 93).

Tencent Cloud expanded its user base and business scale at the expansion stage. In 2019, Tencent Cloud announced 'Wecity' as the brand of smart city and e-government services to further stimulate the adoption of cloud services in the smart city. In December 2019, Tencent Cloud's annual revenue surpasses RMB17 billion with more than 1 million paid users.

Tencent Cloud also enriched and strengthened its business ecosystem through various approaches. In 2019, Tencent announced the 1 billion 'subprogram + cloud' project. In 2020, Tencent started the Qianfan Project, as the SaaS Alliance. Ecosystems were emphasised in its collaborative strategy:

Externally, the Company co-creates ecosystems through strategic investments and M&A, as well as collaboration with business partners. As always, the Company leverages the strength of the new ecosystems to seek new business partners to explore new business opportunities and better approach to responding to the market needs and expectations (Tencent, 2020, p. 93). (Q4.2.11)

Meanwhile, the Company will also work closely with partners to seek solutions to application scenarios during these special periods, and to jointly build an open, innovative and secured digital ecosystem to support the economic recovery and business development in the post-pandemic era (Tencent, 2020, p. 95). (Q4.2.12)

After years of exploration and growth in the cloud computing industry, the CEO of Tencent updated his understanding of cloud computing and its relationship with the internet economy and digital transformation in a public speech,

Tencent Cloud, like Weixin Pay, is Tencent's ecosystem infrastructure. Tencent is striving for connecting everything and is going to step further down the open journey, with more and more partners, with payment and cloud computing becoming more and more important to the entire ecosystem.....The core of applying Internet technology in traditional industries in the future is to use artificial intelligence on the cloud to process big data. (Q4.2.13)

4.3 Huawei Cloud Ecosystem

4.3.1 Overview of Huawei and Huawei Cloud

Huawei Cloud is responsible for R&D, sales, consulting, and end-to-end service of Huawei's cloud computing business. Committed to "providing stable, reliable, secure,

trustworthy, and innovative cloud services”, Huawei Cloud aims to “deliver everything as a service”, and “build the cloud foundation for an intelligent world with ubiquitous cloud and pervasive intelligence” (Huawei, 2022).

The strategy and specialisation of Huawei Cloud are rooted in the history and the corporate strategy of Huawei. Founded in 1987, Huawei has gone through four stages. During the first start-up stage until 1995, it focused on telephone exchanges and evolved from a dealer to a manufacturer. From 1996 to 2004, Huawei experienced a fast growth period driven by the large communications equipment manufacturing business. In the third period of steady growth, Huawei upgraded itself as an ICT solution provider. And since 2011, Huawei has stepped into a new stage to embrace digital transformation and developed a strategy that prioritises the integration of cloud, pipe, and device (Huawei, 2011). In the business structure and organisation design of Huawei (see Figure 4.5), Huawei Cloud is one of the most important units to carry out this new strategy.

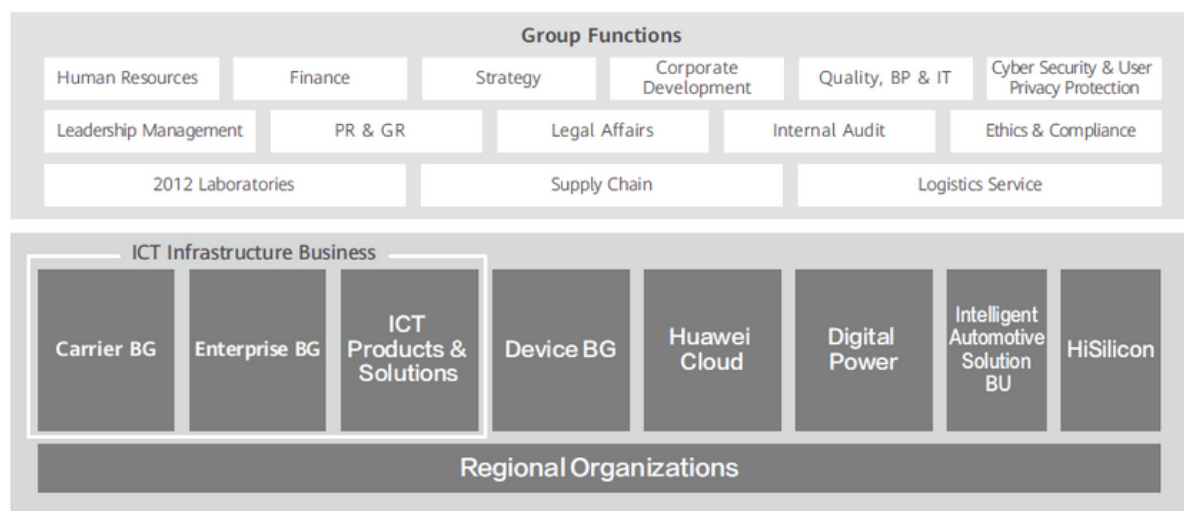


Figure 4.5 Huawei business structure as of 2021 (Huawei, 2021)

Huawei was a latecomer to the cloud computing industry because as an incumbent firm in the ICT industry, although it started R&D of cloud computing very early, the adoption of cloud computing would disrupt the existing ICT industry and affect its existing businesses, thus hampering Huawei's initiative to pioneering the application and

commercialisation of cloud computing. The main businesses of Huawei were initially ICT hardware, including communications equipment, smartphones, and IT equipment. To compete in the cloud computing industry, Huawei needed to transform and adapt itself to the software and service business model. In 2017, showing its determination to enter the emerging cloud computing industry, Huawei established Cloud BU, which was adjusted to Cloud &AI BG in 2020, and later to Huawei Cloud as an independent business group in 2021, as shown in Figure 4.6. Relying on persistent efforts and advantages in 2B businesses, Huawei achieved a quick and successful catch-up by rising to be in the top three cloud vendors in China in 2020 (Huawei, 2021).

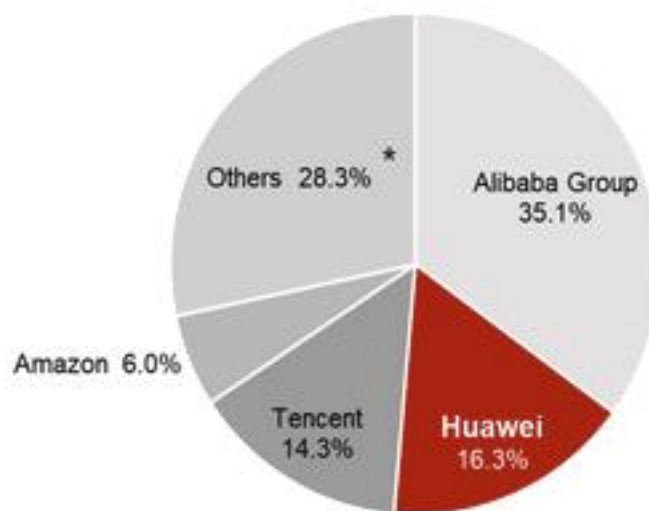


Figure 4.6 2020 China IaaS market share (Huawei, 2021)

By developing Huawei Cloud and other ICT technologies, Huawei aims to drive the digital transformation of industries and society. As is noted in the message from the rotating chairman Ping Guo,

We will continuously increase investment in talent, scientific research, and innovation, in an effort to reshape our foundational technologies. Building on this, we will bring together ICT technologies and our global experience to drive digital transformation across different industries, and create greater value for both our customers and society at large (Huawei, 2021, p. 2). (Q4.3.1)

4.3.2 Huawei cloud ecosystem and its members

The key participants of the Tencent Cloud ecosystem include SaaS/PaaS vendors as complementors, network and hardware suppliers, and important customers. The overview of representative members of each type I visited and interviewed is provided in Table 4.4.

Table 4.4 Overview of Huawei cloud ecosystem members

Type	Organisation	Description
IaaS vendor	Huawei Cloud	Founded in 2005, Huawei Cloud opens up Huawei's over three decades of expertise in ICT and digitalisation. It works with its customers, partners, and developers to dive into the digital era and provide Everything as a Service, together building the cloud foundation for an intelligent world.
SaaS/PaaS vendor	Chinasoft International	Founded in 2000, Chinasoft International Limited is one of the leading global software and information technology services companies in the Chinese software industry and a listed company in the Hong Kong main board. It has branches in more than 46 cities and 75,000 employees worldwide.
	Kingdee	Founded in 1993 in Shenzhen, Kingdee has retained the largest share in the enterprise application software sector for fast-growing enterprises for 16 consecutive years, and has twice grasped the biggest share in the enterprise-grade SaaS Cloud services industry.
	Blacklake	Founded in 2016 in Shanghai, Blacklake is an enabler of digital transformation for factories. Relying on cutting-edge technologies such as cloud computing, Internet of Things, and blockchain, it has successively launched multiple SaaS applications to connect the upstream and downstream of the supply chain, and realise real-time collaboration in production.
	Sinoiov	Founded in 2012 in Beijing, Sinoiov is a leading logistics technology and service platform in China. It has built the world's largest commercial vehicle networking platform based on cutting-edge technologies such as AI, Internet of Things, and big data, empowering the logistics ecosystem with technology, delivering digital and intelligent solutions, and making logistics simpler.
	DAS	Founded in 2007 in Hangzhou, DAS-Security is a cybersecurity enterprise that developed against the backdrop of Zhejiang and Hangzhou's endeavour to play a leading role in the digital economy. It

		strives to provide internet security for the development of the digital economy and society with the mission of 'building a safe and trusted digital world'.
Supplier	Huawei	Founded in 1987 in Shenzhen, Huawei is a leading global provider of information and communications technology (ICT) infrastructure and smart devices. Under the guiding principle of Business-Driven ICT Infrastructure (BDII), Huawei is setting the pace for IT systems based on cloud architecture to lead the transformation of enterprise IT towards cloud architecture.
	China Mobile	Founded in 2000 in Beijing, China Mobile is the leading ICT services provider in China and boasts a world-class telecommunications and information operator with the world's largest network and customer base. Its businesses primarily consist of mobile voice and data business, broadband and other services.
Customer	Haier	Established in 1984, Haier Group is a world-leading provider of a better life and digital transformation solutions. It makes development planning for three major sectors: smart home and living, industrial internet, and great healthcare. It has built a leading industrial internet platform COSMOPlat and the IoT ecosystem brand YK Healthcare.

Specialising in enterprise digital transformation solutions, Chinasoft is a first-class ecosystem member and is acknowledged as the Best Corporation-level Alliance Partner and Best Industry Solution Partner of Huawei Cloud. Early in 2017 when Huawei Cloud was just established, Chinasoft International signed a contract with Huawei Cloud and became its first cooperation partner. Chinasoft International presented its cloud capabilities at HUAWEI CONNECT 2017, attracting high attention. During the 2019 HUAWEI CONNECT, Chinasoft launched Kunpeng Professional Service Joint Solution, Smart Bank Solution, and Smart Store Solution together with Huawei Cloud, becoming the first service provider with Huawei Kunpeng Cloud full-stack capabilities.

Huawei Cloud also established strategic ecosystem partnerships with new ventures that focus on SaaS and PaaS services in specific sectors. For example, Blacklake is a cloud-based intelligence-centric SaaS vendor specialising in Manufacturing Execution Systems (MES), which is the intermediary between a business system such as ERP and a manufacturer's plant floor control equipment. Blacklake's MES is deployed on the cloud and can be accessed and monitored via mobile phones, tablets, and computers, covering

core manufacturing processes such as procurement, scheduling, production, materials, quality inspection, and equipment. The cloud-based smart manufacturing services enable factories to achieve low cost and high efficiency in every step of production, from the order placement by the customer, and the input of raw materials to the output of products. Through real-time and accurate data transmission, the digital management between factories will help to solve various problems encountered in the production process, such as delayed delivery, material inventory backlog, low worker and equipment efficiency, high defective rate, and an untransparent production process. As a member of Huawei cloud ecosystem, Blacklake actively participates in the Huawei exhibitions and conferences to contribute to and promote its specialisation in digital and smart manufacturing.

As a leading logistics technology and service platform company, Sinoiov is also a strategic ecosystem partner of Huawei Cloud. The two companies jointly promote the widespread application of SaaS, PaaS, and other cloud-based services in manufacturing enterprises and logistics enterprises, helping enterprises to improve their logistics operation and intelligent operation ability with the aid of digital technologies. Sinoiov has built an integrated intelligent logistics technology platform featuring "logistics + data" that is supported by the three systems of the Internet of Vehicles and cloud computing, security risk control, and digital transportation capacity. Up to now, Sinoiov has formed a comprehensive logistics intelligent engine, logistics geographic information construction, digital factory logistics, freight risk control engine, and basic algorithm library. Combining modular services and scenario-based insights, collaborating with leading IaaS vendors like Huawei Cloud, Sinoiov's overall logistics technology capability platform leads the industry of digital logistics.

By building ecosystems, Huawei is aimed at building a platform for realising applications in various scenarios. Both Chinasoft and Blacklake are displaced in Huawei Cloud Marketplace, a platform where users can choose, purchase, and access high-quality SaaS that is selected and recommended by Huawei Cloud. As a support program for SaaS and

an effective approach to fostering its cloud ecosystem, Huawei Cloud Marketplace's transaction amount has already achieved RMB 1 billion, and the transaction of the top 30 partners reached over RMB 10 million.

Huawei Cloud's customers span many sectors, such as the Internet, government, manufacturing, and finance. Different to Alibaba Cloud's client base in SMEs and e-commerce, Tencent Cloud's client base is in game and Internet start-ups, while many clients of Huawei Cloud are large companies and government clients. The customer base accumulated from the previous ICT business and the 2B service advantage of Huawei helped Huawei Cloud to secure these big clients. For example, Haier, the largest appliance manufacturer in China and also one of the major global appliances brands, collaborates with Huawei in cloud computing deployment. According to the China Cloud Services Market Q4 2020 report released in March 2021, Huawei Cloud was ranked second by Canalys in China with a market share of 17.4% (Canalys, 2021).

4.3.3 Incubation stage: 2008-2013

The key events and milestones of Huawei Cloud's history are shown in the roadmapping figure, Figure 4.7, and the milestones are highlighted with a heavy back box in the figure. Based on the milestones that led to significant progress and changes recognised by informants and other secondary documents, using the temporal bracketing method to identify discontinuity, four stages are identified. The first stage is the incubation stage starting in 2008 and ending in 2013.

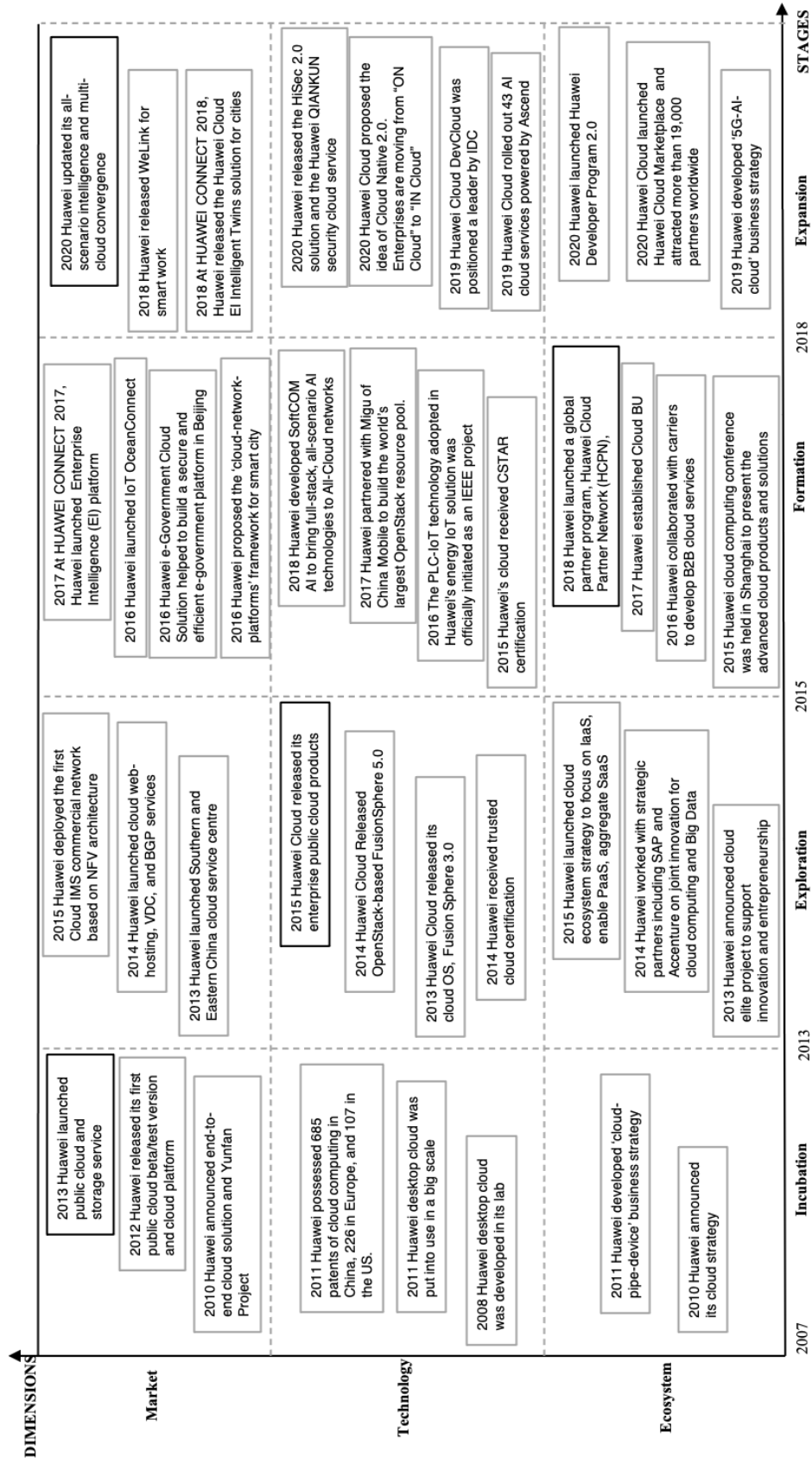


Figure 4.7 Roadmapping of Huawei cloud ecosystem

At the incubation stage, Huawei started R&D cloud computing technology. In 2008, Huawei desktop cloud was developed in its lab. In 2010, Huawei successfully developed and deployed the world's largest desktop cloud internally but it was not offered as a cloud computing solution on the market at that time. In 2011, Huawei desktop cloud was put into use on a big scale. By 2011, Huawei possessed 685 cloud computing patents in China, 226 in Europe, and 107 in the US. In 2012, Huawei released its first public cloud beta/test version and cloud platform. In 2013, Huawei launched a public cloud and storage service.

However, in terms of commercial activities, Huawei participated in cloud business only at the hardware level, functioning as a hardware supplier for other cloud service vendors mainly by collaborating with telecom carriers. As is illustrated in its annual report,

Huawei has extended the reach of its innovative offerings from the telecom carrier network field to the enterprise and consumer fields. To this end, we have coordinated the development of the "cloud-pipe-device" business and put considerable resources towards providing large capacity and intelligent information networks, a variety of smart devices, as well as new-generation business platforms and applications to offer users an efficient, environmentally friendly, and innovative information-based experience (Huawei, 2011, p. 10). (Q4.3.2)

Huawei supplied servers, storage devices/solutions, and other products for the global data centres of cloud computing. By 2011, Huawei was partnered with 85 organisations in 33 countries to help them commercially launch medical clouds, education clouds, and other cloud-based solutions, and had helped customers around the world set up 20 cloud computing data centres (Huawei, 2011).

In its annual report of 2010, Huawei mentioned the transformation of service towards the cloud, when it discussed the improvement of ICT infrastructure and the popularisation of broadband. In 2010, Huawei announced its end-to-end cloud solution and Yunfan Project to prepare for the cloud service industry and announced its cloud strategy. Later in 2011,

Huawei developed its overall "cloud-pipe-device" business strategy, as is shown in Figure 4.8 (Huawei, 2011). This strategy, which has a clear architecture, represents Huawei's design of its cloud computing technology and future vision of the synergy between cloud computing and its main businesses, which guided its further exploration and formation of cloud computing capability and business.

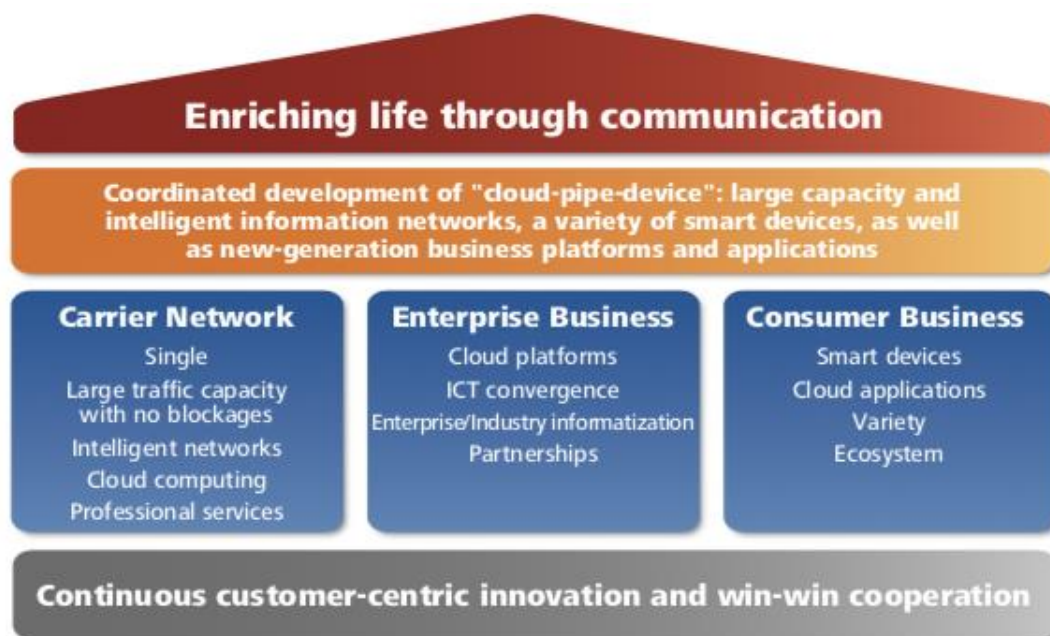


Figure 4.8 Huawei's "cloud-pipe-device" business strategy (Huawei, 2011)

4.3.4 Exploration stage: 2013-2015

At this exploration stage, Huawei developed and opened access to its cloud computing capability. In 2013, Huawei Cloud released its cloud operating system (OS), Fusion Sphere 3.0. In 2013, Huawei Cloud launched the Southern and Eastern China service centre. In 2014, Huawei Released FusionSphere 5.0, which was an OpenStack-based cloud OS. Later this year, its FusionSphere cloud operating system was listed in Gartner's magic quadrant for server virtualisation infrastructure. Based on its newly developed capability, in 2014, Huawei launched cloud web-hosting, VDC, and BGP services and received trusted cloud certification. In 2015, Huawei deployed the first Cloud IMS commercial network based on NFV architecture and launched a cloud ecosystem strategy to focus on IaaS, enable PaaS,

and aggregate SaaS. Finally, in July 2015, Huawei Cloud released its enterprise public cloud products.

