

Jin CHEN, Ximing YIN, Jizhen LI

Firm innovation system: Paths for enhancing corporate indigenous innovation capability

© Higher Education Press 2020

Abstract To obtain a sustainable competitive advantage and achieve global innovation leadership, firms in China and other emerging economies must develop strong indigenous innovation capabilities through the coevolution of strategy, organization, resources, and culture. Drawing on current innovation management theories and practices, this study proposes four systematic paths for improving firm innovation systems (FISs), namely, the R&D-based internal collaborative FIS, the strategic vision-driven FIS, the open and user-driven FIS, and the holistic ecosystem-driven FIS. This study contributes to the systematic approach for enhancing corporate indigenous innovation capability based on FISs. Moreover, this study provides theoretical and practical insights for China as well as other developing countries to cultivate world-class enterprises and build an innovative nation.

Keywords innovation-driven strategy, firm innovation system, national innovation system, holistic innovation theory, core competence

Received October 18, 2018; accepted March 23, 2020

Jin CHEN

Research Center for Technological Innovation, Tsinghua University, Beijing 100084, China; School of Economics and Management, Tsinghua University, Beijing 100084, China

Ximing YIN (✉)

School of Management and Economics, Beijing Institute of Technology, Beijing 100081, China; Research Center for Technological Innovation, Tsinghua University, Beijing 100084, China
E-mail: yxm11@tsinghua.org.cn

Jizhen LI

Research Center for Competitive Dynamics and Innovation Strategy, School of Economics and Management, Tsinghua University, Beijing 100084, China

1 Introduction

Innovation is the main force that drives economic growth and the key to the sustainable competitive advantage of organizations and nations (Schumpeter, 1934; Romer, 1986; Chen et al., 2015). Developed and developing countries consider innovation as a new growth engine and encourage investment in innovation and entrepreneurship (Chen et al., 2018). As a typical emerging economy, China's speed in catching up in terms of economy and innovation is impressive and has attracted attention from the world for decades; however, a long way remains to innovate the country (Lee et al., 2017).

The innovation system approach, which has received increasing attention in organizational research, is useful for improving policy interventions, especially in developing countries (Xu et al., 2007; Aguirre-Bastos and Weber, 2018). Scholars have explored innovation system approach, such as the national innovation system (Nelson, 1993; Lundvall, 2010), regional innovation system (Cooke et al., 1997; Su and Chen, 2015), and sectoral/industrial innovation system (Malerba, 2002). Such efforts contribute to the understanding as well as development of innovation systems. The firm innovation system (FIS) is a set of networks of actors and multi-level organizational groups that jointly interact around firm's strategic goal and facilitate the generation, diffusion and application of new knowledge and/or new product, and consists of technological innovation systems (Markard and Truffer, 2008; Chen, 2017a) (see Fig. 1).

Given the trend of firms becoming increasingly important in the process of building an innovative country and the fact that Chinese firms face stiff competition, the question of how to build a strong and efficient FIS has never been as important as it is today. In 2017, at the 19th National Congress of the Communist Party of China, the Governor stated that the key to China becoming the most innovative country is to improve the national innovation system and cultivate world-class innovation-leading