Following the cloud-pipe-device strategy, Huawei strengthened its capability in cloud technologies and infrastructure. Figure 4.9 from a Huawei presentation in 2014 shows its architecture and strategic positioning vividly. This was consistent with its understanding of the cloud computing industry:

Fully connected enterprises will organize their business around industry cloud services, which are specially designed to address the unique business systems of each industry. Enterprises will gravitate toward hybrid cloud architecture. With cloud services, enterprises can be better positioned to innovate their offerings, collaborate with industry partners, and boost their operating efficiency (Huawei, 2015, p. 15). (Q4.3.3)

Huawei collaborates with customers from a number of other industries, such as public security, finance, transport, energy, and manufacturing, providing the technological foundation for their smart city, smart finance, smart transport, smart grid, and smart manufacturing initiatives. By doing so, we enable their digital transformation and help ensure that they remain competitive in future markets. (Huawei, 2015, p. 11). (Q4.3.4)

At Huawei, we are well aware that customers need commercially viable solutions. And when developing these solutions, no company can meet customer needs on its own – we must join forces with industry partners to build an open ecosystem. (Huawei, 2015, p. 11). (Q4.3.5)



Figure 4.9 Cloud-pipe-device architecture

Due to its complex business units and evolving strategies at this stage, Huawei had a dual role in the cloud computing industry. On the one hand, Huawei still helped its partners to build cloud computing capability by supplying ICT hardware and infrastructure as a complementor. On the other hand, Huawei started to develop cloud platforms and pave the way for establishing its own cloud ecosystem as a leader. This was elaborated in its annual report of 2015,

In an effort to expand digital infrastructure, Huawei looks to partner up with carriers. By fully leveraging each other's strengths in technology and services, we can set a new benchmark for public cloud services used in verticals and large enterprises, and help carriers transform their business more efficiently. (Huawei, 2015, p. 11). (Q4.3.6)

We have launched our cloud ecosystem strategy, under which we focus on IaaS, enable PaaS, aggregate SaaS, and develop a leading cloud operating system, Big Data platform, and PaaS platform based on software platforms and enterprise cloud services to create an open cloud ecosystem. At the end of 2015, the number of Huawei's enterprise cloud partners exceeded 500. (Huawei, 2015, p. 8). (Q4.3.7)

To show its own ambition in the cloud computing industry, Huawei announced its cloud elite project to support innovation and entrepreneurship in 2013. Huawei worked with strategic partners including SAP and Accenture on joint innovation for cloud computing and big data in 2014.

4.3.5 Formation stage: 2015-2018

Concerning the cloud computing development, Huawei adjusted and updated its cloud strategy after seeing the burgeoning growth of cloud services. Huawei emphasised its pipe strategy focusing on ICT infrastructure development in 2015 (Huawei, 2015). In 2016, Huawei strategising about “becoming key enablers for ICT innovation and development” by utilising digital technologies especially cloud computing and big data. (Huawei, 2016, p.17). In 2017, Huawei proposed the All-Cloud network strategy to make the integration of cloud and network a reality (Huawei, 2017).

In light of the strategies, Huawei accelerated the building of its cloud services and ecosystem. In 2015, the Huawei cloud computing conference was held in Shanghai to present advanced cloud products and solutions. The same year, Huawei Cloud received CSTAR certification. In 2016, Huawei collaborated with carriers to develop B2B cloud services and launched IoT OceanConnect. To facilitate the commercialisation of cloud computing, Huawei proposed the 'cloud-network-platforms' framework for a smart city in 2016. And its e-Government Cloud Solution helped to build a secure and efficient e-government platform in Beijing. In 2017, Huawei partnered with Migu of China Mobile to build the world's largest OpenStack resource pool. At HUAWEI CONNECT 2017, Huawei launched the Enterprise Intelligence (EI) platform. In 2018, Huawei developed SoftCOM AI for bringing full-stack, all-scenario AI technologies to All-Cloud networks. By 2018, Huawei Cloud had established a unified architecture including private clouds, public clouds, and hybrid clouds, and had deployed cloud platforms for more than 270 carriers and their subsidiaries worldwide (Huawei, 2018).

Moreover, Huawei established Cloud BU in 2017. Its function and relationship with other BUs are shown in Figure 4.10 and were elaborated in the annual report.

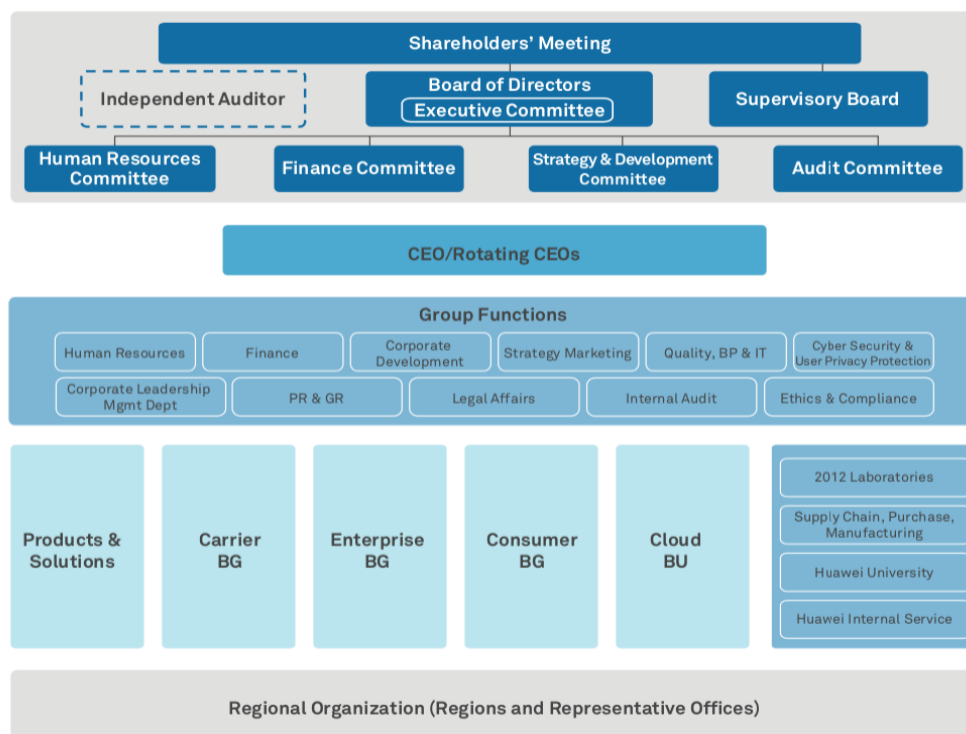


Figure 4.10 Huawei business structure as of 2017 (Huawei, 2017)

The Carrier BG [Business Group] and the Enterprise BG manage and support solution marketing, sales, and services that target carrier customers and enterprise/industry customers respectively. The two BGs provide innovative, differentiated, and advanced solutions based on the business characteristics and operational patterns of different customers while continuously improving the company's industry competitiveness and customer satisfaction. The Consumer BG focuses on serving device consumers and deals with all aspects of the consumer domain. (Huawei, 2017, p. 120). (Q4.3.8)

The company also launched the IaaS business officially and announced its long-term strategic investment in public clouds at the same time. Starting from hybrid clouds, after technology build-up, Huawei started to provide public services on a big scale.

The establishment of Cloud BU facilitated Huawei's cloud services and business greatly. In 2018, Huawei launched a global partner program, Huawei Cloud Partner Network (HCPN), to foster its cloud ecosystem. Huawei Cloud has continued to promote greater integration of digital technologies and physical industries. A manager of Huawei Cloud BU described their work during my fieldwork at Huawei in 2018,

It takes time for us to learn and accumulate knowledge of the business in traditional sectors so that we can integrate them with digital technologies. According to the characteristics of each sector, the cloud services and software are recursive with big data analysis. If we want to dive into digital transformation, we also need to dive into the application scenarios of the traditional sectors. That's why we must build ecosystems with partners and complementors from different sectors. (Q4.3.9)

4.3.6 Expansion stage: 2018-2020

As the expansion stage starting from 2018, Huawei upgraded its cloud strategy by emphasising the advancement of cloud computing technology and its integration with other advanced technology such as AI and IIoT. In 2019, Huawei developed the '5G-AI-cloud' business strategy. At HUAWEI CONNECT 2018, Huawei released the Huawei Cloud EI Intelligent Twins solution for cities, and kept upgrading the solutions to "accelerate the intelligent upgrade of governments and enterprises, with cloud as its foundation and AI at its core" (Huawei, 2020, p. 6). In 2018, Huawei released WeLink for smart work, in order to provide a portfolio of solutions for enterprise customers to increase customer engagement. In 2019, Huawei Cloud rolled out 43 AI cloud services powered by Ascend and its DevCloud was positioned as a leader by IDC. In 2020, Huawei released the HiSec 2.0 solution and the Huawei QIANKUN security cloud service and proposed the idea of Cloud Native 2.0. Enterprises were moving from "ON Cloud" to "IN Cloud". Later this year, Huawei updated its all-scenario intelligence and multi-cloud convergence. As was illustrated in the slides the director of Huawei Cloud shared at the HUAWEI CONNECT

2020 Conference (see Figure 4.11), “scenario-specific applications and promotions” were regarded as the key to “larger business growth”. “Extensive industry know-how” was necessary for the development of “more advanced technologies”.



Figure 4.11 Presentation at HUAWEI CONNECT 2020

During expansion stage, Huawei Cloud kept improving and expanding its cloud products and services with different capabilities and business models. The 2020 annual report summarised:

In cloud & computing, we aim to develop core capabilities for the intelligent hub with “one cloud” (HUAWEI CLOUD), “two wings” (one is computing; the other is data storage & intelligent vision), and “two engines” (general-purpose computing & intelligent computing). Our ultimate goal is to deliver ubiquitous cloud and intelligence and enable all-scenario intelligence. (Huawei, 2020, p. 19). (Q4.3.10)

The Huawei cloud ecosystem also grew prosperously at this stage. By 2020, Huawei Cloud had attracted more than 19,000 partners worldwide, with over 4,000 partner apps available on the Huawei Cloud Marketplace, and through Developer Program 2.0 it attracted more than 4,000 ecosystem partners.

Coordination and collaboration across industries will drive innovation at scale. With the continuous evolution of smart devices, a seamless experience across all scenarios will become the foundation of an intelligent life (Huawei, 2020, p. 14). (Q4.3.11)

With the complementary assets from its business ecosystem, Huawei Cloud promoted its cloud services to a diversity of scenarios and sectors, including e-Government clouds that enable cities to switch to cloud-native services, transportation sector clouds that realise smart airport, railways, and highways, and clouds for industrial Internet innovation centres that help many Chinese manufacturers with their digital transformation.

4.4 The Emergence of the Cloud Computing Industry in China

In the cloud computing industry in China, key actors are the cloud service providers, including IaaS vendors (e.g., Alibaba Cloud, Huawei Cloud, Tencent Cloud, China Mobile Cloud), SaaS vendors (e.g., Kingdee, Hundson, DT Dream, and CityDO), and PaaS vendors (in many cases, PaaS are provided by IaaS or SaaS vendors). As shown in Figure 4.12, the cloud ecosystem also includes customers from various applied sectors (e.g., smart city, finance, gaming, etc.), regulatory agencies for cloud computing industry and applied sectors, universities and research institutes. The IaaS, PaaS, and SaaS businesses of cloud computing have grown dramatically and redefined the ICT industry, with the aid of the other actors in the cloud ecosystem. As described by Huawei (2020, p. 15),

The cloud is as important for intelligent transformation as electricity was for the electrification revolution of the 20th century. The cloud is critical digital infrastructure that underpins the intelligent world.

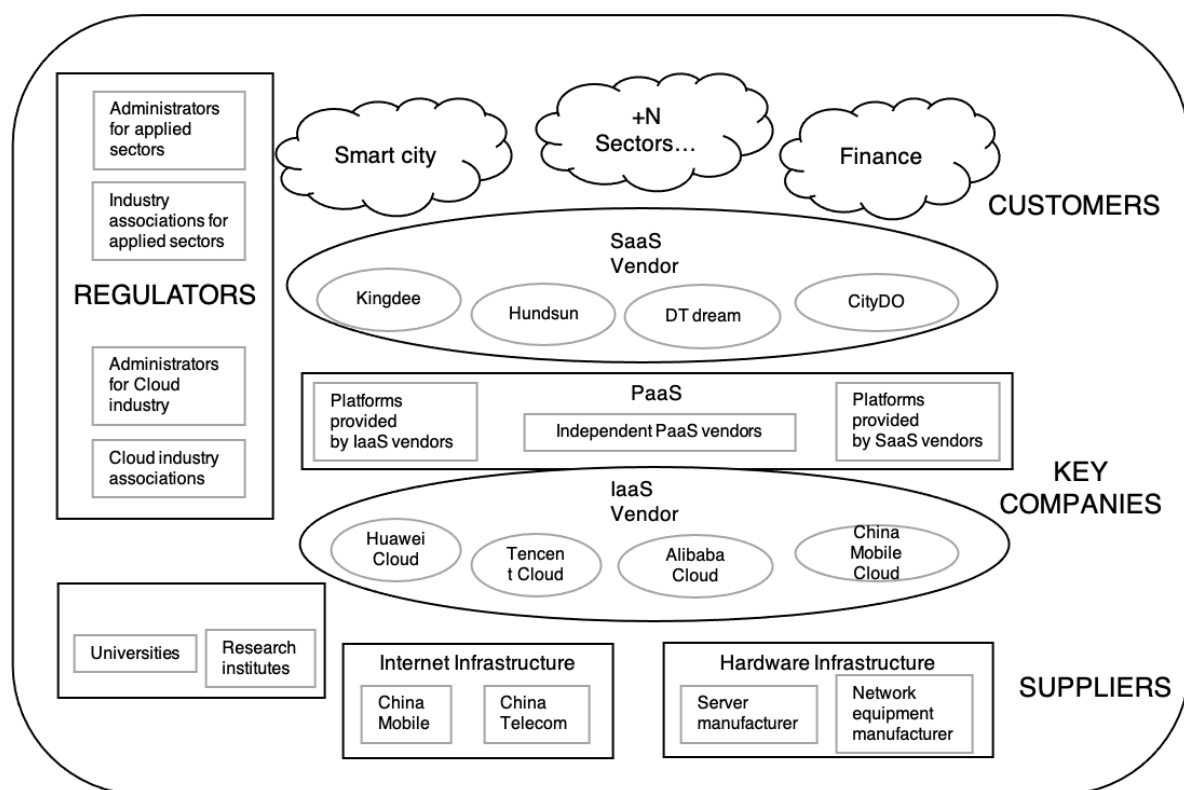


Figure 4.12 Overview of the cloud computing ecosystem in China

The development of cloud computing technology can be traced back to 1961. The global history of cloud computing is analysed and presented in Table 4.5 to provide a background for analysing Chinese cloud computing history.

Table 4.5 Overview of global cloud computing history

1961	Computer scientist John McCarthy proposed the idea of computation delivered as a public utility
1962	Computer scientist J.C.R. Licklider introduced the 'intergalactic computer network'
1972	IBM developed an virtual operating system 'Virtual Machine'
1995	Oracle's founder Larry Ellison proposed the concept of network computer
1996	Compaq first mentioned the concept 'cloud computing' in an internal document
1999	Launch of salesforce.com pioneered the concept of delivering enterprise applications through a simple website
1999	VMWare developed VMware Workstation based on virtualisation
2002	AWS provided a suite of cloud-based services including storage, computation, and even human intelligence through the Amazon Mechanical Turk' ⁴

2004	Google published papers about Google File System, MapReduce, and Bigtable, which laid the foundations of cloud technologies
2005	Hadoop collaborated with Yahoo to explore the cloud computing application
2006	Google's former CEO Eric Emerson Schmidt proposed the concept of cloud computing at the search engine conference to promote the concept of cloud services and it became popular
2006	Amazon launched the Elastic Compute Cloud (EC2) and S3 Storage
2007	IBM planned to launch cloud computing solutions for enterprises
2008	Google announced Google App Engine (GAE)
2008	Microsoft announced Microsoft's cloud services operation, Windows Azure
2009	Web 2.0 and browser-based enterprise application services such as Google Apps became popular
2009	Netflix became the first big public company to operate 100% on AWS'
2010	Microsoft introduced the Azure platform and services
2011	IBM announced the IBM Smart Cloud framework to support Smarter Planet
2011	The Sony breach in April, and a massive outage at Amazon's cloud computing centre, slowed down companies' plans to shift their IT operations to the cloud
2012	Microsoft launched its Azure public cloud
2012	Oracle announced the Oracle Cloud
2012	Google launched Google Platform cloud
2013	AWS won a classified deal from the Central Intelligence Agency
2013	Google launched the official version of Google Compute Engine

According to the cloud computing development survey report of the China Academy of Information and Communication Technology, the scale of China's cloud computing market has grown explosively since 2016, as is shown in Figure 4.13. The size of China's cloud computing market in 2016 was only 51.5 billion yuan, and since then, it has increased year by year, breaking through the 100 billion yuan mark for the first time in 2019, and then breaking through the 200 billion yuan mark in 2020. The proportion of enterprises that have applied cloud computing in China reached 66.1% in 2019, an increase of 7.5% compared with 58.6% in 2018 (CAICT, 2021).

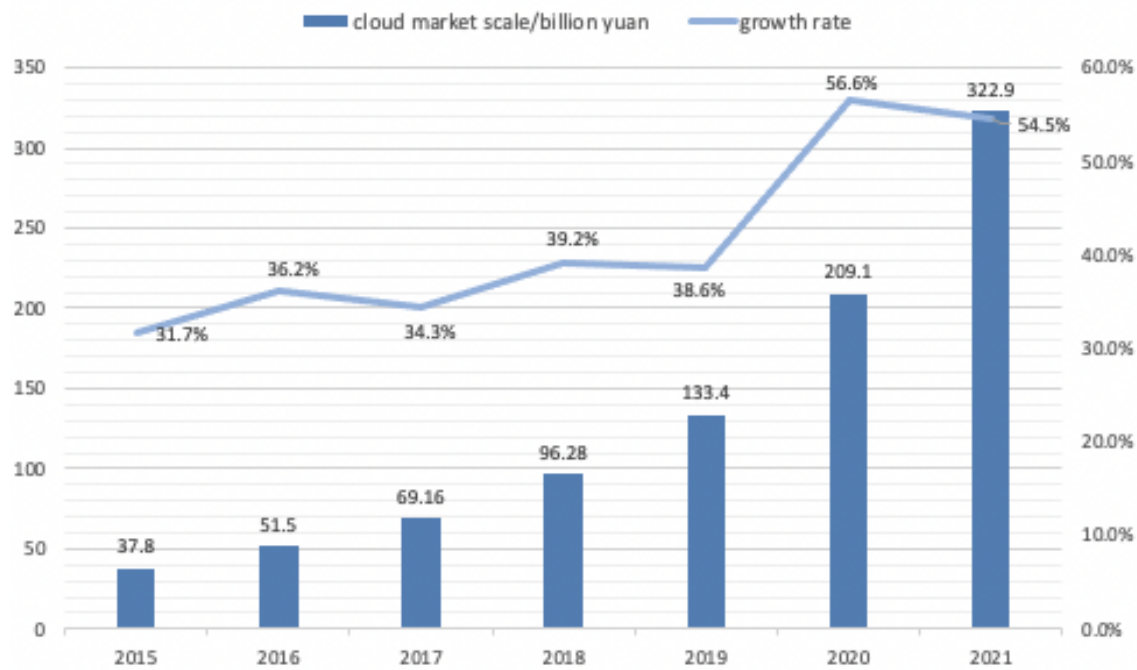


Figure 4.13 The scale and growth rate of the Chinese cloud computing industry

According to the International Data Corporation (IDC) Worldwide Quarterly Cloud IT Infrastructure Tracker, in the third quarter of 2018 (3Q18), quarterly vendor revenues from cloud-based IT infrastructure product sales surpassed revenues from sales of traditional IT environments for the first time, accounting for 50.9% of the total worldwide IT infrastructure vendor revenues. In the second quarter of 2020, the global cloud IT infrastructure reached \$14.5 billion, accounting for 55.13%, which means the cloud expenditure surpassed the traditional IT infrastructure for the first time, which is a milestone for industry emergence. Moreover, a stable market structure gradually formed with Alibaba Cloud, Huawei Cloud, and Tencent Cloud ranking in the top three positions and occupying over 60% of the market share together in 2020 (CAICT, 2021).

From the business model perspective, as shown in Table 4.6, different business models have been developed for different customers and market segments. The emergence process shows how the entrants explore and find viable business models, and how their business models converge. After defining and realising value propositions in various market segments, the emerging industry will see a set of accepted business models for different market segments, which means the emergence of new industries and markets.

Table 4.6 The main business models for the cloud service industry

Business model types/dimensions	Public cloud	Hybrid cloud	Private cloud
Customer identification	Individual/SME	Companies in need of a hybrid and scalable IT environment, such as internet/finance companies	Large traditional companies/organisations
Customer engagement	Cloud vendors offer IaaS/PaaS/SaaS	Cloud vendors offer IaaS/PaaS, customers can develop software/platform on the cloud by themselves or outsourcing	Cloud vendors customise solutions for digital transformation and deploy the cloud, customers can develop and maintain the cloud infrastructure/platform/s software by themselves
Value chain links	Large IaaS vendors provide general service, and a platform of complementary components and applications	Large IaaS vendors provide infrastructure, and a platform of complementary components and applications	Large IaaS vendors provide industry-specific service with their ecosystem partners from the respective industry
Monetisation	On-demand service, subscription/pay-per-use/spot pricing	Tiered pricing, pay-per-use	Project bidding and contract, subscription

Initially, the leading market segment in the cloud computing industry was the public cloud service for internet-based SMEs. Their management and operations, as well industry know-how, were familiar to early cloud vendors. Also, the difficulty of cloud deployment for these ‘born digital’ internet-based companies was lower; therefore, this market segment became the early success of cloud adoption and commercialisation. Specifically, Alibaba Cloud specialised in an enterprise cloud service for e-commerce, and its business model is to share cloud infrastructure and platform with the small e-commerce companies and charge by the on-demand service. Similarly, Tencent’s business model was to offer infrastructure and platform as a service for the other smaller game or

entertainment companies, especially the born digital start-ups. This kind of public cloud-based IaaS and PaaS model became the dominant business model design in the market segment of individuals or SMEs.

With the successful commercialisation experiences in the public cloud, the business models of private cloud and hybrid cloud service were also developed and refined. For the large corporations and organisations from traditional sectors, it was initially hard to persuade them to pay for cloud service. For one thing, they tend to have their own IT departments and existing traditional IT infrastructure. For another thing, they are usually unwilling or unable to move their data to the public cloud due to sensitivity or regulation. Therefore, to provide additional value, more than traditional IT architecture can give, the cloud vendors find it viable and necessary to offer the client a whole solution for digital transformation. Usually, they help the client to design a plan to transform towards a digital and smart future with the aid of ecosystem complementors who can provide the industry know-how in consulting. Also, to address the security concerns, cloud vendors tend to provide these clients with a private cloud service, in which the cloud computing environment is dedicated to a single customer, as well as controlled and maintained by themselves.

The target customers for hybrid cloud – such as Internet or finance companies – need the flexibility of the public cloud for 2C businesses, as well as the security of the private cloud for sensitive data due to confidentiality or regulation requirements. Also, from the technical perspective, they have their own IT department responsible for platform/software-level tasks, and the hybrid mode allows the combination of the existing IT architecture and compatible cloud environment. In contrast, for individuals, SME or start-ups, the public cloud business model provides a complete cloud service covering infrastructure, platform, and software, so that they do not need to have an IT department. The cloud platform provides a set of complementary components and applications for them to choose (Giessmann and Legner, 2016).

Chapter 5 INDUSTRY EMERGENCE: PROCESS AND TRANSITION

5.1 Stages of Industry Emergence

Using roadmapping and temporal bracketing, after comparing organisational processes, I identified the stages based on key events and milestones in the Chinese cloud computing industry, as shown in Table 5.1. Through further thematic analysis, the event data and interview data are categorised into three dimensions: the supply side-related code, the demand side-related code, and the actor and activity-related code. From the three dimensions, the characteristics and tasks of each stage are identified and presented in Figure 5.1.

Table 5.1 Stages and key events of cloud computing industry emergence

Time	Theme/Events
2008-2013	<i>Incubation stage: Pioneer-leading R&D and internal application</i>
September 2008	Alibaba Group determined the strategy of cloud computing and big data to conduct the R&D of its own distributed OS
February 2009	Alibaba's Apsara team wrote down the first line of codes
September 2009	Alibaba Cloud was founded
April 2010	Alibaba Group launched the Shepherd Project on the Apsara system
May 2010	Alibaba Cloud released the first public beta/test version
November 2010	Alibaba Cloud supported the first Singles' Day (11-11) Taobao shopping festival
November 2010	Tencent and Huawei announced their cloud strategies
February 2011	Tencent Cloud released the first public beta/test version
August 2012	China Telecom released the brand and strategy of Tianyi Cloud

October 2012	Yunqi Town was established with the aim of becoming a cloud computing industry cluster
August 2013	Alibaba Cloud became the first company in the world to provide 5k cloud computing capabilities
2013-2015	<i>Exploration stage: Follower entry and commercialisation exploration</i>
September 2013	Tencent Cloud announced its brand and 2B business strategy
September 2013	Huawei Cloud released its cloud OS, Fusion Sphere 3.0
September 2013	All of Yu'E Bao's (Ant Group) core systems began to run on Alibaba Cloud
July 2014	Alibaba Cloud announced its Maxcompute product
August 2014	Alibaba Cloud released its Yunhe Project to recruit cloud service providers to build a cloud ecosystem
January 2015	12306 cooperated with Alibaba Cloud and managed to run smoothly during the Spring Festival travel season
March 2015	DT Dream was founded in Yuqin Town
June 2015	Tencent announced the Cloud+ Project to establish a cloud ecosystem
July 2015	Huawei Cloud released its enterprise public cloud products
June 2015	Alibaba Group and Ant Group completed the 'Moon project' to move all the data and computing tasks from IOE systems to the Apsara system
December 2015	Douyu TV collaborated with Tencent Cloud and began to run on Tencent Cloud
July 2015	Huawei Cloud released its enterprise public cloud products
2015-2018	<i>Formation stage: Commercialisation and ecosystem formation</i>
October 2015	Alibaba Cloud Computing Conference was held in Yunqi Town, Hangzhou, attracting over 20,000 developers
April 2016	Alibaba Cloud released Apsara Stack, a full-stack cloud solution designed for enterprise-level customers
October 2016	Alibaba Cloud and the Hangzhou government announced Hangzhou ET City Brain Project
March 2017	Alibaba Cloud announced ET Industrial Brain Project and ET healthcare Brain Project
March 2017	Alibaba Cloud incorporated Youku CDN and reduced the price by 35%
April 2017	Huawei established Cloud BU
October 2017	Traffic System 1.0 of Hangzhou City Brain was released
November 2017	Tencent Cloud reduced the price of CDN by 44%

2018-	<i>Expansion stage: Mass adoption and ecosystem competition</i>
April 2018–	Alibaba launched the business in the IIoT market
August 2018–	The national government released a guide for enterprises to adopt the enterprise public cloud
September 2018	Tencent CSIG (Cloud & Smart Industries Group) business group of Tencent was established to facilitate 2B businesses
October 2018	At HUAWEI CONNECT 2018, Huawei released the Huawei Cloud EI Intelligent Twins solution for cities
November 2018	Alibaba Cloud and SUPCON released the SupET industrial Internet platform at the fifth Yunqi Conference
October 2019	Zhejiang province announced a unified provincial e-government cloud platform
January 2019	Tencent announced the 1 billion ‘subprogram + cloud’ project
March 2019	Alibaba Cloud released its SaaS accelerator and ‘subprogram cloud’, announcing the 2 billion ‘Star Project’ to facilitate the cloud ecosystem
December 2019	The integrated version of Hangzhou City Brain was released
January 2020	Tencent started the Qianfan Project, as the SaaS Technology Alliance
March 2020	Oceanbase, a database developed by Ant Group, was released globally

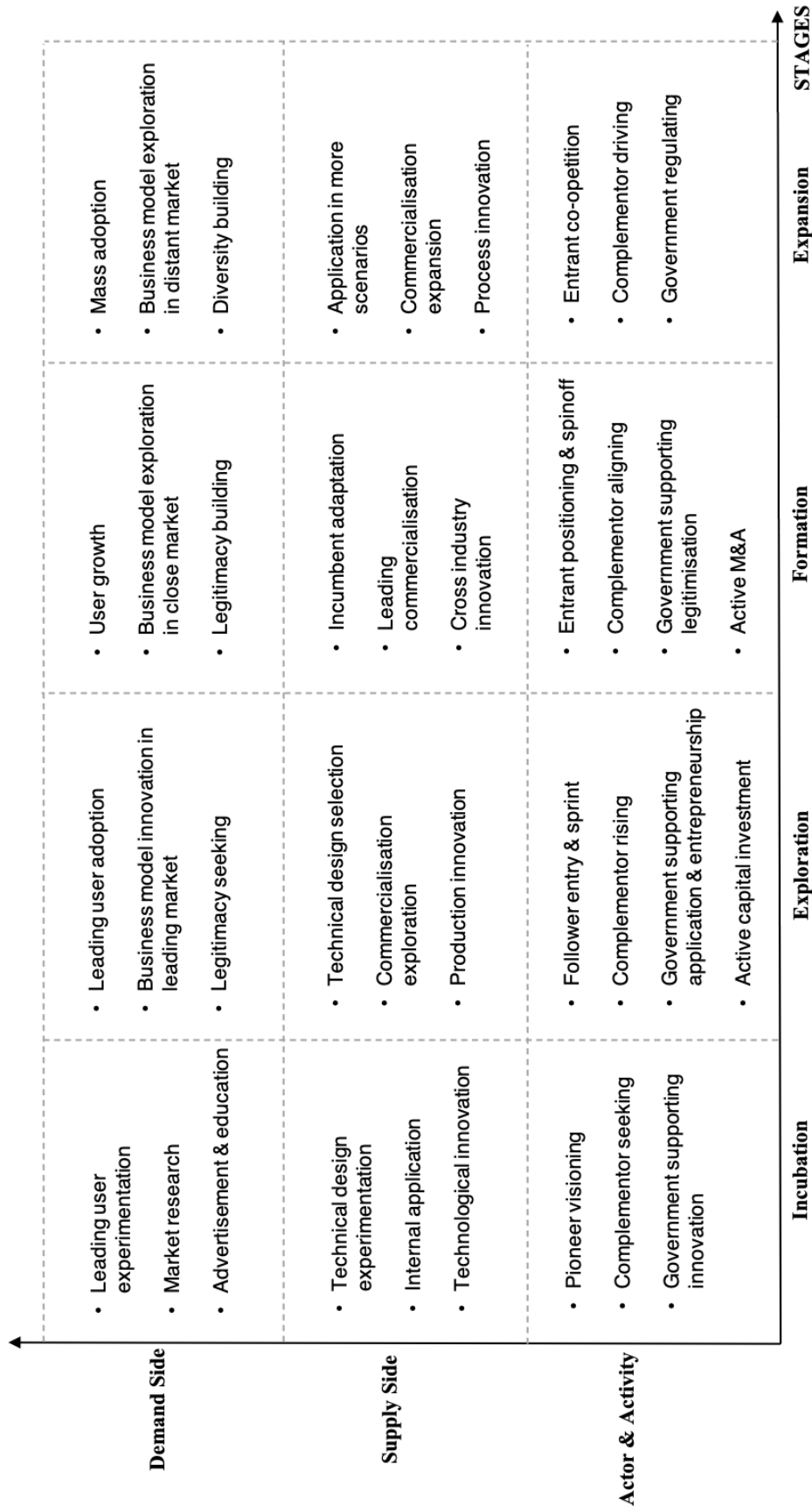


Figure 5.1 Stage model of industry emergence from three dimensions

5.1.1 Pioneer-leading R&D and internal application

The first stage is characterised by the R&D activities and internal application attempts of pioneers. Alibaba Group is the key player in the first stage of cloud market formation. It began the R&D of cloud computing technology in 2008 by forming the Apsara team, as one of the earliest cloud computing service providers in China. In 2010, to facilitate the internal application of cloud computing, Alibaba Group decided to launch the ‘Shepherd Project’ of Alibaba Finance (this division was later separated from Alibaba as Ant Finance) on the Apsara system. This trial encountered rounds of bugs and challenges but, through the hard work and continuous improvement of the Alibaba Cloud team, the recursive training with huge data built up the quality, applicability, and robustness of the Alibaba cloud platform and services. In 2013, Alibaba Cloud completed the 5k challenge and became the first company in the world to provide 5k cloud computing capabilities, which was a milestone for Alibaba Cloud and the Chinese cloud industry in terms of capability maturity for further application and market use.

Thanks to the first-mover advantage, Alibaba Cloud has become China’s largest public cloud service provider and is ranked third in terms of global market share over the last decade. Its pioneering attempts in the application of cloud computing technology are driven by the requirements of its growing core business, as a manager of Alibaba Cloud who joined the early cloud team in 2010 as an IT specialist explained:

Initially, Alibaba developed cloud computing technology not for cloud computing service business, but for our inner use, especially during the 11-11 festival, which requires huge computing capacity. I was initially a software engineer of the Taobao team. But the increasing [numbers of] users and orders placed fast-growing pressure on our server, and the group decided on a big investment in cloud computing because of its unlimited potential, and many engineers like me moved to the cloud team later. (Q5.1.1)

Except for Alibaba Cloud, the Chinese branch of multinational enterprises such as IBM China and state-owned ICT enterprises such as China Mobile also pioneered the technology development of cloud computing, although they failed to initiate commercialisation at this stage to gain a first-mover advantage due to internal and external reasons. Internally, China Mobile's core business of the existing industry hampered their work in commercialisation of this disruptive emerging technology and their strict risk control system of a state-owned enterprise increased the difficulty of high-risk investments in emerging markets. IBM China contributed to the education and advertisement about cloud computing and the "smarter planet" vision for the market formation; however, their cloud computing business faced extensive regulatory pressure and institutional resistance in China. As the extension of its ICT business, Huawei built cloud-based IT solutions and joined with their partners to explore the commercial application of cloud computing technologies. As reported in its annual report,

Huawei built cloud-based IT solutions and joined with over 300 partners to accelerate the commercial application of cloud computing technologies across various industries. By the end of 2011, we had helped customers around the world build 20 cloud computing data centers (Huawei, 2011, p. 05). (Q5.1.2)

Multiple informants who are cloud computing technology experts indicated the importance of Google and AWS and other global high-tech giants in setting the technology framework and dominant category of cloud computing. One of the salient features of technological innovation of the emerging digital technologies differing from traditional technologies is the open source community, which has challenged the classical triple-helix technology transfer model. The open source community such as Openstack and the three cloud computer papers published by Google greatly facilitated the widespread use and further exploitation of cloud computing technology so that more developers and enterprises around the world could jointly explore perspective application scenarios for this emerging technology to create value and promote digital transformation. More

directly, the founder of Apsara team and Alibaba Cloud, Dr Jian Wang, was previously the head of Microsoft Research Asia. Other than the spinoff from global high-tech giants, Alibaba Cloud also benefited from the collaboration with Chinese universities and research institutes such as Zhejiang University, and Hangzhou Dianzi University.

The local government also contributed to the incubation of the cloud market. On 24 December 2012, the Xihu District Government issued the “Policy Support for Promoting the Development of Hangzhou Cloud Computing Industrial Park (Trial)”, including a series of supporting policies such as rent reduction, bandwidth subsidy, and financing subsidy. In addition to industrial policy encouragement and one-stop registration services, Yunqi Town has also established the Cloud Computing Technology Training Institute, “Yunqi College”. The goal of Xihu District is to develop thousands of cloud-related enterprises through three to five years of development, covering cloud computing applications, games, Internet finance, mobile Internet, and data mining, among other things, to form a complete industrial system of the cloud computing industry. The interviewee from Hangzhou Commission of Economy and Information noted:

At first, this industrial park was targeted at some manufacturing industries such as pharmaceutical industries, but the progress and results were not very satisfying. We pivoted by considering the emerging industries and our local resources, and decided to target it as a cloud computing industrial park. We developed a long-term plan for it and did a lot of works to promote cloud computing. (Q5.1.3)

From the actor and activity perspective, pioneers such as IBM China, Alibaba Cloud, and some technology experts – individuals or communities – promoted the new category of cloud computing, and initiated advertisement and education about cloud computing and digital transformation. As it was the embryonic stage, there were very few complementors for cloud service vendors; therefore, pioneers sought complementors to join to prepare for the following commercialisation attempts. Yunqi Town is an example

of incubating and gathering start-ups and complementors, with great support from the government, which aimed to accelerate digital innovation and nurture the emerging industry.

5.1.2 Follower entry and commercialisation exploration

Having achieved progress in R&D and experimental application, leading players in this emerging industry began to explore the commercial and profitable business model of cloud computing. Some of them developed an ecosystem strategy and recruited various complementors because the wide adoption and application of cloud computing require the joint efforts of more contributors. In September 2013, Tencent Cloud announced its brand “Tencent Cloud” as one of the foundations for its open strategy. Tencent Cloud announced a new open strategy to fully open to society; that is, developers, especially mobile developers, can enjoy Tencent’s services. The year 2013 was also a milestone of transformation from PC to mobile end, based on which various mobile applications and business models have emerged. With the further development and popularity of 4G and mobile phones, the live-streaming industry boomed with more than 400 million users. Douyu TV, one of the largest live-streaming platforms, collaborated with Tencent Cloud to run on the cloud. The demand for live streaming matched perfectly with the features of cloud computing and provided a playground for testing the design of cloud products and playing their functions; that is, the stability of the server bandwidth side was the key to a high-quality live broadcast experience. At this stage, Huawei also joined the promising industry by releasing multiple products and services in the pipeline. Instead of just complementing its partners in their cloud business plan, Huawei accelerated its development of and experiments with cloud technology.

At the same time, more start-ups were founded and more IT-related companies set up new divisions to join the emerging cloud industry considering the larger influence of cloud computing and the entrepreneurship support from governments. According to a co-founder of DT Dream:

The mission of DT Dream is to enable digital transformation in government, city and industry, which is our Chinese dream in this digital age. I had plenty of experience in ICT industries before this start-up, and I saw the great potential in this area, especially the opportunities of many niche markets. When I saw Alibaba's achievement and a big investment in the application of cloud computing and big data, I was determined to enter this promising industry. (Q5.1.4)

Capital investments were active at this stage and policies that encourage and support innovation and entrepreneurship were enacted. Followers entered and sprinted at this stage; some of them ran very fast, but only for a short time because they lacked core competence and were just attracted by the 'gold rush' of the emerging cloud computing industry. Even for some of the internet giants, without clear positioning in the future industry structure, they tried different approaches and roles to capture as much value of this industry as possible, and later found it was impossible to play every role or deploy every market segment.

From the perspective of technology, through experiments and accumulations in cloud computing technology, pioneers chose and laid out a pathway that was technically feasible. And commercialisation explorations followed to realise the selected designs of cloud products and services. New product/service developments and product/service innovations were active in the second stage, which featured exploration. An engineer from the early Alibaba Cloud expressed,

During 2013 and 2014, Sanfeng became the CEO of Alibaba Cloud, and prioritised product development. As engineers and designers, we spent more time improving the API and user interface to make the product a more friendly version for users. We tried many different designs and figured out the best through experiments and some pilot applications and projects. (Q5.1.5)

From the perspective of the market, early users began to accept the cloud products and services as a replacement for the traditional physical servers, such as Ant Group, 12306 as the user for Alibaba Cloud, and Webank, Douyu as the user for Tencent Cloud. From the early use cases, the cloud vendors not only set out their technical designs and improved their products and services so that real commercialisation could happen, but also figured out the way in which a cloud business should run, how to deliver services and how to price, which represented the early business model innovation in the leading market.

5.1.3 Commercialisation and ecosystem formation

After firm take-off, a great deal of commercialisation attempts by the increased entrants have given rise to the emergence of some leading markets where successful cloud products and services were launched to meet the demand of users in the leading markets with suitable technical designs and business models. Examples of leading markets for the emerging cloud computing industry are smart city, e-government, e-commerce, game, finance, etc. I defined these markets that accepted the emerging technologies and products early and set an example for the following application on a larger scale as leading markets, which tend to be close to the emerging industry. By 'close', I mean close in three dimensions. First, the targeted market and the emerging industry have shorter knowledge distance; thus, people from the emerging industry can understand the business and requirements of the targeted market more easily. Second, the firms in the targeted market and the emerging industry have similar management styles, cognition, and culture; for example, they are both internet companies, or high-tech enterprises. Third, the targeted market and the emerging industry have a similar level of management, especially the information management level.

Through the sprints and attempts of the exploration stage, wrong positioning and incompetent firms were gradually ruled out. An officer from CAICT elaborated,

At first, many large vendors wanted to establish a super ecosystem that covers most of the sections and captures most of the value. But you know the rule of the market is co-specialisation and division of labour. Every company has its own expertise and according role in the market. After the exploration, each player found its market segment to do business and to establish its ecosystem. The entrants found their position in the industry, and key vendors formed their ecosystems and aligned their complementors to deliver cloud services in various areas. This is actually very crucial for the healthy growth of this nascent industry. We also worked on policies to protect the legal application and transaction of the new cloud services and to regulate the chaotic explorations. (Q5.1.6)

Major cloud vendors successfully launched various leading markets by choosing the close market for them based on their own backgrounds. For example, Alibaba Cloud succeeded in e-commerce and smart city markets. In its annual report of 2018, Alibaba Group described its cloud business as follows:

We are engaged in the development of a wide range of IoT technologies, such as PaaS, microchip design and development framework, operating systems and cloud computing capabilities for transportation, home, mobile, public and industrial applications. Our IoT PaaS and data allow hardware to work in more application scenarios and solutions as well as for applications to have more hardware options (Alibaba Group, 2018, 86). (Q5.1.7)

Complementors were ready and aligned to deliver a value proposition based on cloud technologies. Leaders in the emerging cloud market began to establish their ecosystems as an approach to attract and secure partners and clients, which was crucial for promoting the cloud offering and disrupting the traditional IT market. For example, Alibaba Cloud held a cloud-themed conference – Yunqi Conference– in Hangzhou to display the successful applications of cloud computing and share their vision about the future cloud

market. More evidence can be seen in Table 5.1. As an approach to secure complementors and also a natural process of either adapting to or dying in the market system, M&A also happened frequently at this stage and led to the formation of the major cloud ecosystems, thus enabling the stabilisation of the industry structure in the next stage.

As cloud computing gains increasing legitimacy as a new market category, the vendor develops a portfolio of strategies and leverages a political toolkit to respond to and shape the emergence and evolution of the market (Su, 2011). The government also plays a vital role at this stage in promoting the acceptance of cloud computing by introducing regulations and policies that prescribed the category of cloud computing. As an incumbent firm from the traditional ICT industry based on the physical server, Huawei established Cloud BU in April 2017, which showed its determination in the transformation to cloud computing and its ambitions in the cloud business landscape.

5.1.4 Mass adoption and ecosystem competition

In stage 4, the category and design of cloud offerings were gradually recognised by the market, and cloud computing was adopted in various sectors and scenarios. The broader application also means the diversity of products and services in the emerging cloud industry, which also signalled a milestone in industry emergence. As was illustrated in a description of the cloud business in Huawei's annual report in 2019,

We enable greater synergy between cloud, AI, and 5G to provide public cloud services and hybrid cloud solutions that deliver several layers of added value, especially in terms of stability, reliability, security, trustworthiness, and sustainability. HUAWEI CLOUD has launched more than 200 cloud services and 190 solutions, while over 3 million enterprise users and developers currently use HUAWEI CLOUD to develop products and solutions (Huawei, 2019, p. 30). (Q5.1.8)

Successful applications in more scenarios also enabled process innovation with efficiency improvement and cost reduction (Moeen et al., 2020). Along the value chain, to deliver a new value proposition, the procedure of new service development became clear for the cloud vendors. With the experiences of prior applications and developments, the cloud vendors kept improving the process and figured out the best design for the decomposition of the tasks, components, complements, and the division of labour within the ecosystem for each element.