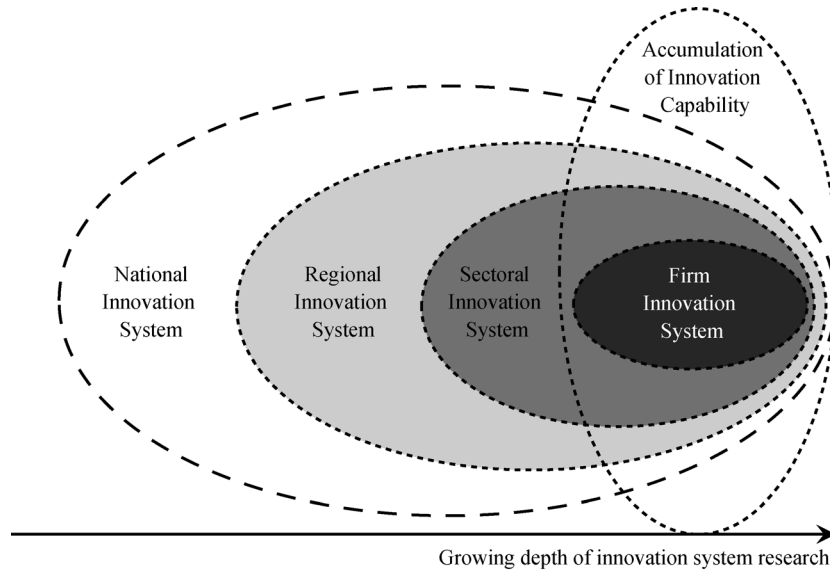


Fig. 1 Evolution of innovation system (based on Russell and Smorodinskaya (2018)).

enterprises. Studies shedding light on this question will undoubtedly contribute substantial value in cultivating world-class innovation-leading enterprises and strengthening the country's global competitive innovation capabilities, which can lead to a sustainable innovative socioeconomic society (Chen, 2017a).

Drawing on current innovation management theories and managerial practices, this paper first introduces the typical road toward world-class enterprises as well as challenges in Section 2. Section 3 presents four systematic paths for enhancing FISs, and Section 4 summarizes and concludes the study. This study contributes by providing a systematic approach for understanding and enhancing FISs as well as theoretical and practical bases for China and other developing countries to cultivate world-class innovative enterprises and build an innovative nation.

2 Road toward world-class innovative enterprises and challenges

Innovation, which derives from the Latin noun “innovates”, was first introduced by Schumpeter (1934) as a modern systematic definition of a new product, resource, process, market, or organization. In 2016, the Chinese government published the *National Innovation-Driven Development Strategy Outline* (hereafter called the “Outline”), in which the government identified a three-step goal toward building an innovative country. The *Outline* states that innovation is the main driver of productivity and must be addressed as the core of the national development strategy to meet requirements of “endeavoring for the international frontier science and technology (S&T) breakthroughs, meeting major needs of the country, and serving economic development”. The first task to lead

innovative development is to cultivate world-class innovative enterprises (Ministry of Science and Technology, 2016).

Uncovering the characteristics of innovative enterprises is the first step in cultivating world-class innovative enterprises. The “Top 50 Most Innovative Companies” lists by the Boston Consulting Group in the past 10 years are based on surveys of senior executives representing various industries in different regions worldwide as well as on analyses of selected subjective and objective metrics. For example, Apple, Google, Microsoft, Amazon, Samsung, Tesla, Facebook, IBM, Uber, and Alibaba were the top 10 companies in the 2018 list, whereas three Chinese companies were among the top 50, namely, Alibaba (10th), Tencent (14th), and Huawei (46th) (Ringel et al., 2018). Regardless of their country of origin, these world-class innovative companies share three common characteristics, that is, high total sales volume, high firm valuation, and high market share in specific industries or areas. Behind these apparent traits, two inherent characteristics drive their external financial performance, namely, tangible knowledge, such as core technology, and intangible knowledge, such as talents and intellectual property management routines. These five factors lead to a sixth characteristic, namely, high brand value. Looking back on modern management evolution history, a matrix demonstrating a shift in market demand and managerial focus since the 1970s can be seen. Market demand shifts from price, quality, and newness to diversification, whereas associated managerial focus shifts from efficiency, quality, and flexibility to innovation, which calls for considerable attention to the innovation of enterprises (Chen, 2017b).

Notably, world-class innovation-leading enterprises are those that demonstrate global competency and the potential to influence the world by providing disruptive technologies

or new products and services (Chen and Yin, 2019b). Although world-class status is highly correlated with size, revenue, market share, market value, and brand value, the core of becoming a world-class company is sustainable innovation capability (Chen and Yin, 2019b) that can be obtained by large enterprises as well as hidden champions (Simon, 1996).