Cloud technologies began to be applied in more scenarios, especially those in distant markets with higher difficulty in developing new products and services. Alibaba Cloud, Huawei Cloud, Tencent Cloud, and other cloud vendors launched their cloud services featuring IIoT to transform traditional manufacturing industries, which were generally distant markets for the emerging cloud industry. However, it was much more difficult to apply and promote cloud services in manufacturing companies than in internet-based companies. First, software engineers may have a different cognition and style from hardware engineers, and the cloud service providers tend to have a different culture from manufacturing companies. It was also difficult for the staff to understand and learn the industry know-how of manufacturing sectors, let alone the confidential knowledge about the production process. Second, the information management level of many factories was still too low to employ cloud-based services.

To address these obstacles, the Ministry of Industry and Information Technology and the incumbent firms promoted IIoT and cloud computing to improve the awareness of manufacturers in digital transformation. With the mass adoption in close markets and the process innovation that allows for more efficient and smooth new service development, cloud services were gradually applied in more and more manufacturing scenarios. The governments also strengthened regulations to ensure the appropriate expansion of cloud services. Companies in the emerging industry paid more attention to adapt to and comply with regulation requirements.

As digital transformation accelerates across industries, the application of new technologies – such as cloud computing, artificial intelligence (AI), 5G, and big data – brings with it opportunities, but also risks. We need to consider how to meet the increasingly strict compliance requirements of regulators, and how to provide secure and trustworthy products and services that fulfil our commitments to customers. We also need to embrace a defence-in-depth approach to provide better security, ensure business continuity, and improve efficiency and customer experience while all the time protecting user privacy (Huawei, 2021, p. 82). (Q5.1.9)

The market structure began to stabilise after the large cloud vendors established their ecosystems via M&A, spin-off, incubation, strategic collaboration agreements, and other means. One of the managers from the ecosystem strategy division of Tencent explained:

Our employees are talented but they don't have time to learn the know-how of all the sectors, and we cannot hire experts in all areas, so we have to rely on the ecosystem to facilitate the adoption of the cloud in various industries as our business grows. The ecosystem participants benefited us a lot, to be honest, and a large part of our new markets was opened by them, which was also why we set up the ecosystem division. In the game of cloud market nowadays, it is not only the competition of technology, it is more like a competition of ecosystem. (Q5.1.10)

The expression by the founder of Brand New Data also confirmed and further elaborated on the importance of complementors to an ecosystem and the industry,

The Internet giants, whose human costs and marketing costs are so high that they typically don't go to smaller cities, find smaller clients for smaller projects. After the giants make up the big clients, the remainder of the market is there for smaller firms to explore. The internet giants, the BAT (Baidu, Alibaba, Tencent), provide the technology foundation, a platform based on

which we can develop customised software on the cloud for smaller clients. And the BAT also benefited from this by charging the consumption of their cloud resources. (Q5.1.11)

During this stage, Alibaba Cloud's Star project, Huawei's Cloud Partner Network, and Tencent's Qianfan project, were announced to attract complementors to join their cloud ecosystems. Leading a group of ecosystem members, the major IaaS vendors competed in many project bids, and the competition might turn into collaboration as each group worked on one sub-project under the umbrella of a grand project. Considering the importance of complementors and ecosystems, the competition was not only firm level, but also ecosystem level. A manager of the strategy department from Huawei Cloud expressed the following during their interview:

In the game of cloud market nowadays, it is not only the competition of technology, it is more like a competition of ecosystem. We have to change our style and show our good faith to attract ecosystem partners. Although we have strong and comprehensive capabilities, we may still encounter difficulties in bidding and delivering some projects, in which case partners are very important. (Q5.1.12)

5.2 Transitions and Mechanisms

5.2.1 Internal dominance of fundamental technology design

As is shown in Figure 5.2, from stage 1 of the incubation to stage 2 of exploration, the key transition is the internal dominance of fundamental technology design. This transition means a technological breakthrough in two aspects. First, the individuals, firms, and other organisations of the technology community at the incubation stage converge on a common and dominant design of fundamental technology so that the later applications can all be based on this fundamental technology design. Second, this marks the

accomplishment of R&D and internal application by the early entrants, and also the major players in this rudimentary industry. Internal dominance means that they establish their internal dominant design so that they can proceed to the next stage of new product/service development.

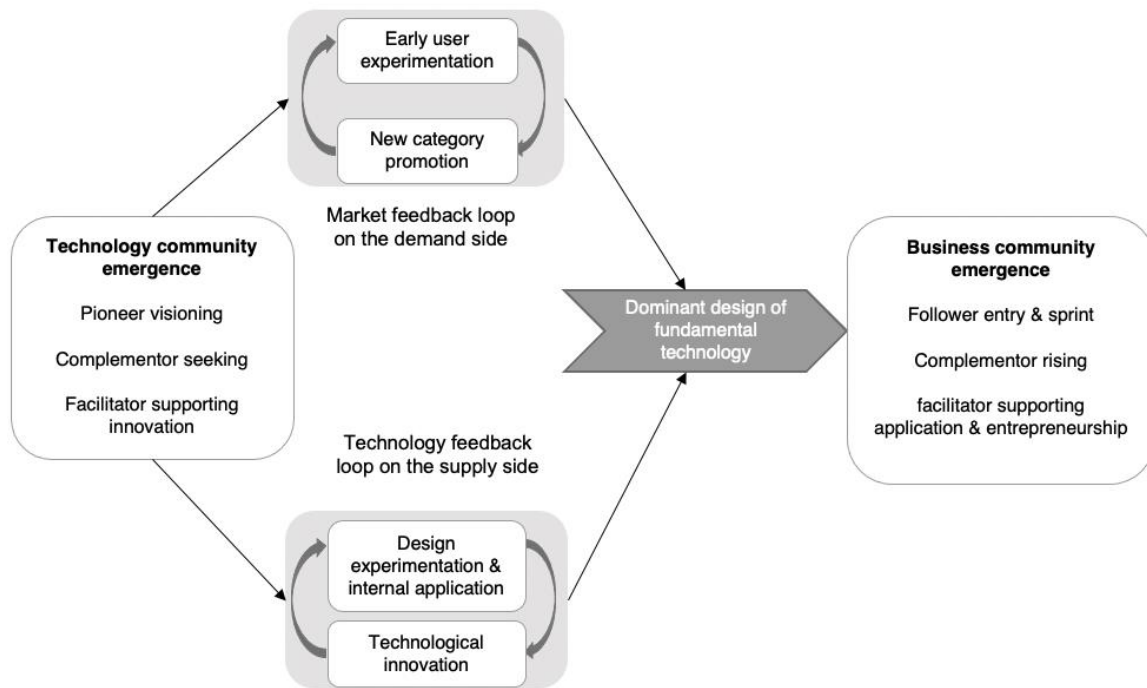


Figure 5.2 Transition mechanism from stage 1 to stage 2

Through the efforts of the pioneers, and the interaction between design experimentation, internal application, and technological innovation, the dominant design of fundamental technology emerges. The 5k challenge of Alibaba Cloud shows vividly how a design dominates internally. As a senior manager of Alibaba Cloud described in our interview,

To solve our IT challenges brought by the dramatic increase of orders happening on Taobao, we had two teams following two routes to finish the 5k task, using open community platform or building our own fundamental system. We were uncertain about the result, and, finally, the later one won.
(Q5.2.1)

The self-developed Apsara platform completed the 5k challenge and became the internal dominant design for Alibaba Cloud. Although Tencent and Huawei chose the open community platform Openstack as their internal dominant system, these platforms have a common design of fundamental technology – the cloud computing operating system – which represents the dominant design of fundamental technology in the cloud computing industry.

A dominant design results from “the experiments, technical possibilities, choices and proprietary positions of its day”, and will result in “a profound impact on both the direction of further technical advance, on the rate of that advance, and on the structure of competition” (Utterback and Suárez, 1993, p. 2). The internal dominance of the fundamental technology design also means that the company’s internal technology capabilities are mature enough to enable application for potential use. This transition as a crucial technological breakthrough leads to more confidence in the feasible future of the emerging industry and the entry of followers to explore the business opportunities, therefore paving the way for commercialisation explorations and the appearance of the emerging industry’s business community.

5.2.2 Dominance of technology design on the supply side

The emergence of dominant application technology designs, which also means the dominance of complete technology design on the supply side, marks the industry transition from the exploration stage to the formation stage (see Figure 5.3).

The three layers of architecture, IaaS, PaaS, and SaaS, became the dominant cloud computing design, especially in terms of application technology and architecture. A cloud computing expert I interviewed commented about the architecture of cloud computing and its use in smart city,

IaaS is for networking and storage to replace servers and provide unlimited storage space for millions of users to share and store enormous data; PaaS is

like a virtual operating system with a lot of development tools you can access to develop software, which is SaaS. For example, the Hangzhou city brain is a typical PaaS; there are various [types of] software based on that covering many aspects of city life and functioning to make the place a better place to live through digital transformation. (Q5.2.2)

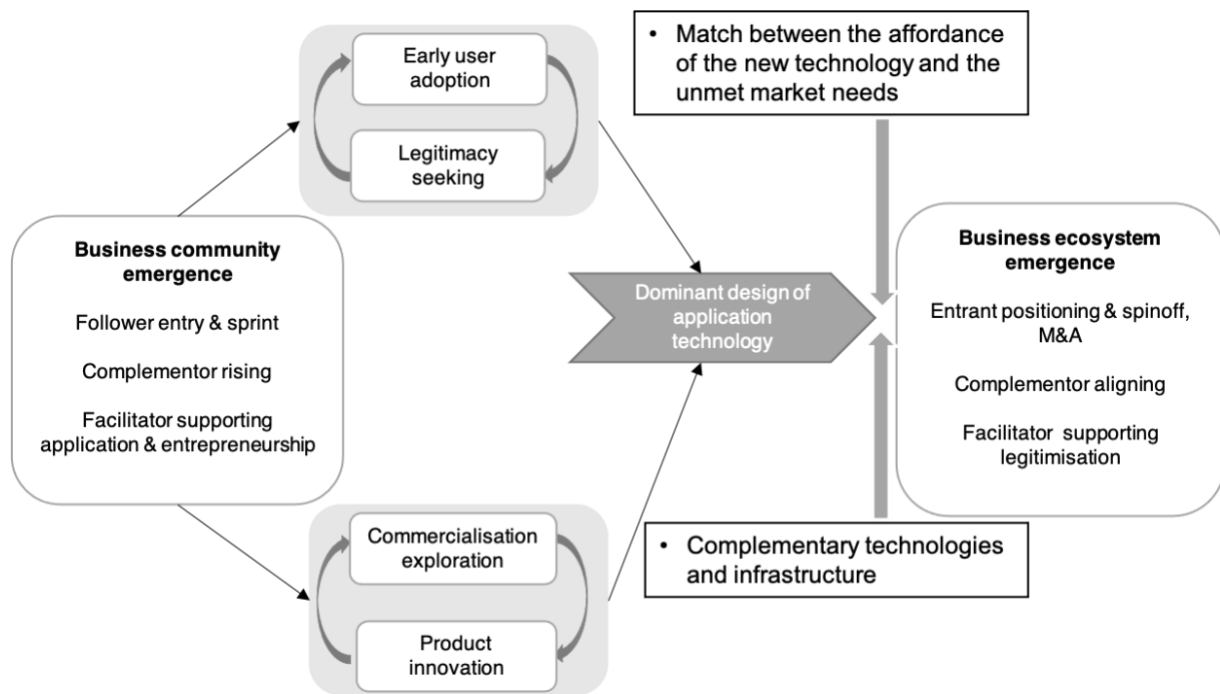


Figure 5.3 Transition mechanism from stage 2 to stage 3

The increasing number of entrants leads to more commercialisation explorations and attempts; with the rise of complementors in the business community, new products/services based on the emerging technology appeared. As a software engineer in the early Alibaba Cloud team expressed, “*We have many whimsical and failed trials; you can't imagine our most successful product ECS came from a program one of our colleagues did at home.*” Through the exploration by entrants in different scenarios they were familiar with and rounds of trial and error, this stage has seen successful product innovations in a diversity of application scenarios, such as the cloud-based 12306 booking website backed by Alibaba Cloud, which has experience in e-commerce website maintenance, the cloud-based Douyu live-streaming gaming platform backed by Tencent, which has a games business itself. Although in different forms and scenarios, the

dominant application technology design and the overall architecture became the consensus in the emerging industry.

The appearance of a dominant technology design sheds light on the alignment of value creation and the structure of ecosystem and industry, and leads to the business ecosystem formation with entrant positioning and complementor aligning in the next stage of formation. However, it should be highlighted that, to achieve this transition, there are two other requirements and conditions; otherwise, the commercialisation cannot succeed and the industry cannot emerge. First, there must be unmet market needs with mass growth potential (Agarwal et al., 2017; Phaal et al., 2011), and the unmet needs must match the affordance of the new technology. Second, there must be complementary technologies and infrastructure. For example, the application of cloud computing in live streaming is possible because the stability of the server bandwidth side of cloud computing satisfies the requirement of live streaming in a high-quality live broadcast experience. Meanwhile, the emergence of 5G technology and the construction of 5G infrastructure are also necessary conditions. The application of cloud computing in a smart city also verifies this rule. A senior manager of DT Dream provided the following explanation about the emergence of smart city-related cloud business,

For one thing, the local government wanted to improve their governance and administration performance, [they] especially [needed] some exemplary projects to promote for widespread use. And there were some pain points in people's livelihood, such as the red tape, or the traffic jam. Based on the popular public-private partnership scheme in [today's] governance, driven by the pain points, the unmet needs in city governance and our technology capability intersected. Like our e-government project made it possible for citizens and firms to deal with anything with at most one visit to the government because most of the data and paperwork were transferred online with the aid of cloud computing technology, our Hangzhou city brain

improved the efficiency of the red-green light system and the overall traffic via storing data on the cloud and analysing the big data. (Q5.2.3)

5.2.3 Dominance of business model design in the leading market

From the formation stage (stage 3) to the expansion stage (stage 4), it is the appearance of a dominant business model design in the leading market that leads to the transition (see Figure 5.4). The leading markets tend to be the close market because it is less difficult to apply the new technology. The common designs of offering and value creation are explored and confirmed by the practices in the leading market, but remain to be examined and adjusted in more market segments to reach a final and complete dominant business model design.

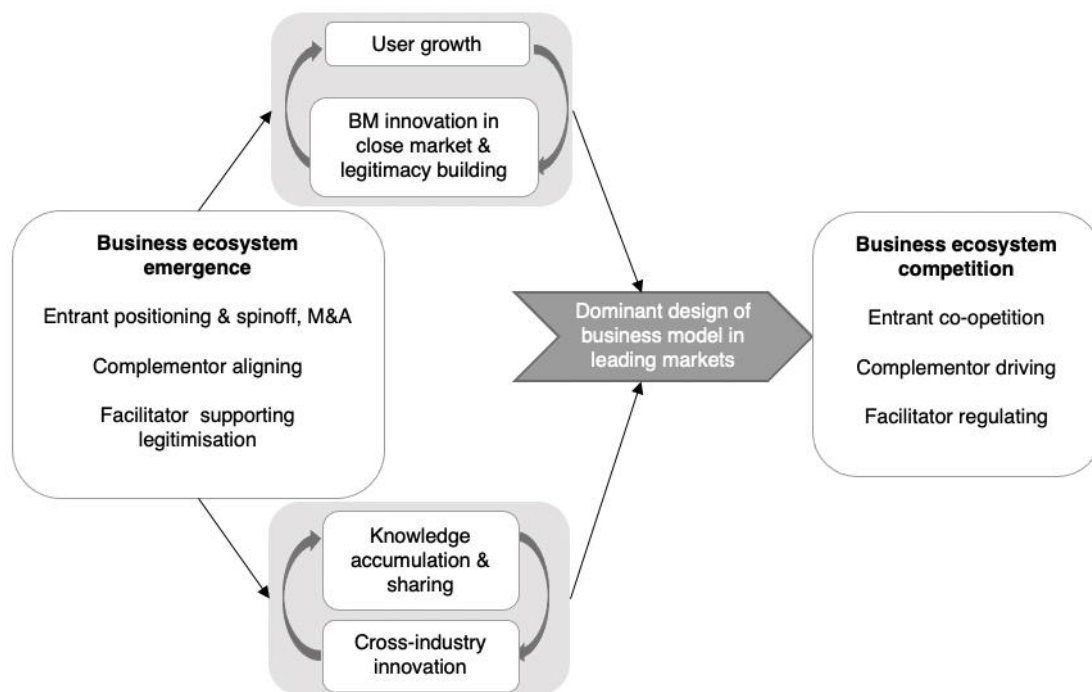


Figure 5.4 Transition mechanism from stage 3 to stage 4

After the spinoff from large vendors and M&A activities in the formation stage, the major business ecosystems with many start-up participants are equipped with complementary assets and knowledge to facilitate cross-industry innovations and commercialise cloud

services on a big scale in leading markets. Other than knowledge accumulation and sharing, business model innovation is also important for launching and expanding the cloud business. As was illustrated in a description of the cloud business unit in Huawei's 2017 annual report (Huawei, 2017, p. 20), the dominant business model in the early or leading market is providing cloud services as a solution for customers to enable their business success:

As industries grow more digital, providing cloud services will become a standard business model. The same goes for Huawei...In 2017, we formed a Cloud Business Unit as part of our commitment to strengthen our core cloud capabilities, create a cloud ecosystem, and become a leader in cloud services for key focus industries. As part of these efforts, we are forging cloud service alliances with carriers around the world to make our mark in the global cloud service market. Moving forward, we will continue promoting evolution towards All-Cloud ICT infrastructure, and maintaining technological leadership with open hybrid cloud architecture and our 'connectivity + cloud' platform that harnesses greater synergy between networks and the cloud.
(Q5.2.4)

According to the extant literature, the emergence of a dominant design is not necessarily the result solely of its technical potential, but also of timing and other circumstances (Utterback and Suárez, 1993). As is explained above using this case, the two requirements of market needs and complementary technologies are also necessary to give rise to the leading market and the dominant design of the business model in it. More than the design of technology architecture, entrants need to wait for the timing of suitable market opportunities and design a viable business model.

The importance of a business model in industry emergence is explained by McDonald and Eisenhardt (2020):

Companies in a new market don't know what business model will actually make sense; most can't even answer the age-old questions "Who is the customer?" "What does the customer value?" and "How will we deliver that value at an appropriate cost? The uncertainty of new markets requires a different framework for strategic thinking. We call it parallel play. They learn about their markets and their customers—and about what is likely to work. Trying to differentiate too early can lead a company down a blind alley.

This case study identifies the importance of business model design, not only for individual firms as described above, but also for the emergence of a new industry concerning the key transitions. The “parallel play” by entrants and the selection mechanism of the market gradually bring the emerging industry to a dominant business model design (McDonald and Eisenhardt, 2020, 2019).

5.2.4 Emergence of comprehensive dominant designs and the new industry

The business ecosystem competition in the formation stage (stage 3) facilitates the emergence of the industry and the stabilisation of the industry's structure. Since the new products/services spread to more market segments and scenarios, the sales of the new industry take off, the value is delivered more efficiently with process innovations, and the dominant designs of a set of business models in more market segments appear (see Figure 5.5), which also means that the new fundamental technology transits from a “general-purpose technology” to “applied, specialized, commercially mature technologies” (Gambardella and McGahan, 2010, p. 263).

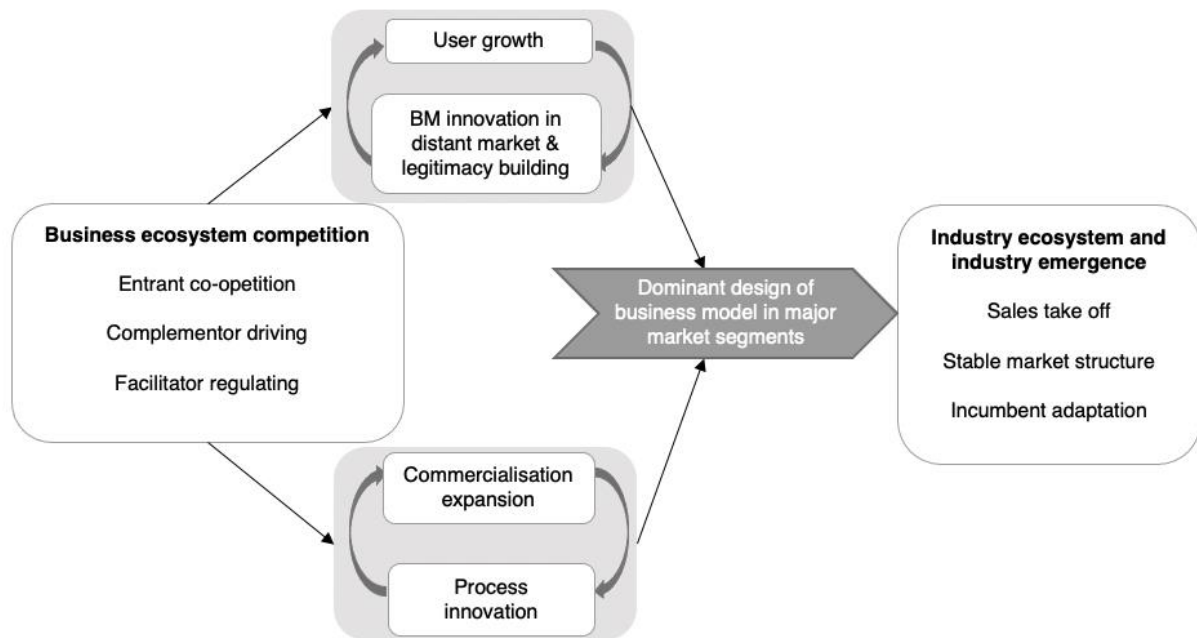


Figure 5.5 Transition mechanism from stage 4 to emergence

By comparing the chronology with the literature, I identified the year of 2020 as the emergence year of the cloud computing industry in China. As summarised in the literature review, there are three indicators for industry emergence, as detailed below.

First, the emergence of a dominant design is a milestone in the industrial emergence process. As a new industry emerges, the standards of this industry are gradually inaugurated and adapted. A dominant design embodies the beliefs about a product as it standardises several key features of product technology (Frenken, 2006). This can be a new technology, product or a set of key features incorporated from different distinct technological innovations introduced independently in prior product variants. And this study based on digital industries added a new element, business model, into the dominant design conceptualisation. The emergence of a dominant design is the result of a fortunate combination of technological, economic, and organisational factors and has a strong and significant effect on firms' survival (Suárez and Utterback, 1995).