However, despite the importance of innovation, a large innovation performance gap exists, which can generate considerable challenges for firms to achieve success in innovation and sustainable growth. According to the McKinsey Global Innovation Survey¹⁾, though at least 84% of executives agree that innovation is the key to growth, only 6% are satisfied with innovation performance. Very few executives know what the real problem is, let alone how to improve innovation within an organization. Therefore, venturing beyond pure research and development (R&D) and improving FISs to develop corporate indigenous innovation capability and cultivate world-class enterprises remain crucial challenges to be overcome.

3 Four systematic perspectives for improving FISs

Reasons behind the innovation performance gap include executives' previous misunderstanding of innovation and lack of appreciation toward corporate strategies and R&D systems or the absence of a constructive culture to attract talents and motivate innovation (Chen and Yin, 2019a). Moreover, innovation has been considered as a one-way, successive, and gradual linear process. For example, numerous managers believe that innovation equals invention, ideas, improvement, or R&D. However, practice indicates that innovation is a diverse process embedded with multilevel integrated complex feedback mechanisms between factors and other elements rather than a simple linear process or partial improvement (Markard and Truffer, 2008; Chen et al., 2015).

Therefore, the best way to improve innovation and cultivate world-class enterprises is to establish FISs based on a systematic innovation management framework that combines strategy, organization, resources, and culture (Chen and Lyu, 2017). Drawing on the innovation process

perspective of Rothwell (1994) and the research of Chen et al. (2015) on the design and improvement of key state-owned enterprises (SOEs), the evolution of FISs and paths toward a strong FIS is a dynamic process, upgrading from R&D-based internal collaborative innovation to strategic vision-driven innovation to open and user-driven innovation and finally to holistic ecosystem-driven innovation (see Table 1). FISs have different morphological characteristics and evolution mechanisms for different types of firms in different industries (Chen, 2017a). Despite the four paths following a systematic evolutionary logic based on the level of integration and complexity, firms aiming to improve their FIS and venture beyond the pure R&D investment model should choose a path according to their technology base, management experience, and industry development levels. Thus, they can gradually upgrade their FIS to a high level to make the most of system advantages.

An innovation system, as an interactive process (Lundvall, 2010) in which the producers and users of an innovation cooperate and interact to co-create and distribute value (Baldwin and von Hippel, 2011), is an extremely powerful and sustainable method for building core competence (Prahalad and Hamel, 2000). With the upgrading of an FIS, the total population of participants enrolled in an innovation system increases in a nonlinear direction, whereas the level of integration and complexity within the FIS will exhibit an exponential growth (see Fig. 2). Top management teams (TMTs) and policymakers must have a clear vision in managing complexity and the balance between openness and maintaining control of the innovation system (Russell and Smorodinskaya, 2018). On the one hand, the more the participants in an FIS, the more the novel ideas or new knowledge would be produced for value creation. On the other hand, firms should establish strong absorptive and integrative capacities, undergo the diffusing process, and transform new ideas or knowledge into profitable products or services (Martinkenaite and Breunig, 2016). The ultimate purpose of innovation system upgrading is to motivate innovators to leverage all elements to conduct innovative activities and create value every possible moment everywhere (Xu et al., 2007).

3.1 FIS 1.0: R&D-based internal collaborative innovation

According to theory of knowledge-based view (KBV),

Table 1 Four systematic path for improving FISs

FIS	Path	Key characteristics
1.0	R&D-based Internal Collaborative Innovation	Internal and collaboration
2.0	Strategic Vision-driven Innovation	Strategic and governance
3.0	Open and User-driven Innovation	Open and user participate
4.0	Holistic Ecosystem-driven Innovation	Ecological, holistic, and total

1) Available at: mckinsey.com/business-functions/strategy-and-corporate-finance/how-we-help-clients/growth-and-innovation.