At stage 4 ending in 2020, most of the case companies had developed a comprehensive portfolio of cloud services, covering IaaS, PaaS, and SaaS, which is the technology

dominant design. And a dominant offering and pricing system model was established. Alibaba Cloud, Huawei Cloud, and Tencent Cloud all provided a suite of on-demand digital solutions in the forms of public cloud, private cloud, or hybrid cloud, which made up the dominant design of the business model in the cloud computing industry. The breakthrough in this stage is to apply cloud computing to widespread sectors with mass adoption, and establish a set of dominant business model designs that can be commonly used in every scenario is established. This is illustrated and evidenced in their annual reports:

Products that differentiate Alibaba Cloud from our domestic peers include proprietary security and middleware products, large scale computing services and analytic capabilities supported by our big data analytics platform. These products not only enable customers to quickly build IT infrastructure services on-line without on-premises work, but also equip them with leading big data analytics capabilities, providing deep data insights by efficiently handling the complex computing tasks of hundreds of millions of data dimensions (Alibaba Group, 2018, p. 78). (Q5.2.5)

The Company is accumulating and solidifying its experience in the ToB business, it does so by analyzing trends in different industries and changes in user needs. The Company has started to increase its foot prints in ToB business and is providing supports to the companies in their digitalisation initiatives via Cloud and AI solutions. This has been applied across many industries including finance, education, etc. The Company is continuously developing its ToB business, and keeps optimising its management over business structure, human resources, management policies and business processes to ensure the effective operation of the ToB business for rapid and sustained development (Tencent, 2019, p. 89). (Q5.2.6)

Huawei is innovating at every level of the cloud technology stack, and delivers public cloud services and hybrid cloud solutions that stand out for their excellent value, availability, and data security. Huawei itself focuses on platform services and capabilities. Through AI enablement, data enablement, and application enablement, Huawei speeds up innovation in industries and simplifies application development. With ecosystem partners, Huawei aims to drive digital transformation and intelligent upgrade in all industries (Huawei, 2020, p. 15). (Q5.2.7)

McDonald and Eisenhardt (2019) suggest that the business model concept should include and capture the interpretations of the key elements of value proposition, activity system, and related revenue model. As is illustrated in my cases, the dominant business design also includes three elements: (1) the value creation design (i.e., the offering); in the case of the cloud computing industry, the design is providing cloud services as a solution); (2) the value delivery design (i.e., service system and delivery); in this case, cloud vendors in an ecosystem provide a suite of cloud services collectively, and for the different needs in data storage, in three deployment forms, public cloud, private cloud, and hybrid cloud; (3) the value capture design (i.e., pricing model and structure): in this case, cloud vendors dominantly adopt a hybrid pricing strategy based on the spot-price for on-demand services and subscription fees for software so that the ecosystem members can get their respective revenues – IaaS and PaaS vendors get the on-demand service revenue, and SaaS vendors get the software subscription fees – and the users can pay per use (Huang et al., 2015).

Second, changes in sales reflected the pace of industry emergence and evolution. Anderson and Tushman (1990) find that sales always peak after a dominant design emerges. Commercialisation and market take-off are critical milestones in the evolution of an industry. Sales take-off means the new product has reached the expansion stage from the introductory stage (Golder and Tellis, 1997). Sales in new markets are initially low because the first commercialised forms of new innovations are primitive. Then, as

new firms enter, actual and perceived product quality improve (and prices may drop), which leads to the take-off in sales. New firm entry is the dominant factor in sales take-off (Agarwal and Bayus, 2002). According to CAICT, the cloud computing market size reached 200 billion yuan in 2020, and the proportion of enterprises that had applied cloud computing in China reached 66.1% in 2019, an increase of 7.5% compared with 58.6% in 2018 (CAICT, 2021). The sales of the cloud computing industry took off in 2019 and the growth rate of sales reached a peak in 2020.

Third, the index of industry concentration serves as an indicator of industry emergence. Deans et al. (2002) developed an industry consolidation cycle including four stages: opening, scale, focus, balance, and alliance. The number of firms in an industry – the industry's density – will also be directly affected by the emergence of a dominant design (Suarez and Utterback, 1995). In the fourth stage, a stable market structure gradually formed with Alibaba Cloud, Huawei Cloud, and Tencent Cloud ranking in the top three positions and occupying over 60% of the market share together (CAICT, 2021).

Last but not least, the extent to which the traditional industry is replaced is another indicator. The dominance of the cloud IT environment over the traditional non-cloud one since 2020 indicates the emergence of the cloud computing industry. In the second quarter of 2020, the global cloud IT infrastructure reached \$14.5 billion with mass adoption, accounting for 55.13%, which means the cloud expenditure surpassed the traditional IT infrastructure for the first time. This is an important turning point and a milestone in the development of cloud computing that indicates that the balance between cloud computing and traditional IT infrastructure has tilted, and the world is accelerating into the cloud era (IDC, 2020). For example, in the finance sector, the adoption and maturity of cloud computing are evidenced by the description in Hundson's annual report,

Cloud computing, as an infrastructure of financial technology application, has entered a mature stage of development. Compared with some 'clouded' functions or transactions, the more critical core system functions of financial

institutions have been gradually deployed on the financial cloud...In the future, the Company will make continuous investment in cloud native architecture (Hundson, 2020, p. 25). (Q5.2.8)

5.3 Summary: A comprehensive process model of industry emergence

For each phase, three dimensions of the evolution were examined in depth: the technology dimension from the perspective of the supply side, the ecosystem dimension from the perspective of actor and activity, and the market dimension from the perspective of the demand side.

The three dimensions appeared as I classified events and codes, and were also supported by the literature as the key dimensions of industry emergence (Moeen et al., 2020). When analysing each dimension, I focused on and labelled the common activities pursued by different actors and key tasks completed in each phase concerning this dimension, and searched the literature on this dimension to refine the labels as concepts (Denis et al., 1996). A comprehensive process model of industry emergence has been developed based on the process study with an emphasis on dominant design dynamics and interaction between the three dimensions, as is shown in Figure 5.6. The conceptual activities and tasks noted in each dimension help to understand and explain the industry emergence process from the perspectives of technology commercialisation, ecosystem emergence, and market emergence.

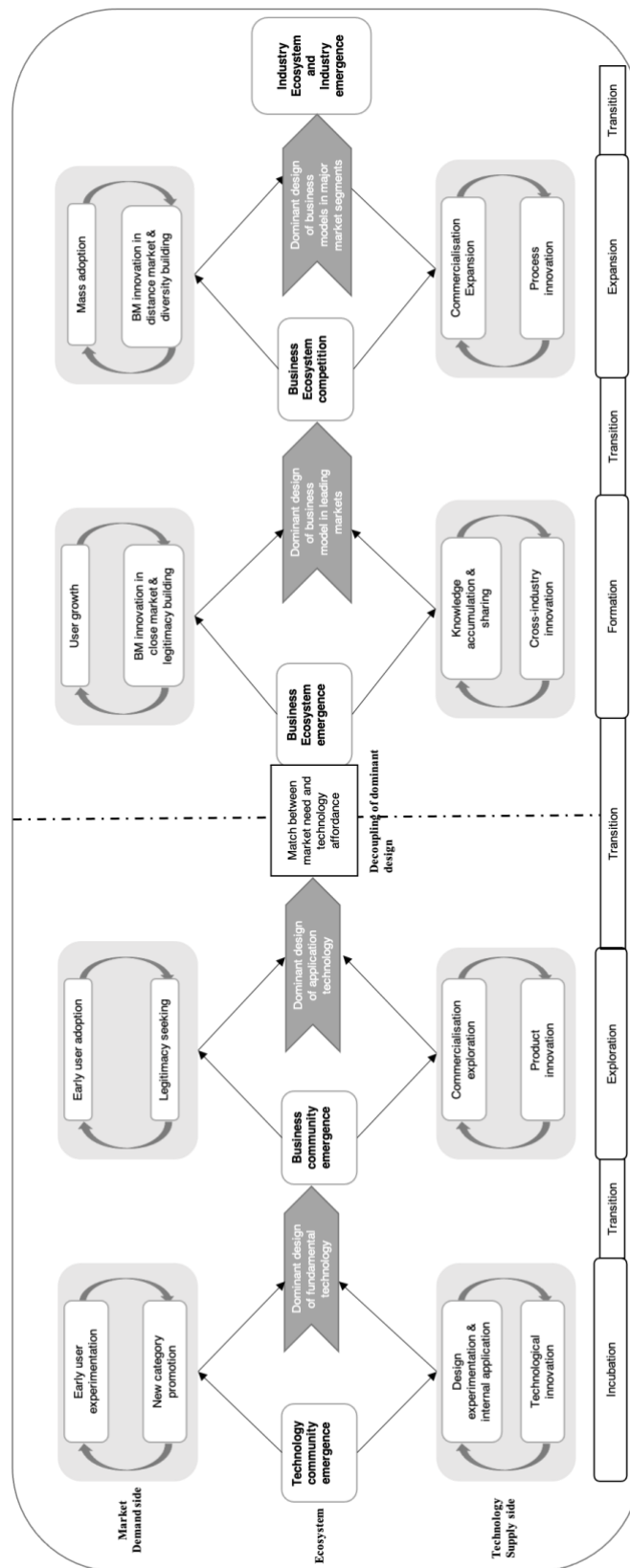


Figure 5.6 Process model of industry emergence

From the ecosystem level with a focus on actor and activity, the process model shows that the industry is nurtured from technology communities. Driven by the commercial aim, the technology communities evolve into business communities, and then into business ecosystems. Finally, the interactions between business ecosystems give rise to the formation and emergence of the industry. From the incubation stage to the expansion stage, the number of companies increases from a small number to a large number. After the exploration stage with active new venture entry and investments, the number of entry firms declines, and a number of companies are eliminated in the competition or fail in commercialisation. The remaining companies that survive find their own positions in the industry structure and several major business ecosystems are established, such as the cloud ecosystem of Alibaba, Tencent, and Huawei. The government and intermediaries play an incubating role in the early stage, helping to provide resources and application scenarios, and large companies play a main role in shaping the industry in the later stage.

From the perspective of technology and the aspect of the supply side, industry emergence involves a process from exploration and design dominance of fundamental technology to application technology, from the co-existence of various designs to the mainstream and dominant designs. At the early stage, the knowledge accumulation and technological innovation of cloud computing are the focus; however, as the application and commercialisation proceed, the exchange and accumulation of market knowledge – know-how of the applied industry – and cross-industry innovation become increasingly important.

From the market level and demand side aspect, the application scenarios start from internal needs in the early markets with a close knowledge distance and then spread to the other, distant, markets. From the perspective of legitimation building and sensemaking, the close markets are also easier to enter. And the user base grows continuously from internal users and early users, to mainstream users in the leading market, and then to larger users in more markets. The value proposition provided and the needs met evolve from simple to complex and diversified.

The interactions between the three levels and the mechanisms of how transitions between stages happen are also illustrated in Figure 5.6. The transitions and the emergences of community, ecosystem, and the final industry are realised through the continuous interactions between the three levels. First, the exploration and interaction of ecosystem members lead to the emergence of different designs and the establishment of dominant designs, as well as user growth and legitimacy building. Second, the experiments and progress in the technology level lead to the diversity of products and services in the market and the satisfaction of more market demands, as well as triggering the changes in the number and survival of entry firms, and the reactions and initiatives of communities or ecosystems. Third, the feedback of market demand helps the exploration and dominance of technology design, and the new resources and knowledge accumulated from commercialisation in the respective markets are embedded in the business ecosystem, thus enabling the evolution of ecosystems and the industry.

The pattern of industry emergence process is visualised in Figure 5.6, and summarised as follows.

The four stages of industry emergence have different patterns and foci:

- 1) incubation stage is characterised by pioneer-leading R&D and internal application,
- 2) exploration stage is characterised by follower entry and commercialisation exploration,
- 3) formation stage is characterised by commercialisation and ecosystem formation,
- 4) expansion stage characterised by mass adoption and ecosystem competition.

Underlying ecosystems co-evolve with and support an emerging industry:

- 1) during the incubation stage, the pioneers develop and envision technology communities;
- 2) during the exploration stage, business communities are formed with the entrance of more firms, especially complementors, and support from policy and investors;

- 3) during the formation stage, business ecosystems are formed when the entrants find their position in the ecosystem and complementors are aligned,
- 4) during expansion stage, business ecosystems compete and form the industry ecosystem.

As visualised in Figure 5.6, the transitions between stages are marked by dominant design dynamics, which are facilitated by the interactions between technology, ecosystem, and market:

- 1) technological experiments and applications during the incubation stage lead to the emergence of the dominant design of fundamental technology, which leads to the exploration stage by paving the way for follower entry and commercialisation exploration;
- 2) early user adoption and successful commercialisations during exploration lead to the emergence of the dominant design of application technology, which leads to the formation stage by enabling new value propositions;
- 3) the cross-industry innovations and business model innovations in close markets during the formation stage lead to the emergence of the dominant business model design in close markets, which leads to the expansion stage by preparing for expansion to more markets;
- 4) the mass adoption and diversity building during the expansion stage lead to the emergence of dominant business model designs in various markets, which leads to the integrity of the industry ecosystem.

Chapter 6 INDUSTRY ECOSYSTEM: ACTORS AND ACTIVITIES

As the pioneer of business ecosystem research, Moore (1993) introduced the ecosystem concept to replace the industry concept since business activities nowadays frequently happen across industries. Teece (2007, p. 1325) also noted the necessity of “utilizing the ecosystem as the organizing paradigm for assessing developments in the business environment”, because “the very concept of an industry is itself of questionable value, “for instance, the telecommunications ‘industry’ may have had distinct boundaries over half a century ago around the telegraph and the telephone and associated regulated services”.

In this digital era, the fluid and blurred boundaries between industries – for example, it is hard to separate cloud computing industry and big data industry – make it more important for management research to adopt new units of analysis. Not only are firm boundaries crossed in the context of distributed innovation and value co-creation, but also industrial boundaries are crossed to create the new complex value proposition in emerging industries. In addition to the business ecosystem for a focal firm, we also need the concept of an industry ecosystem in order to analyse the emergence and evolution of a new industry. As is noted by Autio and Thomas (2013), beyond the traditional value chain of suppliers and distributors, an ecosystem also includes other actors such as outsourcing companies, financial institutions, technology providers, competitors, customers, and regulatory and coordinating bodies. Different to the limited scope and focus on the competition relationship of the industry concept, the industry ecosystem also considers the actors and resources involved in this emerging industry but coming from other related industries, and the maturity of an industry ecosystem also represents the emergence of a new industry. An industry ecosystem develops based on the co-evolutions between business ecosystems and interactions through innovation ecosystems.

As is reviewed in Chapter 2, most of the existing industry emergence research is from a process perspective or firm level, lacking a systematic, organisational, and structural perspective to capture the transaction mechanisms and dynamics of how a new industry

is organised. In addition to the process model of industry emergence highlighting transition mechanisms in Chapter 5, in this chapter, I develop the industry ecosystem model to explain the dynamics of industry emergence from an ecosystem perspective. By conceptualising and modelling the industry ecosystem, I integrate the multifaceted findings of this research and expatiate on how the underlying ecosystems enable industry emergence. From an activity perspective, section 6.1 focuses on activities and interactions between organisations and the ecosystem, and thus the structural components of the industry ecosystem. From an actor perspective, section 6.2 focuses on actors and roles in the industry ecosystem.

6.1 Industry Ecosystem Model from an Activity Perspective

By integrating different streams of ecosystem research and distilling from the research findings, I develop the multi-level ecosystem model – see Figure 6.1 – that examines the configuration and interaction between different-level ecosystems that explains the underlying mechanism of industry emergence from an ecosystem perspective.

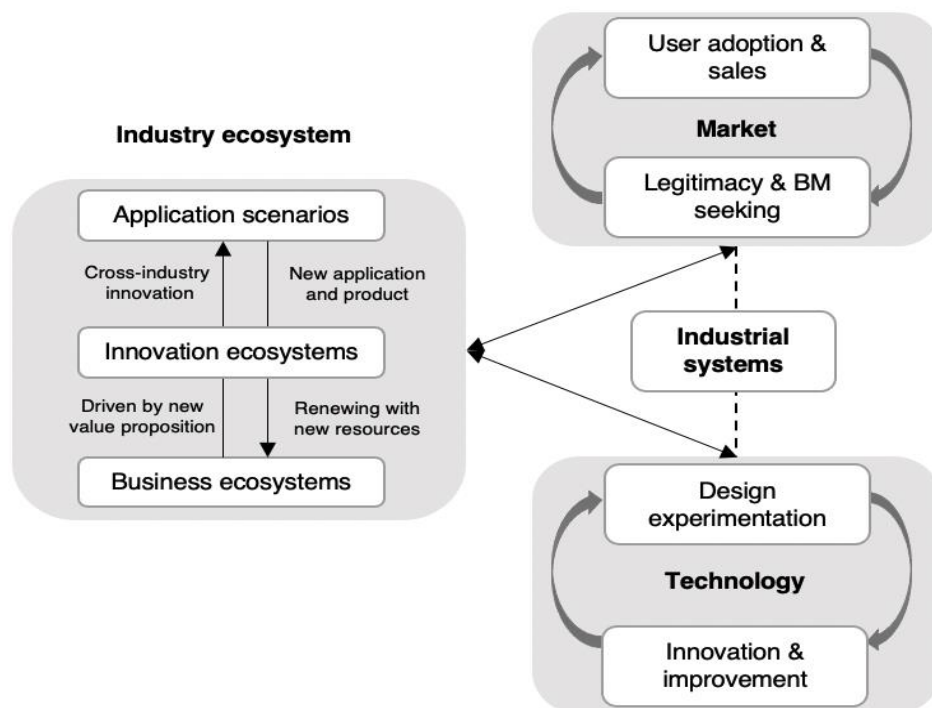


Figure 6.1 Industry ecosystem model from an activity perspective

6.1.1 From business ecosystem, innovation ecosystem to industry ecosystem

Multiple ecosystems can exist and compete within a given product market (Teece, 2018). The left part of Figure 6.1 shows the industry ecosystem structure in which a group of business ecosystems provide a basis and innovation systems driven by various new value propositions that serve as the channel between business ecosystems and application scenarios in the markets.

Business ecosystems are established and governed by large companies in the emerging industry. As is defined by Teece (2012, p. 105), “a business ecosystem is typically created by an innovator choosing which elements of the value chain must be internalised, and deciding what needs to be supported externally, in order to provide it the best opportunity for capturing value”. The two key characteristics of a business ecosystem are co-evolution, in which the ecosystem members become more closely complementary, and co-creation, in which the organisations in the business ecosystem combine forces to pioneer new markets. The business ecosystems – for example, Alibaba cloud ecosystem, Tencent cloud ecosystem, and Huawei cloud ecosystem in the emerging cloud industry – compete and interact with each other, and gradually find their own positioning and specialisation. This constitutes the foundation of industry ecosystem.

When exploring a new application scenario and opening up a new market, it is necessary to form an innovation ecosystem with this focal innovation as the core in conjunction with partners in the targeted market to gain the industry know-how about the new application scenario. The paradigm and importance of collaborative and cross-industry innovation are illustrated by Q4.2.2, Q4.2.5, Q4.3.5, Q4.3.6, Q4.3.11, Q5.1.2. Industry know-how as complementary knowledge is crucial for cross-industry innovation, which is the key to new product/service development for a new market. This innovation ecosystem is dynamic and may include members from different business ecosystems to deliver a new value proposition and form a new industrial system for this newly opened market. The

successful application and product/service innovation will in turn feed back to the underlying business ecosystems with new resources, knowledge, and capabilities accumulated, which will strengthen the organisational basis and resource pool of the industry ecosystem.

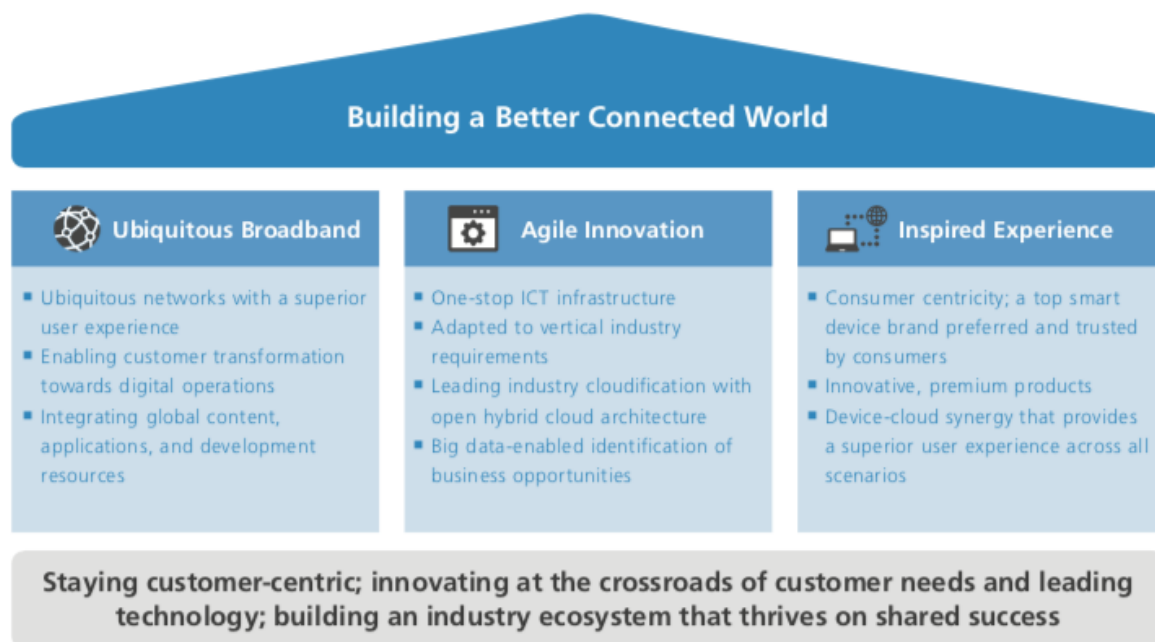


Figure 6.2 Huawei business vision (Huawei, 2016)

Although they have not been widely discussed in management scholarship yet, “industry ecosystem” and “application scenario” have become hot topics among practitioners. In my data analysis, “industry ecosystem” and “application scenario” are mentioned and emphasised frequently and simultaneously in interviews, annual reports, internal reports, and public news reports about many cloud computing companies and related organisations. For example, Huawei (2016, p.17) used Figure 6.2 to depict their “value propositions”, highlighting “building an industry ecosystem that thrives on shared success” and building “device-cloud synergy that provides a superior user experience across all scenarios”. Based on data analysis, this research conceptualises the “industry ecosystem” and elaborates its structure by linking “application scenario”, “business ecosystem”, and “innovation ecosystem”. This industry ecosystem model contributes to

ecosystem research by filling in the gap in knowledge about industry-level ecosystem and resolving the disagreements and inconsistencies of different ecosystem streams with the integration of multi-level ecosystems.