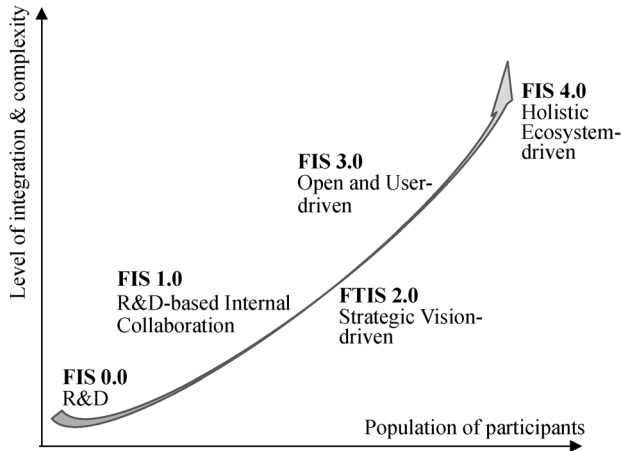


Fig. 2 Stage model to go beyond pure R&D.

knowledge is the key resource of innovation (Grant, 1996). Internal R&D has been proven as the key step for achieving technological breakthroughs and generating new knowledge for innovation, such as patents and disruptive technologies (Chen, 2017b). However, the innovation performance gap indicates that strong innovation capabilities need more than pure R&D inputs. The first systematic perspective to narrow the innovation performance gap involves integrating R&D groups with manufacturing and marketing departments and making the most of R&D-based indigenous innovation (see Fig. 3).

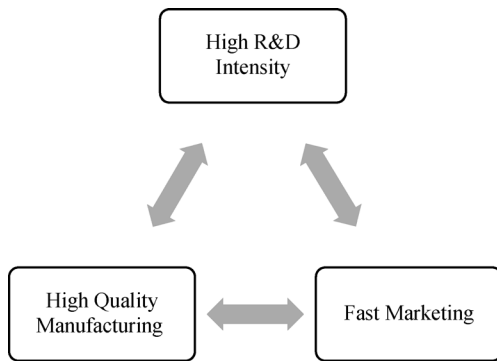


Fig. 3 FIS 1.0: Internal R&D-based collaborative innovation.

Huawei Technologies Co., Ltd. is taken as an example. Huawei is a leading global information and communications technology solutions provider. By applying a high-efficiency internal collaborative innovation system combined with high R&D intensity (an average of more than 10% revenue is spent on R&D, and R&D personnel comprises 45% of total employees), high-quality manufacturing (customers' requirements and expectations are communicated to the company's entire value chain), and rapid market processes (product development efficiency is increased by more than 60% after the integrated product

development strategy is applied), Huawei can control key technologies (e.g., 5G core technology patents) and create high technical entry barriers for competitors. Huawei has built a competitive information and communication technology (ICT) portfolio of end-to-end solutions in telecommunications, enterprise devices, and cloud computing. Moreover, the company ranked first in patent applications in the world in 2017. In addition, its products and services benefit more than 170 countries and regions.

3.2 FIS 2.0: Strategic vision-driven innovation

Innovation strategy is a crucial part of overall corporate strategy, which is related to innovation leadership (Zuraik, 2017). Strategic vision can empower participants to work together cohesively with a strong and clear purpose in complex processes involved in high-risk and boundary-breaking activities (Fleming and Waguespack, 2007). The strategic design of FISs is key in capturing long-term technology trends, which are important not only for national development but also for a firm's sustainable growth (Ministry of Science and Technology, 2016). Chandler (2009) argued that when the historical perspective is used to understand what drives the most successful innovative companies in different industries, only those who combine clear long-term strategies and continuous R&D will remain successful. To achieve cohesive collaboration between R&D, manufacturing, and marketing management, TMTs must reach an agreement on a corporate-level technology development strategy that can lead the direction of firm technological innovation (Zuraik, 2017) (see Fig. 4).



Fig. 4 FIS 2.0: Strategic vision-driven innovation.