6.1.2 The generic ecosystem mechanism for transitions in industry emergence

As is shown in Figure 6.1, the industry ecosystem, as a whole, interacts with the market and technology sides, which represents the generic ecosystem mechanism for transitions in industry emergence. The industrial systems linking technology and market represent the input-output system of production/service delivery. The emergence of a new industry is the result of the co-evolution of organisations and business ecosystems involved in the business environment.

Each transition in the emergence process of a new industry is also a bottleneck for both the overall industry ecosystem and the business ecosystems of enterprises. To resolve the ecosystem bottleneck, cross-industry innovation and sub-industrial systems – the materialisation of product innovation and new product development – are created by forming a corresponding innovation ecosystem to realise the innovations. In the continuous formation of new markets and the development of new industrial systems, knowledge and experience are accumulated and embedded in the underlying industry ecosystem. With the maturity of business ecosystems and the integrity of industrial systems – through the accumulation of sub-industrial systems and driven by the diversity building of products and services – the industry ecosystem gradually becomes rich and mature, thus leading to the emergence of a new industry.

These large companies and their ecosystem members promote product innovation, service innovation, and business model innovation through exploration, trial and error, and interaction, forming a suite of sub-industrial systems of specific products and services. Through enriching sub-industrial systems covering IaaS, PaaS, and SaaS, the final

industrial system of cloud computing is formed. As an emerging economy, China has created an outstanding cloud computing industry. The key lies in the formation of a cloud industry ecosystem, in which Internet companies as shapers play a leading role. The establishment of their own cloud ecosystems provides the foundation for the industry ecosystem and industry emergence. The relationship between the offerings, their enabling industrial systems/chains, and the industry ecosystem is illustrated by Huawei (2014, p. 3) as follows:

Each of these offerings will help our customers build a technological foundation for their business innovation in the cloud era. We are committed to establishing an open and innovative industry ecosystem amid ICT convergence to integrate value across the industry chain. (Q6.1.1)

Different from the manufacturing industry based on standardised products, the application of services of cloud computing and other IT industries in this digital era requires a new service design and a new sub-industrial system for delivering value for customers in a new market. The continuous exploration and development of new service processes, business models, and value alignment when opening up new markets gradually foster an industry ecosystem. As Lubik and Garnsey (2016, p. 394) highlight, the entrants in an emerging industry “must experiment with the often large number of markets where their technologies could be applied to find where they can create the most value”.

As shown in Figure 6.1, the bidirectional arrows indicate that industry ecosystem is comprised of the recursive cycles and feedback loops in ecosystems, with rounds of explorations and experiments, and trial and error. The industry ecosystem as a whole co-evolves and interacts with the feedback loops of technology and market. The co-evolution leads to the establishment of industrial systems, whose maturity and integrity lead to the emergence of a new industry.

6.2 The Roles in an Industry Ecosystem

By coding the interview and secondary data and comparing it with literature, three kinds of roles in the industry ecosystem are identified: ecosystem shaper, ecosystem complementor, and ecosystem facilitator. Following the Gioia method (Gioia et al., 2013), the data structure can be seen in Figure 6.3.

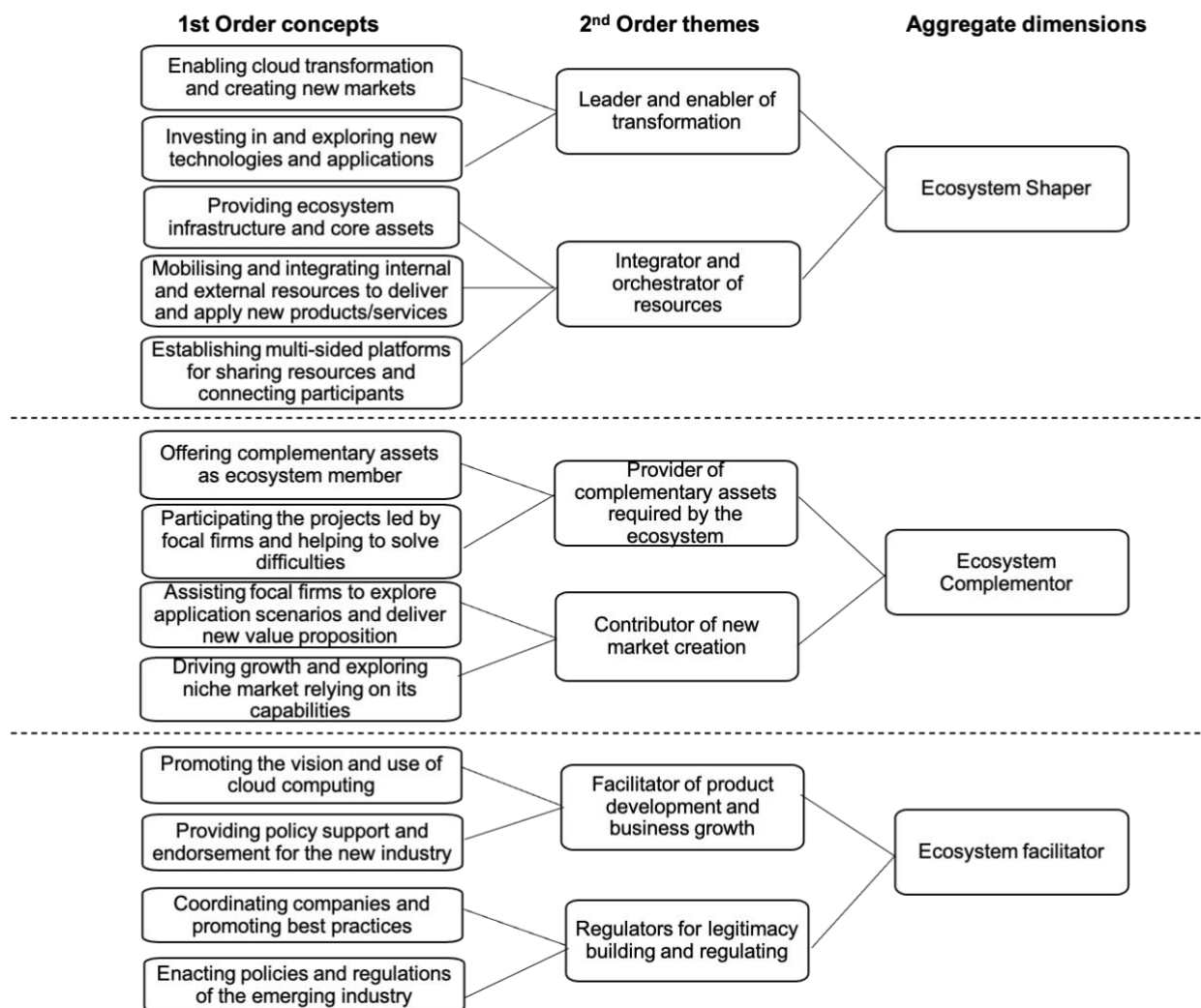


Figure 6.3 Data structure

Actors may play slightly different roles at different stages (e.g., see Q4.3.6, Q4.3.7, Q5.1.2), and the importance and impact of a role may also vary from stage to stage, as is shown in Table 6.3. Overall, ecosystem shapers – typically the large firms owning key capabilities,

big market shares, and business ecosystems – play the most crucial role in the emergence of a new industry. Specifically, the facilitators such as technology associations, NGOs, and the government play an important role at the early stage because of the lack of commercial drivers and market mechanisms; the shaper plays the major role in the exploration and formation stage to enable commercialisation and production; and the complementors play a driving role in the expansion stage by exploring new market segments. It is the orchestrator, complementors, users, and external actors together that drive ecosystem legitimacy (Thomas and Ritala, 2021).

Table 6.1 Industry ecosystem from an actor perspective

Stages Tasks	Incubation	Exploration	Formation	Expansion
Shaper	Shapers make strategies for the emerging industry and start R&D; leading companies apply the new design into practice to improve its design and capabilities through trial and error.	Shapers update their strategies and prioritise commercialisation; develop and promote their brands and best practices with leading users to attract more users; create and establish their ecosystems.	Shapers compete with each other for the big new market and in a race to develop the most competitive ecosystem by M&A or investment projects.	Shapers promote the new products and services to more areas with the abundant resources from their ecosystem.
Complementor	Complementors rise with start-ups joining the new market by developing new applications based on the new technologies.	Complementors are incubated with the spin-off from the large companies and supportive policies.	Complementors are aligned for value creation in ecosystems. Some start-ups are acquired by large companies, some grow rapidly within the ecosystems.	Complementors promote the new products and services to more organisations in more sectors and regions.

Facilitator	Facilitators including research institutes, technology associations, consulting companies, and policymakers accelerate the application of the new technology. Governments support the application of new technology by providing funding, policies and opportunities for applications.	Facilitators stimulate entrepreneurship and product innovations. PE/CV invested in new ventures. Governments enact supportive policies for the adoption of new products and the new venture creation.	Facilitators help the formation of ecosystems. Financial institutes support M&A and spinoff start-ups. Governments enact supportive policies for the widespread adoption and legitimisation of the new products.	Facilitators ensure the healthy growth of the emerging industry. Industry associations promote legitimacy, diversity and standards making. Governments enact regulations and improve governance.
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6.2.1 Ecosystem shapers

Ecosystem shapers lead and influence the emergence and evolution of an emerging industry by allying with other enterprising actors and shaping the technological and commercial trajectory and design dominance through the power and impact of business ecosystems. Santos and Eisenhardt (2009) found that firms proactively shape nascent markets through market-demarcating alliances with prominent firms and acquisition of potential competitors. Similarly, Ozcan and Eisenhardt (2009) showed that new ventures can shape the architecture of a nascent market by establishing early alliances with prominent firms that have not yet entered the market. My findings echo this shift in strategic management from strategising based on the industry environment to shaping the industry.

As shown in Figure 6.3 and Table 6.2, the data analysis suggests that a group of large companies recognise themselves and are also described by other actors as the leader and enablers of the digital transformation towards cloud computing. This case study shows

how the key enterprising actors lead to and shape industry emergence. The details of the tasks and functions of ecosystem shapers during each stage can be seen in Table 6.1.

Table 6.2 Representative quotes about ecosystem shapers

First-order concepts	Quotes
Enabling cloud transformation and creating new markets	Q4.1.7, Q4.1.14, Q4.2.6, Q4.2.8, Q4.2.9, Q4.3.3, Q4.3.4,
Investing in and exploring new technologies and applications	Q4.1.6, Q4.1.11, Q4.1.15, Q4.2.3, Q4.2.7, Q4.3.1, Q5.1.5, Q5.2.1
Providing ecosystem infrastructure and core assets	Q4.1.9, Q4.1.12, Q4.2.13, Q4.3.10, Q6.2.1, Q6.2.2, Q6.2.3
Mobilising and integrating internal and external resources to deliver and apply new products/services	Q4.1.10, Q4.1.13, Q4.2.10, Q4.3.2, Q4.3.8, Q5.2.4, Q6.2.4
Establishing multi-sided platforms for sharing resources and connecting participants	Q4.1.1, Q4.2.4, Q4.3.7, Q5.1.8

In the emerging cloud computing industry, my data analysis suggests that the three major IaaS vendors – Alibaba Cloud, Tencent Cloud, and Huawei Cloud – play the role of ecosystem shapers, as illustrated by the identity claims and strategic orientations from their annual reports.

We will continue to be an innovator in products and technology as well as an enabler of new business models... With cloud computing as an easily accessible and scalable service, and data as a value-enhancing resource, we believe that new technology will play a fundamental role in social and commercial interactions (Alibaba Group, 2019, p. 64). (Q6.2.1)

Tencent Cloud is the foundation for our smart industry solutions. We integrate our cloud computing technology with AI and data analytics capabilities, to assist the digital transformation of various industries. Our online security capabilities enhance the stability and reliability of our cloud solutions (Tencent, 2018, p. 7). (Q6.2.2)

As industries go digital, new business models and new entities, such as industry knowledge platforms, are emerging. Standards will play a different role in the digital economy. To adapt, we need to change our mindsets, and proactively anticipate and analyze future directions and patterns of industry development, as well as the shape of new ecosystem value chains, their key nodes, and the roles of different players (Huawei, 2021, p. 86). (Q6.2.3)

More than the direct contribution to the capability developments and commercial activities, they also shape the industry ecosystem by building their business ecosystems and leverage with their ecosystems. As the integrator of the business ecosystem resources, the shapers are able to influence the trajectory of technological and commercial actions and changes. For example, the venture capital department of Tencent acquired or invested in many SaaS start-ups to have a wider influence on the emerging cloud markets, as stated in the annual report.

In addition to growing our core businesses organically, we make strategic investments in best-in-class companies so we can focus our management attention and company resources on our own core platforms, while capturing emerging opportunities in adjacent verticals through investee companies (Tencent, 2018, p. 7). (Q6.2.4)

6.2.2 Core and peripheral ecosystem complementors

The ecosystem complementors include core complementors who provide complementary assets and knowledge for the core architecture of the product or service, concerning certain sections of the core industry system, and the peripheral complementors who provide complementary assets and knowledge for the specific application in certain application scenarios. For example, in this case of the cloud computing industry, DAS and Kingdee are core complementors, while DT Dream, CityDO, and Brand New Data are peripheral complementors. However, both core and peripheral

complementors are integral and unifying elements of the industry ecosystem. Autio and Thomas (2013, p. 208) argue that an ecosystem is “an evolving community that specialises in the development, discovery, delivery, and deployment of evolving applications that exploit a shared set of complementary technologies and skills”, which implies the evolving characteristics and complementarity nature of ecosystems.

As is depicted in Table 6.3 and Figure 6.3, ecosystem complementors provide complementary assets required by the ecosystem, and develop and share their complementary knowledge and capabilities.

Table 6.3 Representative quotes about ecosystem complementors

First-order concepts	Quotes
Offering complementary assets as ecosystem member	Q4.1.3, Q4.2.11, Q4.3.9, Q6.2.5
Participating the projects led by focal firms and helping to solve difficulties	Q4.1.8, Q4.2.12, Q5.1.12
Assisting focal firms to explore application scenarios and deliver new value proposition	Q4.2.2, Q4.2.5, Q4.3.5, Q4.3.6, Q4.3.11, Q5.1.2
Driving growth and expanding new markets relying on its capabilities	Q4.1.2, Q4.1.4, Q4.2.1, Q5.1.4, Q5.1.10, Q5.1.11, Q5.2.8

For one thing, complementors provide complementary assets required by the ecosystem. They help to solve difficulties and disagreements the hub firm faces when leading projects. The vice president of DAS described it as follows in their interview,

We are like the anti-virus software in the cloud era. Cloud computing is replacing server and physical computers, and we are replacing traditional anti-virus software. Of course, our clients are mostly enterprises instead of individual users, and we design customised cloud security services for our clients. For example, to provide a suite of cloud services, our division of labour is like, IaaS vendors like Alibaba cloud deal with the storage and computing without worrying about security because we are responsible for cloud

security services such as building and maintaining the WAF on the application level, which is our expertise. (Q6.2.5)

In the later stage of expansion, complementors drive the growth of the emerging industry by exploring new markets, such as the rural market, or niche markets with new application scenarios. To this end, complementors develop and update their complementary knowledge and capability, and share it with the hub firms. To explore new markets and materialise new value propositions, new knowledge such as the industry know-how of the targeted market is needed. It is the enormous complementors with various specialities that make the launching and growth of new markets possible.

6.2.3 Third-party facilitators

According to the data analysis shown in Table 6.4 and Figure 6.3, the facilitator – including governments, research institutes, technology associations, industry associations, NGOs, incubators, venture capitals, private equities, consulting companies, and other public, academic, or intermediary organisations – supports the capability and connectivity within the ecosystem (Boon and Edler, 2018). As third-party actors, these actors are not involved in the production or value delivery directly, but facilitate and foster the emergence of the new industry.

Table 6.4 Representative quotes about ecosystem facilitators

First-order concepts	Quotes
Promoting the vision and use of cloud computing	Q4.1.5, Q6.2.9
Providing policy support and endorsement for the new industry	Q5.1.3, Q6.2.6
Coordinating companies and promoting best practices	Q6.2.7, Q6.2.8
Enacting policies and regulations of the emerging industry	Q5.1.6, Q5.1.9

First of all, my findings suggest that, in industry emergence, the government as a facilitator plays an important role by enacting supporting policies, since “those policies use the entire array of demand-side measures to create an environment that reduces the uncertainty for buyers and for innovators, and allows for rapid economies of scale and scope” (Boon and Edler, 2018, p. 436). For example, an energy policy has various measures to create and foster markets for cutting-edge energy-efficient technologies, such as solar panels, LED lighting systems, or electric vehicles (Alkemade et al., 2011; Boon and Edler, 2018). In recent years, China’s central government has introduced a series of supporting policies for the development of the cloud computing industry, as listed in Table 6.5 (CAICT, 2021).

Table 6.5 Overview of cloud-related policies

Time	Policy and regulation
October 2010	The Development and Reform Commission and the Ministry of Industry and Information Technology jointly issued the "Notice on Executing the Pilot Project of Cloud Computing Service Innovation and Development", and assigned Beijing, Shanghai, Hangzhou, Shenzhen, and Wuxi as the pilot cities to carry out the exploration and demonstration work of cloud computing service innovation, and planned that, by October 2011, a 660-million fund for cloud computing would be allocated.
December 2011	The State Council of the People's Republic of China issued a guideline on accelerating the development of the high-tech service industry, including cloud computing as a key high-tech service industry.
September 2012	The central government introduced the "Plan for the Cloud Technology Development in China" that specified the development goal and supporting measures.
March 2013	The Ministry of Industry and Information Technology issued the "Top-Level Design Guide for E-Government Public Platforms Based on Cloud Computing" to guide the construction of e-government public platforms across the country and guide e-government to transform the development mode through the construction and application of e-government public platforms.
September 2013	The Ministry of Industry and Information Technology issued the "Top-Level Design Guide for E-Government Public Platforms Based on Cloud Computing" to guide the construction of e-government public platforms across the country and promote the digital transformation of administration and governance through the construction and application of e-government public platforms.

January 2015	The State Council issued the "Suggestions on Promoting the Innovative Development of Cloud Computing and Nurturing New Industry Ecosystem of Information Industry", and set the goal that, by 2020, cloud applications would be basically popularised, and the capabilities and key technologies would be equipped, and several leading companies with international competitiveness would have emerged.
May 2015	The Cyberspace Administration of China issued "Suggestions on Strengthening the Network Security Management of Cloud Computing Services in Party and Government Departments" to specify regulations about cyberspace security in cloud adoption.
July 2015	The State Council issued the "Suggestions and Guidelines on Promoting the 'Internet Plus' Action", and cloud computing was a strategic focus and digital infrastructure.
May 2016	The "National 13th Five-Year Plan" included the development of cloud computing and highlighted the promotion of a wide application of big data, cloud computing, and the Internet of Things.
August 2018	The Ministry of Industry and Information Technology issued the "Implementation Guide for Facilitating the Migration to Enterprise Cloud", to promote the digital and intelligent transformation of enterprises based on cloud computing, and promote the deep integration of the Internet, big data, artificial intelligence, and the real economy.
July 2019	The Ministry of Industry and Information Technology released the "Notice on the Security Assessment Methods of Cloud Computing Services" to regulate the healthy development of cloud services.
April 2020	The National Development and Reform Commission and the Cyberspace Administration of China jointly issued the "Implementation Plan for Promoting the Transformation to Cloud and the Application of Data and Intelligence to Cultivate New Economic Development", proposing to accelerate the R&D and application of common technologies and key technologies in digital transformation, and encourage qualified sectors and enterprises with suitable application scenarios to explore the application and integrative innovation of new generation digital technologies such as big data and cloud computing.
March 2021	the National People's Congress issued "the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Long-term Goals for 2035", highlighting the commercialisation and industrialisation of digital technologies, and the nurturing and development of emerging digital industries such as artificial intelligence, big data, blockchain, cloud computing, and network security. Cloud computing was listed and emphasised as one of the key industries in the digital economy.

July 2021	the Ministry of Industry and Information Technology issued the "Three-Year Action Plan for the Development of New Data Centres (2021-2023)", proposing to accelerate the integration and development of traditional data centres with networks and cloud computing, accelerate the transformation to new data centres, and build an intelligent computing ecosystem with new data centres as the core in order to play their enabling and driving role in the digital economy.
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Governments utilise supply-side and demand-side policies to facilitate the diffusion, transfer, and commercialisation of a technological innovation. As is stressed by Boon and Edler (2018, p. 435), the recent innovation policies have paid growing attention to “a combination of the various demand-side instruments, such as monetary or price-based incentives (demand subsidies or tax allowances) that should stimulate consumers to buy an innovative product, public procurement of innovation, as well as soft measures to increase awareness and information (e.g. labels, demonstration projects) and training of users”. My findings verify that the demand-side instrument is important for both innovation and industrial policy in that it can stimulate user adoption and demand conditions (Boon and Edler, 2018), which are vital for industry emergence.

Government endorsement is also very valuable and useful as part of the policy support for emerging industries (Georgallis et al., 2019). The findings suggest that using cloud services in public procurement, collaborating with cloud vendors in smart city projects, promoting exemplary projects of cloud computing applications, and the endorsement from central and regional governments all facilitate the fast development of the emerging market. As one officer from the Hangzhou Commission of Economy and Information described in the interview,

To push the cloud application we spared no effort. One year the information office of the provincial government enacted a regulation that all the budgets to buy servers will not be approved. All levels of government should adopt e-government and transfer the data to [the] cloud. This has an effective short-term impact and a profound long-term influence. You know e-government is a foundation for the development of the city brain project. Only when all the

data is digitalised and connected, then you can build a smart city. So public procurement of cloud services not only means a big market for cloud vendors, but also an endorsement showing other users, a foundation paving the way for more cloud-based applications and businesses. (Q6.2.6)

The interviewee from DT Dream also highlighted the role of the local government:

Zhejiang province has a solid ICT industry that provided a good environment and infrastructure for cloud market, and the government helped to coordinate and recruit great companies and talents for the project so we had a successful project to set an example. (Q6.2.7)

This case study shows that industry associations and other government-affiliated intermediaries serve as connections between governments and companies, and are used by governments as avenues for increasing firm-level innovativeness, because institutional intermediaries can help entry firms into the emerging industry by providing both information and legitimacy, which enable access to government support (Yao et al., 2022). The industry associations – under the supervision of governments – facilitate the standard creation in market formation. According to Lee et al. (2017, p. 448), “standards organisations played a key role in articulating central features of the category and legitimating it”, considering standard-creation and verification practices are important for market formation. As the officer I interviewed from the Big Data and Cloud Computing Association elaborated,

Our association is one of the communication channels between the government and enterprises, providing an important platform for information transmission for both parties, and promoting the healthy development of the cloud industry through formal and informal communication and coordination. Under the guidance of the Municipal Economic and Information Commission, together with the Hangzhou Small and Medium Enterprise Service Center, we compiled and developed the

'Hangzhou Cloud Computing and Big Data Products and Services Catalogue', which helped to demonstrate best practices and outstanding cloud enterprises in Hangzhou, [and] facilitated the connection between the supply and demand sides of the industry. Our objective is to ensure the smooth progress of the 'cloud adoption campaign', and to promote the sustainable and rapid development of the cloud industry. (Q6.2.8)

Academic organisations such as universities and research institutes play a role mainly in the early stage of incubation. For example, the Cloud Academy of Engineering Research Institute kept exploring the possibility of the applications and affordances of cloud computing technology. As a non-profit institute, the long-term vision it depicted and its promotion of a cloud vision played a special role in nurturing the cloud industry and market. For another example, as the most selective and most prestigious university in Zhejiang province with national and international impact, Zhejiang University plays a crucial role in the growth and industrial upgrading of this area, and also pioneered the R&D of cloud computing technology. It has participated in many important events across industries either directly or indirectly, especially the ICT industry. On 3 April 2018, the Information Technology Centre of Zhejiang University and Alibaba Cloud jointly initiated the 'Smart Cloud Laboratory', which explores technologies and theories concerning cloud computing, artificial intelligence, and the Internet of Things. From the perspective of the university, this lab will bolster the development of tertiary education and promote the construction of educational informatics. For Alibaba Cloud, as their CEO, Xiaoming Hu, said,

It is hoped that we will improve the computing capacity of universities and create a unified information platform through the Smart Cloud Laboratory. We will make joint efforts in improving teaching and learning efficiency, promoting scientific research and development and pushing forward the development of a Digital China via modern information technology (Global Communications, 2018). (Q6.2.9)

6.3 Summary: mechanisms, actors, and activities of the industry ecosystem

Due to business diversification, a firm may have multiple roles. For instance, Huawei is a cloud service provider as well as a hardware supplier for other cloud vendors. And China Mobile is one of the main network providers; it also has its own cloud services business. Due to the dynamics of industry emergence and strategic adjustment, the major role played by an actor at different stages may also be different. For example, IBM China was one of the industry ecosystem shapers in the early stage, but later failed to establish its own ecosystem due to strategy and regulation reasons, and acted mainly as a complementor in the later stages.

Industry ecosystem mechanisms are shown in Figure 6.1. This provides a generic framework of the transaction mechanisms during industry emergence. Industry ecosystem is comprised of business ecosystems and on-demand innovation ecosystems. It links the interactions between technology and market, and supports industry emergence. There are three key roles in an industry ecosystem, and they have different tasks and functions during different stages:

- 1) Ecosystem shapers – typically the large firms owning key capabilities, big market shares, and business ecosystems – play the most crucial role in shaping industry emergence; they enable technology commercialisation and market development during the exploration and formation stage.
- 2) Ecosystem facilitators such as technology associations, NGOs, and government play a facilitating role at the early stage because of the lack of commercial drivers and market mechanisms;
- 3) Ecosystem complementors provide complementary assets for commercialisation and play a driving role in the expansion stage by exploring new market segments.

Chapter 7 DISCUSSIONS AND CONCLUSION

This chapter discusses and extends the findings and results. Section 7.1 builds the theory and propositions based on results of the case study. Section 7.2 and 7.3 highlight the theoretical and practical contributions. Section 7.4 concludes the research and points out limitations and future research directions.

7.1 Discussions

Based on the research findings, discussions, and the related literature, this dissertation develops a few propositions, which can be used for further refinement and empirical testing.

Table 7.1 Propositions based on findings and discussions

Theme	Proposition
Patterns of industry emergence	P 1a: Firm take-off has a positive effect on the applications and commercialisations of a technology. P 1b: During industry emergence, cross-industry innovation and business model innovation are positively related, and they have a positive effect on sales and market expansion.
Entry strategy and dominant design	P 2a: The window of opportunity for entry is after the dominant design of technology has emerged and before the dominant design of business model emerges. The firms that enter during the window of opportunity are more likely to survive. P 2b: For pioneers of technology commercialisation who enter after the emergence of the dominant technology before the emergence of the dominant business model, the first-mover disadvantage is more likely to predominate, while pioneers of R&D who enter before the emergence of dominant technology have a higher risk of being affected by the first-mover disadvantage.
Competitive and collaborative strategy	P 3a: Firms leading the technology commercialisation and business model innovation are more likely to succeed and dominant the new market. P 3b: The success of diversification into to an emerging industry depends on business synergy and organisational adaptation. P3c: Core complementors are more likely to adopt a multi-homing strategy, peripheral complementors are more likely to adopt a single-homing strategy.

Industrial strategy and policy	P 4a: Public supports in new technology application, application scenario exploration, and ecosystem building are positively related to new industry development. P 4b: The effects of public policy and support on firms in an emerging industry can vary from firm to firm. The effects on a firm is influenced by the firm's prior-industry affiliation, public-private partnership, and enterprise ownership.
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7.1.1 Patterns of industry emergence: the contemporary industries enabled by digital technologies

As the findings suggest, from the first stage of incubation to the second stage of exploration, the dominant fundamental technology design appears as the key transition. For one thing, the individuals, firms, and other organisations of the technology community at the incubation stage converge on a common and dominant design of fundamental technology so that later applications can all be based on this fundamental technology design. For another thing, this marks the accomplishment of R&D and internal application by the early entrants, who are pioneers in the rudimentary stage. Internal dominance means that they establish their internal dominant design so that they can proceed to the next stage of new product/service development. Also, their internal technology capabilities are mature enough to enable application for potential use. At the industry level, the emergence of a dominant fundamental technology design results in less technology uncertainty and more confidence in the emerging industry, thus leading to the entry of followers to explore the business opportunities, and therefore paving the way for commercialisation explorations and the appearance of the emerging industry's business community.

Based on the commercialisation activities carried out by the newly entered firms during the second stage of exploration, the development and dominance of application technology design set the stage for industry formation. Through the explorations by entrants in their familiar application scenarios, the second stage embraces successful product innovations in the leading markets. For example, the cloud-based 12306 booking

website backed by Alibaba Cloud, which has experiences in e-commerce website maintenance, and the cloud-based Douyu live-streaming gaming platform backed by Tencent, which has a games business itself. Although in different forms and scenarios, the dominant application technology design and the overall architecture of IaaS, PaaS, and SaaS became the consensus in the emerging industry. The appearance of the dominant technology design sheds light on the alignment of value creation and the structure of ecosystem and industry, and leads to the business ecosystem formation with entrant positioning and complementor aligning in the third stage of formation. Based on these stylised facts and mechanisms, I propose:

Proposition 1a: Firm take-off has a positive effect on the applications and commercialisations of a technology.

The forming of the ecosystem and market in the third stage leads to the emergence of a dominant business model, thus facilitating the emergence of the industry and the stabilisation of the industry's structure. Since the new products/services spread to more market segments and scenarios, the sales of the new industry take off, the value is delivered more efficiently, and the dominant business model design appears. When the industry emerged in 2020, most of the case companies developed a comprehensive portfolio of cloud services, covering IaaS, PaaS, and SaaS, which is the dominant technology design. And a dominant offering and pricing system model was established. Alibaba Cloud, Huawei Cloud, and Tencent Cloud all provide a suite of on-demand digital solutions in the forms of public cloud, private cloud, or hybrid cloud, which made up the dominant design of the business model in the cloud computing industry. The breakthrough in this stage is to apply cloud computing to widespread sectors with mass adoption, and a dominant business model design that can be commonly used in every scenario is established. Based on the findings and discussion above, I propose the following:

Proposition 1b: During industry emergence, cross-industry innovation and business model innovation are positively related, and they have a positive effect on sales and market expansion.

As a new industry gradually emerges, the standards of this industry are inaugurated and adapted. Incorporated from different distinct technological innovations introduced independently in prior product variants, the dominant design embodies the beliefs about a product or service as it defines and standardises the key features of a technology, as well as the common elements and alignments to apply the technology in a diversity of scenarios. My findings enrich the conceptualisation of the dominant design by including the design of the business model. In doing so, this research expands the boundary condition of dominant design to explain the mechanisms of service-based emerging industries enabled by digital technologies. My case study also illustrates how the emergence and change of a dominant design – as the result of a fortunate combination of technological, economic, and organisational factors – influence firm activities and industry evolution (Suarez and Utterback, 1995).

7.1.2 Dominant design and entry strategy in the digital era

Compared with the product-based industrial age, the digital age has seen major changes that brought challenges to the extant dominant design theory that is generally based on the evidence of manufacturing sectors in the industrial age. Instead of pursuing mass production of standard products, the locus of emerging industries is customised service and solution. The existing definition of dominant design focuses on the product architecture design (Abernathy and Utterback, 1978; Anderson and Tushman, 1990; Utterback and Abernathy, 1975), which cannot capture the dominant design complexity of digital service industries such as the cloud computing industry. In manufacturing sectors, after laboratory tests, observations, and simulations, physical prototypes are developed for a new product or component, and as long as one prototype design dominates the market it becomes the dominant design (Moeen et al., 2020; Thomke,

2003). However, in the service-oriented industry in the digital era, in addition to the technology architecture, more attention should be paid to the business model design that explains customer value and how to deliver and capture that value. Based on an emerging industry in this digital age, my findings suggest that, after the dominance of technology design, it is the emergence of a dominant business model design that marks the emergence of a new industry (see Figure 7.1). Based on the findings, I propose the following:

Proposition 2a: The window of opportunity for entry is after the dominant design of technology has emerged and before the dominant design of business model emerges. The firms that enter during the window of opportunity are more likely to survive.

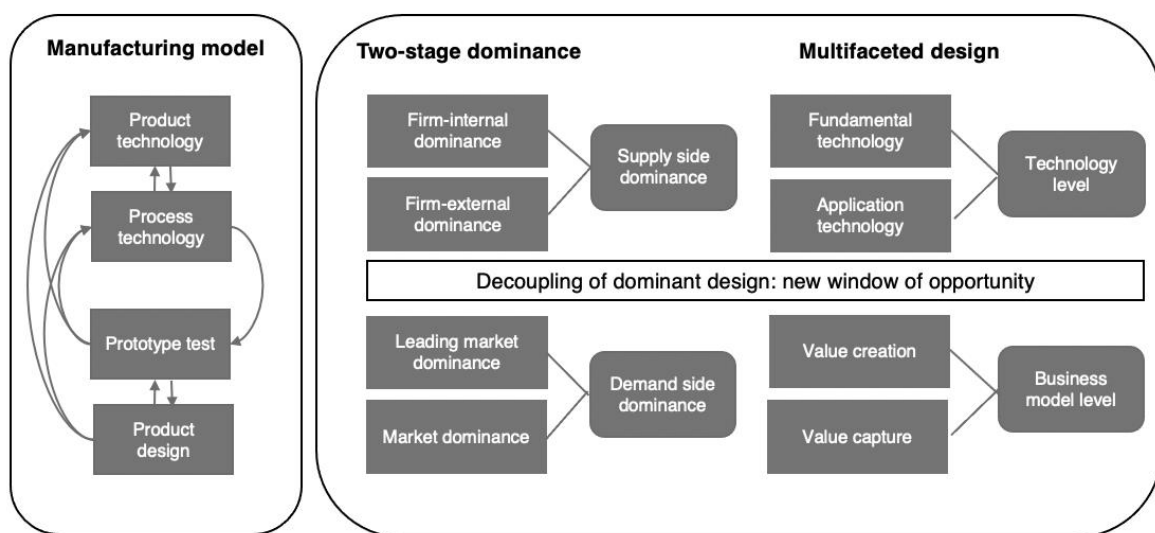


Figure 7.1 Decoupling of dominant design

Moreover, my case study identifies a decoupling between dominant technology design and dominant business model design, which helps to resolve a paradox about entry strategy in the extant literature. Although it has been assumed that the perfect timing to enter an emerging industry – in other words, the window of opportunity – is before the emergence of a dominant design, being a pioneer has advantages as well as disadvantages

(Markides and Sosa, 2013; Lieberman and Montgomery, 1988). The extant studies suggest the disadvantages of pre-dominant design entry as well as the advantages of post-dominant design entry. For entrants before the appearance of a dominant design, although they have chances to become the dominant design, the sunk costs are high for new ventures considering the technological lock-in (David, 1985). Even if a company did win the dominant design competition, Eggers (2014) finds that too early commitments to the winning technology may impede bringing the best product to market (Eggers, 2014). The weak design strategy and market share results for early entrants need to be investigated further (Tegarden et al., 1999). On the other hand, studies suggest that post-dominant design entry also has advantages from several aspects, including the adoption of the new conventions by incumbents (Leblebici et al., 1991), the building of legitimacy and industry identity (Rao, 2004), and the clarification of a competitive environment (Munir and Phillips, 2005).

My case study echoes these pieces of research and can explain this paradox by narrowing down the window of opportunity and specifying the conditions of first-mover advantages predominating over disadvantages. Based on the case study, I propose:

Proposition 2b: For pioneers of technology commercialisation who enter after the emergence of the dominant technology before the emergence of the dominant business model, the first-mover disadvantage is more likely to predominate, while pioneers of R&D who enter before the emergence of dominant technology have a higher risk of being affected by the first-mover disadvantage.

In the cloud computing industry, the first-mover in R&D, for example, China Mobile, did not display a good performance in the emerging industry because it failed to pioneer commercialisation. It was Alibaba Cloud that started commercialisation early and achieved a first-mover advantage. Although Huawei and Tencent were latecomers after the dominant technology design appeared, they successfully caught up by leveraging the

existing dominant technology architecture and focusing on business model innovation and exploration of new application scenarios. This is because decoupling from a dominant design leads to a new window of opportunity, which is after the dominant technology design and before the dominant business model design. The firms that dominate a market tend to be among the ones that pioneer technology commercialisation and enter during the window of opportunity, rather than the earliest pioneers of a new technology and industry (Markides and Geroski, 2005).

7.1.3 Competitive and collaborative strategies for diversifying firms and entrepreneurial firms

Entrants in a new industry can be divided into two types, the diversifying entrants that enter the emerging industry as a new business unit of an incumbent firm for the purpose of strategic diversification, and entrepreneurial entrants that are start-ups by entrepreneurs (Kapoor and Furr, 2015; Sosa, 2013, 2011).

Table 7.2 Comparison between diversifying entrants

	Industry Affiliation	Entry strategy	Competitive and collaborative strategy	Outcome
Alibaba	e-business, 2C	Early move in R&D, early move in commercialisation	E-commerce platform and ecosystem strategy, first-mover	SME, Stable market leader
Huawei	ICT, 2B	Late move in R&D, early move in commercialisation	Large corporations, technology and 2B advantage, cloud ecosystem	Successful catch-up
Tencent	e-business, 2C	Late move in R&D, early move in commercialisation	Games and entertainment sectors, advantage based on QQ & Weixin, cloud ecosystem	Successful catch-up

China mobile	ICT, 2B	Early move in R&D, late move in commercialisation	Small cities and rural areas, advantage in the national service network, strategic partnership	Slow development
Hundson	Financial technology service, 2B	Early entry	Industry know-how , professional financial services	Successful transformation and fast growth
Kingdee	Enterprise software vendor, 2B	Early entry	Platform-based enterprise software capabilities	Successful transformation and fast growth
Huber Cloud	Garment manufacturer	Late entry	Sectoral cloud platform	Internal application
Cosmo Plat	Appliance manufacturer	Late entry	Sectoral cloud platform and cloud research institute	Internal application

For incumbent firms, early moves to adapt to the disruption of new generation technology are crucial. In the digital era, the lifecycle and clock-speed of industry have become shorter; therefore, the ‘adapt or die’ question for incumbents is more salient. Technological change or the emergence of a radically new technology are found to be particularly deadly for established firms considering the difficulty of organisational change and capability evolution (Henderson and Clark, 1990; Tripsas and Gavetti, 2000; Tushman and Anderson, 1986). Firms tend to utilise the existing technological and complementary assets for the development and commercialisation of a new technology (Helfat, 1997; Teece, 1986), thus falling into competency traps easily (Leonard-Barton, 1992; Tripsas and Gavetti, 2000).

Successful adaptation requires immediate and persistent actions. For example, because of its early entry and persistent efforts to explore the cloud market, Kingdee developed a well-defined business model of enterprise SaaS cloud services, and grasped the biggest share in the enterprise-grade SaaS Cloud services industry for four years. Its great performance also resulted from its continuous learning and capability-enhancing to

improve user experience and create more value. High-performing business models are those that can accelerate firms' learning and support the development of focal firms' capabilities (Aversa et al., 2015). As the only Chinese SaaS company to win a 2020 IDC SaaS Customer Satisfaction Award (Kingdee, 2020), its cloud transformation is beyond successful. In contrast, as suggested by Chesbrough and Rosenbloom (2002), the unsuccessful entrants have limited search for viable business models, and fail to modify and innovate their business models constantly to the interactions between technology applications and market demands. Therefore, I propose following:

Proposition 3a: Firms leading the technology commercialisation and business model innovation are more likely to succeed and dominant the new market.

Concerning the antecedents of the strategy and performance of entrants in a nascent market, the existing research has examined the effect of prior industry affiliation and pre-existing capabilities on strategic decision and entry behaviour, thus influencing the diversification and entry outcome (Sosa, 2011; 2013). A firm's prior industry affiliation and experience also influence how it conceptualises and frames a new product by shaping its belief and behaviour (Benner and Tripsas, 2012; Raffaelli et al., 2019). The divergence in the technical design of digital cameras is linked to differences in firms coming from consumer electronics, analogue cameras, and computer industries (Benner and Tripsas, 2012). Industry-specific experience leads to less flexibility among ventures facing the need to shift to the dominant design (Furr et al., 2012). This research articulates that the prior industry affiliation affects the early market that a firm chooses to enter, and the competitive strategy making. As is shown in Table 6.3, a successful competitive strategy is generally based on the synergy of prior industry affiliation and the new business launched. The diversifying entrants from an industry that has less synergy and connection with the emerging industry – for instance, Huber Cloud as a subsidiary of the leading garment manufacturer Huber, and Cosmo Plat as a subsidiary of the leading appliances manufacturer Haier – are less successful even if the parent company mobilised and invested enormous resources.

In the turbulent emerging industry, organisational adaptation to changes determines the survival of the entry firms to a large extent. In diversification into the emerging cloud computing industry, Internet companies perform better than those from traditional manufacturing industries. Internet genes enable them to perform better in building an ecosystem and adapting to the emerging digital industry. The existing literature has indicated the role of capability and cognition in explaining “incumbent inertia and subsequent failure” (Tripsas and Gavetti, 2000, p. 1148). In addition to the differences in prior industry knowledge, the differences in management style and strategic decisions between the two kinds of companies are also the main attributes. For entrepreneurial entrants, although new ventures are often characterised as flexible actors, recent studies have suggested start-up inertia even in nascent industries (Zuzul and Tripsas, 2020).

The adjustment of organisation design is important for organisation adaptation. As indicated by Q4.1.12, Q4.2.10, and Q4.3.7, Alibaba integrated Ding Talk and Alibaba Cloud, Tencent formed CSIG in 2018, and Huawei established Cloud BU in 2017; these actions mobilised their internal resources for the delivery of complex value propositions and paved the way for cloud ecosystem building, thus improving their cloud business performance significantly. In re-designing an organisation’s structure, resource cognition of the management team is a vital factor (Danneels, 2007) because it influences a firm's dynamic capability, which operates by resource alteration processes. George and Bock (2011) examine the relationship between business model organisational design and suggest that managers and entrepreneurs can assess existing and potential business models to establish new organisations. Using the case of Polaroid’s transformation towards digital camera, Tripsas and Gavetti (2000) find that the company had little difficulty in knowledge evolution thanks to its early investments in leading-edge capabilities; however, the senior management team's adherence to the old business model and the primacy of technology constrained commercialisation of a digital camera product. This research also implies the importance of the synergy between old and new businesses, and organisation adaptation. Based on the discussion above, I propose:

Proposition 3b: The success of diversification into to an emerging industry depends on business synergy and organisational adaptation.

For entrepreneurial entrants, the founder's background in specific industries will also influence the configuration of ecosystem activities (Zuzul and Tripsas, 2020). For example, as is shown in Table 6.4, Brand New Data – a spinoff start-up from Alibaba Cloud – joined the Alibaba cloud ecosystem as a complementor due to the connection, and its strategy focuses on exploring the niche market that Alibaba Cloud does not address. However, new ventures as a result of technology transfer from research institutes, such as DAS, may choose multi-homing, relying on their core technology capabilities. Comparing the strategies of the entrepreneurial firms that enter the emerging market, I propose:

Proposition 3c: Core complementors are more likely to adopt a multi-homing strategy, peripheral complementors are more likely to adopt a single-homing strategy.

Table 7.3 Comparison between entrepreneurial entrants

	Industry Affiliation	Entry strategy	Competitive and collaborative strategy	Outcome
DT Dream	ICT	Early	Specialising in E-government, join Alibaba ecosystem	High-growth
CityDO	ICT distributor	Early	Specialising in Smart city, join Alibaba ecosystem	High-growth
DAS	Start-up by researcher	Early	Specialising in the niche market of cloud security, ecosystem multi-homing	High-growth
Brand New Data	Start-up by former Alibaba employee	Late	Specialising in markets in lower-tier cities, Alibaba ecosystem	Low-growth

In this research, the IaaS vendors, mostly diversifying entrants, have a higher survival rate than entrepreneurial entrants, mostly start-ups. Kapoor and Furr (2015) suggest that the pre-entry possession of key downstream complementary assets allows diversifying

entrants to pursue technological choices that are not at the technological frontier; however, entrepreneurial entrants have to prioritise technological performance in their decision making because of their limited assets and resources. Lack of organisational legitimacy, complementary assets, and integrative capabilities explains why start-ups have a higher risk of technology exit than diversifying entrants (Chen et al., 2017).