The Midea Group is taken as an example. Midea was established in 1968 and developed from a local workshop to a leading global technology group in consumer appliances and industrial automation systems. Midea's strategic vision focuses on continuous technological innovation to maintain the company's global leadership position in the consumer appliances market and to catch the next generation of technologies. Led by this strategic vision, Midea has established a corporate-level technology roadmap and global platform, with 84 innovation centers, 21 production facilities, 260 logistics centers, and more than 2400 retail stores worldwide to support online and

offline technological innovation, manufacturing, and market operations. In addition, its customer-oriented fast-response strategy has helped Midea successfully transit into a multiproduct global operation group, thereby enriching lives worldwide. On the one hand, Midea generated a global revenue of more than 33 billion US dollars by the end of 2017, with a 60.53% increase compared with 2016 and a 24% average annual growth rate in cash dividends for shareholders in the past 5 years¹⁾. On the other hand, under a corporate-level innovation-driven strategy, Midea has established the Midea Corporate Research Center, which focuses on basic and prospective research. By applying a four-level R&D system with globally distributed R&D centers, the Midea Corporate Research Center has built a technological map spanning one to over five years of frontier technologies. According to our interview with Dr. Fuchang Zhou, who is the technology strategy director of the Midea Corporate Research Center, the company's strategic vision-driven FIS has helped Midea achieve disruptive innovations consistently, such as the world's first smart rice cooker integrated with AI image recognition technology and the first phase-change energy storage electric water heater in 2017. These new and disruptive technologies are more important than current revenues in Midea's mission and sustainable leading advantage²⁾.

3.3 FIS 3.0: Open and user-driven innovation

Industrial firms previously developed new technologies for their products internally using relatively “closed” innovation strategies with limited interactions with the outside environment, such as boundary-spanning activities necessary for obtaining new knowledge for innovation (Fleming and Waguespack, 2007). von Hippel (1986) introduced lead users as a new source of innovation, and Chesbrough (2003) formally proposed “open innovation”. Open and user-driven innovation has been proven effective in replacing producer-driven innovation in numerous aspects of the economy owing to its low design, architecture, and communication costs and high potential for novel ideas and superior user experience, which can lead to high market success compared with the traditional “producer model” of the innovation paradigm (Baldwin and von Hippel, 2011).

Haier is taken as an example. Haier has continuously invested in core technologies and paid considerable attention to the establishment of the Haier Open Partnership Ecosystem (HOPE). This platform was launched in 2013, and updated in 2015 and 2016, followed by the “HOPE-based Partner Program”, which aims to explore new models of open and user interactive communities

around the world. HOPE positions itself as an interactive platform that provides value-added services to stakeholders involved in the overall innovation process, from consumer pain points to new product/function generation. The platform uses mainly co-creation and crowdsourcing mechanisms to generate new products, functions, and business models. The user is an active participant in the process and is used to initiate projects (i.e., find needs for projects), give feedback during decision making, and validate prototypes in offline activities (selected from the online user base and invited to participate in focus groups). Through the “individual-goal combination” model and exploration, Haier has built an ecosystem that accelerates interaction between firms and users. The ultimate goal of HOPE is to achieve “zero distance” between employees and users. To achieve a win-win individual-goal combination model, Haier has reduced its organizational hierarchy, thereby becoming a dynamic network organization that can attract user participation to further improve its innovation efficiency and market revenue. Through an open and user-driven FIS, Haier has successfully transited from a traditional manufacturing giant to a digitalized platform to accelerate the growth of self-managed entrepreneurs (Kanter and Dai, 2018), thereby providing the company with a strategic blueprint to lead and profit in the hyperdynamic global market (Krings-Klebe et al., 2017). Statistically, after six years of development, the HOPE platform has become the world's leading open platform for technological innovation, which clusters more than 3.8 million organizational players. As a result, Haier's organizational ability to obtain and absorb external innovation resources has improved a hundredfold, yielding more than 6000 innovative ideas and over 200 innovation programs yearly. The development time of new product is shortened by more than 50%, with an annual innovation revenue of 50 billion yuan and an average annual revenue growth of 20%. Haier has won the High-Tech Manufacturing Supply Chainnovators Award in 2017 and would continue its global leadership as a better-life solutions provider³⁾.

3.4 FIS 4.0: Holistic ecosystem-driven innovation

In the current highly competitive world, neither a country nor a firm can survive or obtain competitive advantages without a portfolio of core technologies that can build core competence (Chen, 2017a). TMTs must apply the total innovation management philosophy to motivate innovators to make the most of innovation elements to perform creative activities at all times and locations to create value (Xu et al., 2007). To render efforts made by innovation search effective, firms and the government should integrate

1) For more information, refer to the Midea Annual Report: midea-group.com/global/investors/reports.