7.1.4 Industrial strategy and policy: nurturing industry ecosystem as a policy approach

My research findings show how state and local governments play a facilitating role in nurturing an industry ecosystem and creating a new industry. Industrial strategy and policy is one of the key drivers of industry emergence (Geels, 2004), and the government is an important actor in my industry ecosystem model in the context of industry emergence. Considering a better position in the future strategic industry is significant to economic growth and industrial upgrading, thus impacting employment, competition, and sustainability in the modern market; policymakers have the incentives and abilities to shape the development of emerging technologies into new industries (Hung and Chu, 2006). Nascent industries and the firms that populate them are lacking in cognitive acceptance from stakeholders, and are sometimes in direct opposition to entrenched industries; thus, favourable regulatory environments can help them to take root (Georgallis et al., 2019). The interactions between government and firms are captured in the ecosystem models of this research.

By incorporating the boundary-spanning phenomena and ecosystem mechanisms for innovation and industry development (Vicente-Saez et al. 2021), this research presents the ecosystem approach as a new policy instrument, which contributes to the updating of the existing policy research and practical measures. In the existing literature, policy scholars have paid attention to the ecosystem but most of them regarded it as a context instead of a policy instrument (Ma et al. 2019; Dawson et al. 2016; Li and Garnsey 2014). Traditionally, R&D investments have been emphasised by firms and policymakers; this

research suggests that, in the playground of a nascent industry, the search for profitable business models and applicable markets is crucial and deserves more attention in strategy development and policymaking. There is no exact formula for the creation of such an ecosystem, but policy leaders should pay more attention to the role of local conditions and bottom-up processes when building an ecosystem (Isenberg, 2010).

Moreover, this case study shows that flexibility of industrial strategy and policy measures is important in nurturing an emerging industry. Both demand-pull and technology-push public supports are necessary for facilitating new industry development (Costantini et al., 2015). In terms of demand-side and supply-side policy instruments, although stimulation of demand is able to create markets that support innovation and economic activities in a country, as is evidenced by this research, this shift noticed by some policy reports has not been applied in practice or broadly discussed by academia (Boon and Edler, 2018; European Commission, 2007). It is increasingly acknowledged in governance theory that the role of a government is as a mediator or an enabler (Pelkonen, 2006). Apart from financial support, the orchestration and coordination of other resources such as social capital, which may lead to application and collaboration opportunities, are significant for supporting companies to develop new capabilities and nurture an emerging industry from new technologies. Also, this research suggests that the focus and function of policy support should adjust in different stages: policy is focused on supporting R&D and application during the incubation stage, nurturing innovation and entrepreneurship and supporting legitimisation during the formation stage, and supporting regulation during the expansion stage. Based on the findings and discussion, I propose:

Proposition 4a: Public support in new technology application, application scenario exploration, and ecosystem building is positively related to new industry development.

From the perspective of companies, the policy support each company receives and the effects of a policy on each company are different. Most studies evaluate the

macroeconomic or overall effects of public support or a policy (Montmartin and Herrera, 2015). However, as suggested by some research examining the effects on individual firms (Lee, 2011), the differential effects of public support on firms depend on various firm- or industry-specific characteristics; for example, firms with high technological competence are more likely to enjoy a smaller technological-competence enhancing effect of public R&D support. In line with that, this research advances the understanding of differential effects of public policy on companies from a micro-level, and sheds light on the factors that determine the differences. This research suggests that the effects of public support for industry development on companies of a similar size in the same industry can also be different. Based on the case study and discussions, I propose the following:

Proposition 4b: The effects of public policy and support on firms in an emerging industry can vary from firm to firm. The effects on a firm is influenced by the firm's prior-industry affiliation, public-private partnership, and enterprise ownership.

For one thing, considering the significant endorsement and promotion effects of public procurement on the companies in an emerging industry, public procurement contracts are important for entrants especially during the nascent stage of an industry. Other things being similar, the companies with 2G (to government) business experience and stronger public-private partnership, or the state-owned companies, are more likely to be the winning bidder. Also, the diversifying entrants from a prior industry in which public support is more common and important may show a greater enhancing effect of public support. For example, although Huawei entered the cloud market later than Alibaba and Tencent, its cloud for e-government business has grown rapidly due to its reputation and experience in public-private partnership.

7.2 Theoretical Implications

7.2.1 Contributions to Industry Emergence research

Firstly, this research provides a holistic industry emergence model from the three perspectives of market, technology, and ecosystem. The existing industry emergence literature with disparate research streams from technology and product innovation, market and category formation, and institutions and policy requires integration (Moeen et al., 2020). By linking the three perspectives, and connecting the supply side and demand side with ecosystem dynamics, this process model contributes to the integration of industry emergence research and provides a conceptual framework for future research in industry emergence.

Secondly, this industry emergence model fills in the gaps of transitions with the lens of dominant design. In the extant literature, transitions between stages of industry emergence are not clear (Gustafsson et al., 2016). This research identifies the dominant design dynamics as the key to transitions between stages. By introducing the construct of industry ecosystem, the industry ecosystem model from an activity perspective explains how the interaction between industry ecosystem, market feedback loop, and technology feedback loop leads to the emergence of dominant designs and thus the transitions between stages.

Thirdly, this study advances our understanding of the impact of business model innovation on industry emergence and structure. According to Gambardella and McGahan (2010), industry structure and organizational capabilities are shaped by the innovation of business models, which can define and supply various applications to numerous ultimate customers. As illuminated by Chesbrough and Rosenbloom (2002), there are both technical and market uncertainty, as well as many possibilities on the journey from the technical domain to the economic domain. Specifically, the upstream science and general-purpose technologies can afford different down-stream specialists and create

various value (Gambardella and McGahan, 2010). My industry emergence model and industry ecosystem model suggest that the co-evolution and interactions between industry ecosystem, technology and market lead to the emergence of dominant designs of applied technologies and business models, which enable sales take-off, thus representing the successful emergence of the new industry. The dominant design of business models define value the alignment of value creation and appropriation, thus paving the way for establishing of industrial systems on the supply side and grow markets on the demand side.

Fourthly, the industry ecosystem model from an actor perspective uncovers the organisational form and key roles of industry emergence. The industry pool of knowledge, together with the spillovers and the network of collaborating entrants, not only influences individual entrants, but also shapes the industry landscape (Kotha, 2010). Agarwal and Bayus (2002) find that, for a new product market, if the level of new firm entry is higher, the take-off time will be shorter. Based on evidence from the encryption software industry, Giarratana (2004) also claims that new firms and linkages to them are at the core of new industry formation. However, whether large firms or start-ups are more important in the industry emergence process is still open to discussion. Audretsch and Thurik (2001) suggest that there is a paradigmatic shift towards entrepreneurial regimes that emphasise support for new entrants and a reduced role for incumbents, while Lechevalier et al. (2014) argue that the industry emergence is mainly triggered by established large firms, rather than by new firms, based on evidence from the service robot industry. This research suggests that it is different actors that play a leading role at different stages.

Fifthly, this research unpacks the new pattern and mechanism of industry emergence and dominant design in this digital era. The case study indicates the importance of business model design in emerging industries compared with the industrial age. Concerning the debate about technology push or market pull (Di Stefano et al., 2012; Nemet, 2009; Peters et al., 2012), this research helps to integrate the two theories by identifying the decoupling between supply-side dominance and demand-side dominance. To achieve

industry emergence, the technology and demand need to be bridged by the emergence of a new value proposition when the market is ready. Moreover, the existing literature has identified industry evolution led by technological change and moving from the old to the dominant new technology (Tripsas, 1997; Tripsas and Gavetti, 2000), while this research explores industry formation from an emerging digital technology, as a totally new industry and disruption.

Last but not least, this research contributes an innovative industry-level research method. The extant industry emergence research is based on two methods, quantitative empirical research using industry-level datasets (Eggers, 2014), and qualitative single or multiple case studies that fall into firm-level research that studies strategy, entrepreneurship, and organisation identity and change (Hannah and Eisenhardt, 2018; Tripsas and Gavetti, 2000). This research adopts a four-stage data analysis approach that combines different qualitative research techniques comprising within- and cross-case analysis, road-mapping, temporal bracketing, and coding. The comprehensive research design allows me to capture the structural and processual elements of industry emergence.

7.2.2 Contributions to Ecosystem research

Firstly, this research contributes an industry ecosystem model to fill in the gap of ecosystem research from an industrial level. The extant ecosystem literature has focused on the focal firms of ecosystems, mainly orchestrators and hubs (Gawer and Cusumano 2014; Wareham et al. 2014), or examined the impact of ecosystem participation on firm performance for hubs or complementors (e.g., Knockaert et al., 2019). The industry ecosystem refers to a collection of firms and other third-party organisations that focus on one emerging industry (Ansari et al., 2016; Iansiti and Levien, 2004; Wareham et al., 2014), where each firm takes a specific role of either orchestrator or more or less central complementor (Jacobides et al., 2018), and government, media, and other peripheral actors comprise the institutional environment and support the alignment. Bogers et al. (2017) claim that in industry there exists an important contingency factor for how

relevant stakeholders can provide input into a production or innovation process: the ecosystem can enable new forms of industrialisation and cross-industry collaboration, and the mutual dependence between the ecosystem and the industry in which it is implemented is also complex and requires more research. Struben et al. (2020, p. 246) note that “actors tend to allocate private-oriented resources rather than market-oriented resources. This bias towards investing in firm capabilities instead of market infrastructure leads to collective action problems”. The industry ecosystem model developed in this research responds to the calls for industry-level ecosystem research.

Secondly, from both actor and activity perspectives, this industry ecosystem model developed based on a case study in this research contributes to ecosystem research by explaining how ecosystem and industry evolve, and how the actors in the ecosystem play their roles to create a new industry. The existing ecosystem research has demonstrated the importance of the evolution and dynamics of an ecosystem, but our understanding of how industry platform and ecosystem emerge is still limited (Gawer and Cusumano, 2014). The parts of an ecosystem, such as the actors, and their relations and actions, have been examined by many studies but most ecosystem research has overlooked the ecosystem as a whole (Wang, 2021). Moreover, contrary to traditional industry definitions, the definition of ecosystems is characterised by the spirit of ecosystems in biology, which emphasises the strength and nature of interactions, rather than any preconceived categorisations (Iansiti and Levien, 2004). From the actor perspective, although the influence of governments in entrepreneurial ecosystems (e.g. Shi and Shi 2021; Spigel and Harrison 2018) and the role of intermediaries in knowledge or innovation ecosystems (e.g. Hewitt et al. 2017; Kivimaa et al. 2019) have been examined, the business and innovation ecosystem literature often ignores the influence of government agencies and their nurturing and governance roles that support the ecosystems, and therefore “the deliberate fostering of ecosystems to support innovators” as a new policy lever remains to be explored (Li and Garnsey 2014, p. 763). In this research, ecosystem shapers, complementors, and facilitators and their tasks at each stage are identified. It should be highlighted that this industry ecosystem model also

sheds light on the role of governments in industry emergence and ecosystem growth. And my industry ecosystem models have significant policy implications for policymakers.

Third, this research provides a multilevel ecosystem model and explains how ecosystems are formed by integrating ecosystems of different levels and identifying ecosystems as the linkage between market and technology, between supply side and demand side. Firms in the digital era bring together developers and partners from around the world to build specific ecosystems to "explore new business scenarios and business models" (Huawei, 2020, p. 74). The process of establishing the cloud computing industry is also accompanied by the development of the big data industry, and it is also the process of digital transformation gradually covering multiple industries. Cross-industry innovation and the underlying innovation ecosystems are needed to facilitate cross-industry knowledge exchange and cooperation, as well as to overcome more complex institutions and offerings. Ecosystems do not just emerge spontaneously, but emerge as the result of deliberate experimentation and engineering from different parties (Jacobides et al., 2018). To seize the opportunities in the digital era, companies should track new trends that may upend the ecosystem and build a management team to start a new ecosystem (Moore, 1993).

7.2.3 Contributions to Innovation studies

Firstly, this research contributes to dominant design theory by identifying the multi-levels and decoupling of the dominance in this digital era, and articulating the relationship between dominant design and industry emergence. It was acknowledged that dominant design emerges as manufacturers, suppliers, customers, and regulatory agencies compete to decrease the uncertainty (Anderson and Tushman, 1990). This research elaborates on how the interaction and co-visioning of the stakeholders lead to the emergence of a dominant design. One of the fundamental assumptions in the extant dominant design literature is that the emergence of a dominant design marks the transition of a new industry from a fluid state to a specific state in industry evolution (Utterback and

Abernathy, 1975). Although emphasising that the number of participants in the emerging industry and the survival rate decline after the emergence of a dominant design, Utterback and Suárez (1993) also note that entry and innovation can also happen after the appearance of the dominant design, for instance, in Japan, and indicate that, in addition to the competition in the dominant core technology design, firms can also pursue widely different strategies to explore the remaining business opportunities so long as they follow the dominant core technology design and keep pace with the evolution of the core technology. My research elaborates on the dynamics of dominant design and its impact on entrants and business opportunities in emerging industries by highlighting the value of business model innovation and design dominance.

Furthermore, this research explains how dominant design dynamics unfold in industry emergence in the new context of the blurred industry boundary driven by increasingly complex value propositions. Dominant design research has focused on its competition and its impact on survival; more research is needed to explore the interaction between dominant design and industry emergence (Tegarden et al., 1999; Suarez et al., 2015). Recent practices and studies have suggested that the value propositions are becoming increasingly complex and various according to various application scenarios (Baldwin, 2012; Wang, 2021). The delivery of the value propositions – for instance, that of the cloud computing industry – requires the integration of other digital technologies, such as 5G, big data, AI, and IoT. The delivery of IoT services is also typically in the form of cloud services so that they are available upon launch to help users rapidly deploy applications in a cost-effective way (Huawei, 2018). Consequently, the relationship between dominant design and industry emergence has become more dynamic, about which our understanding is still limited. By introducing cross-industry innovation and application scenario as elements in the industry ecosystem, my industry ecosystem model explains how an emerging industry expands its markets and boundaries and how, during this process, the dominant designs of technology and business model are gradually established after rounds of the recursive cycles and feedback loops in market and technology.

Secondly, this research contributes to technological innovation and diffusion theory by elaborating on the comprehensive innovation journey from a seed technology to a new industry, including technological innovation, product innovation, business model innovation, cross-industry innovation, and process innovation (Baden-Fuller and Haefliger, 2013; Gassmann et al., 2010; Utterback and Abernathy, 1975). Innovation studies provide insightful analysis of new industry phenomena from product level, technology level, regional level, and firm level. However, the discipline fails to offer a holistic sector-level theory in the context of emerging industries. In fact, the enabling mechanisms of transiting from technological innovation to successful product and industry based on the emerging technologies remain largely unexplored, which is also a big issue for executives and managers. At the HUAWEI CONNECT 2020 Conference, an executive from Huawei Cloud shared four keys to successful commercial deployment that get beyond the death valley of innovation between technology and commercialisation: clear business scenario, readily available computing power, continuously evolving services, and organisation and talent adaptation. This case study identifies the integration of innovation at different levels as the key element in industry emergence, and explains how the innovations are enabled by and co-evolve with the ecosystems and organisations.

This research also enriches the cross-industry innovation research by identifying the importance of cross-industry innovation in this digital age and conceptualises application scenario as a key to cross-industry innovation and industry emergence. The existing cross-industry innovation research focuses on micro-foundations. For example, Gassmann et al. (2011) emphasise the ability to adapt a process and competency in technology and innovation management as one of the methods and tools to transfer analogical solutions. Gassmann and Zeschky (2008) demonstrate that analogical thinking across industry boundaries can be used for product innovation, and absorptive capacity is necessary to recognise the value of new, external knowledge and to apply it to commercial ends (Cohen and Levinthal, 1990). In order to take advantage of spillovers from different industries, a company has to acquire, assimilate, transform, and exploit external knowledge (Zahra and George, 2002). In addition to these abilities, this research

suggests the importance of the external application scenarios for cross-industry innovation. In the service-centric industries in this digital era, the emergence and evolution of an industry is also a process of a series of cross-industry innovations that apply the new technology and services to various scenarios. This finding also responds to the call for more research on the “interesting contemporary ways of organizing for innovation” (Lifshitz-Assaf et al., 2021, p. 704). The existing innovation studies are largely based on traditional ways of organising for innovation that are rooted in the Industrial Revolution and corporations’ mass production (Chandler, 1993; Lifshitz-Assaf et al., 2021); this research contributes a new organising form and elements of innovations based on an emerging industry in this digital age.

7.3 Practical Implications

7.3.1 Policy implications for policymakers

The extant literature on policy is most established in the context of science and technology policy (Howells, 2006; Lauritzen, 2017), while its role in the market and industry formation process is seldom addressed (Kivimaa, 2014). Innovation and industrial policy literature has been centred on the evaluation of public policy impacts on R&D performance and the mechanism of technology transfer in technology-push industry (Francelino et al., 2019; Jasinski, 2003; Villasana, 2011). Existing literature, however, offers limited insights into how and why policy intervention can address the evolving innovation and industrial challenges (Ho and O’Sullivan, 2019). This research provides a systematic ecosystem approach to advance the understanding of the dynamics and interactions between various public and private sector actors in incubating an emerging industry following a technology innovation (Solbu, 2021). Also, the fast-changing market and boundary-less industries suggest the need for new policy instruments and tools. Beyond R&D and entrepreneurial activities, my findings shed light on policy research for supporting enterprises throughout the whole process of innovation and industry development by exploring how government agencies track emerging technologies and

industries to design strategic policy at each stage to enable the companies to resolve ecosystem bottlenecks, which provides foundations for the transitions between stages of industry emergence.

This case study provides implications for government agencies regarding how to leverage business strategies such as ecosystem nurturing in policy implementation mechanisms to nurture a new industry. The essence of strategy is maximising access to limited resources to keep a competitive advantage, similarly, the development of a public sector strategy should leverage strategic management theories (Brown, 2010), in order to improve public business support (Freitas, 2007). The development of public sector organisation strategies for better management (Johansen, 2009) has seen the increased use of project-based agencies (Sahlin-Andersson, 2003) in the public context, as the decision made by core departments, and the policy implemented by public agencies with managerial autonomy (Verschuere, 2009). However, the failure of cooperation between public agencies has long been an issue for public management research (Weiss, 1987). There has been a growing body of knowledge and research surrounding policy implementation and government agency coordination (Braun and Guston, 2003; Daim and Oliver, 2008; Landry et al., 2003; Neergaard and Ulhøi, 2006; Schillemans, 2013; Van der Meulen, 1998). It is acknowledged that agencies are better coordinated if they are pursuing the same objectives and each agency has its mission well-defined and stated (Weiss and Piderit, 1999). In this case, the firms and the related government agencies collectively create the cloud computing industry with a shared ecosystem vision, which provides valuable insights for governments on incubating emerging industries and improves the synergy between departments and agencies. As is explained by Jacobides et al. (2018, p. 2260), “while new coordination issues always arise, ecosystems provide processes and rules on how to resolve them, and encourage alignment through rules of engagement, standards, and codified interfaces”.

Last but not least, policymakers should support intermediaries, research institutes, and other peripheral actors to function better. Research institutes and NGOs have important

role in exploring the vision of emerging technologies and industries because their starting point is not short-term sales or private profits. Industry associations such as standard-setting organizations are a key organizational form that allows industry participants to coordinate on a standard technical design (Fiedler et al., 2023). In this case, the roles of these actors are not salient, partly because of the strong roles played by large companies and governments. Future research could further explore the roles and functioning of these peripheral actors.

7.3.2 Strategic implications for companies

When examining the industry emergence at firm level to see how firms navigate in the uncertain context, this case study offers meaningful insights into strategy for entry firms in an emerging industry. In addition to implications for entry strategy based on the new windows of opportunity for entry strategy identified, this case study also offers implications in terms of competitive and collaborative strategies that emphasise an ecosystem approach for different types of entry firms.

First, companies entering emerging industries nowadays should adapt to the ecosystem approach to achieve sustainable competitive advantage by leveraging the drivers of sustainable growth and complementary knowledge and resources provided by complementors. The case of the cloud computing industry shows vividly how the business ecosystem benefits the focal firm from the two aspects of growth driving effects and complementarity effects. On one hand, if SaaS vendors do not migrate to the cloud, it will be difficult for the end users and enterprises using their software to migrate to the cloud. In contrast, once the complementors sell their software and service to a new customer, one more customer consumes and pays for the computing resources provided by the IaaS vendor in the form of infrastructure like electricity. On the other hand, without the customised software developed by SaaS vendors and the platform maintenance provided by PaaS vendors, IaaS vendors cannot provide complete solutions and end-to-end services on their own. Also, it is impossible for a company to dive into the knowledge of

every niche market and application scenario; thus, complementors' industry know-how is a valuable complementary asset. Therefore, the large IaaS vendors have all adopted an ecosystem strategy and utilised multiple measures to attract more complementors and build business ecosystems, such as exhibitions, conferences, direct and indirect investments, establishing incubators and platforms, and setting up an ecosystem department. The findings also suggest that firms should adjust their strategy and organisational structure in a timely manner according to the different tasks at different stages of industry emergence.

For start-ups, their competitive and collaborative strategies should also prioritise ecosystem-related decisions, which should be made according to their core technology and asset. Start-ups specialising in a niche market can adopt a single homing strategy to secure the necessary support from the ecosystem, while start-ups with core competence in a certain section of the industrial system can adopt a multi-homing strategy for more opportunities. To discover entrepreneurial opportunities, start-ups that focus on a niche market with the knowledge and resources of a certain market segment should pay more attention to the dominance of business model design, while start-ups that focus on a section of the industrial system with expertise and capability of this technology should pay more attention to the dominance of technology design. After the emergence of the dominant technology design, entrants can still find entrepreneurial opportunities by choosing the dominant technology and leveraging the existing ecosystem, with a focus on exploring a specific market segment and business model innovation.

7.4 Limitations and Future Research

Due to the characteristics of the cloud computing industry and the Chinese market, the industry is largely shaped by large vendors, which are mostly large high-tech companies. This research provides one of the patterns under the conceptual framework developed. In light of the industry emergence and industry ecosystem models, future research can further explore other empirical settings. Although in general whether large firms or start-ups are more important in the industry emergence process is still open to discussion (Giarratana, 2004), which kind of actor plays a key role may depend on the characteristics of industries and institutions. Also, in the emergence of an industry, the interactions and comparisons between different countries and markets are worth further investigating.

Second, regional boundary as another element can be introduced in the industry ecosystem model by future research. In the case of the cloud computing industry, the digital interaction makes the regional boundary less important in this case. However, the prior empirical studies suggest that the emergence of new technology-based sectors at the regional level is based on local technological competences and resources (Colombelli et al., 2014; Sanderson and Simons; 2014; Foray and Raffo, 2014). Future research is needed to exploit the boundaries of firm, industry, as well as region in the context of industry emergence.

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