2) We thank Dr. Fuchang Zhou for granting us an interview and for his speech during the International Conference of Innovation Studies at Tsinghua University on June 24, 2018.

3) For additional details, refer to *Gartner Announces Winners of the 2017 Supply Chainnovators Awards*.

their internal processes with the external environment to make the most of internal and external knowledge (Nonaka and Takeuchi, 1995; Yin et al., 2019). From the perspective of innovation ecosystems (Russell and Smorodinskaya, 2018) and total innovation management theory (Xu et al., 2007), the best way to establish a sustainable innovation system and obtain ecosystem advantages is to develop a comprehensive strategic innovation vision (Chen et al., 2018) and build a competence-based open innovation ecosystem as well as to protect focal players, that is, either firms or the country.

Reviewing the deficiency of current innovation paradigms in the context of China, Chen et al. (2018) introduced a new innovation paradigm based on the Chinese philosophy and best innovation practices, which they called holistic innovation (HI). HI is defined as total and collaborative innovation driven by a strategic vision in modern open environments. This theory provides a systematic view for achieving dynamic capabilities and development through vertical integration and horizontal interaction. This theory is consistent with the argument of Xu et al. (2007) that the key to enhancing firm competence is the application of a long-term management philosophy and corporate strategy that can motivate people to create and utilize knowledge.

From an ecological perspective, innovation management no longer only involves coordination across single factors (Leviäkangas et al., 2018; Chen and Yin, 2019a). Players cohabiting a holistic ecosystem should view innovation from holistic, strategic, and global perspectives. HI is an original theoretical paradigm that conforms to the needs of enterprise technological innovation management in the context of an open innovation era and supports the implementation of the innovation-driven development strategy. Moreover, HI can help enterprises build global innovation leadership and improve national innovation capability. FISs that can match the HI paradigm with ecosystem structures (Adner, 2017) can achieve the recombination of science, technology, and engineering (STE); humanities, arts, and the market (HAM); and holistic and coordinative mindsets and engineering philosophy (HCE) under the direction of overall corporate strategic vision, which can help firms address increasing complexity followed by increasing participants (see Fig. 5).

The holistic ecosystem-driven FIS comprising technology, knowledge, and organization integration can explain several major innovation achievements of SOEs in China, such as those of China Railway Rolling Stock Corporation (CRRC) Co., Ltd., China International Marine Containers Co., Ltd., and Commercial Aircraft Corporation of China Ltd., as well as those of new successful innovative

enterprises, such as Alibaba, Tencent, Iflytech, BGI Genomics, and so on.

CRRC, which is the world's largest train car provider, is taken as an example. To integrate resources from internal members and external partners, CRRC has created a technology-based FIS with a strategic vision of achieving global innovation leadership in railway core technologies. The technology component of CRRC's holistic ecosystem-driven FIS consists of five core technology systems, namely, shock absorption, noise reduction, lightweight, insulation, and water treatment technology. As for the HAM component, CRRC has continuously paid attention and resources to employee trainings on creativity, experimental ability, and design thinking, which has contributed to sustained process and product innovation (Chen, 2017a). As an example of CRRC's international innovation competence, on March 9, 2018, it won first place in New York MTA's "Genius Challenge", which called on transit experts to submit proposals for improving the crumbling subway system. By providing a lightweight carbon fiber-based modular subway car with advanced technology that enabled the car to be continually phased with cutting-edge technologies, CRRC beat 438 highly competitive companies, such as Nokia, from 23 different countries¹). Owing to long-term strategic planning, continuous investment, and holistic ecosystem-driven FIS construction, China has built more than 29000 km of dedicated high-speed railways, which is longer than the total length of railways in the rest of world combined, and has successfully become the first middle-income country to develop a high-speed railway network and affordable service for people of all income levels (Lawrence et al., 2019). After scrutinizing the planning and delivery mechanisms that enabled the rapid construction of the high-speed rail system in China, the World Bank published a report entitled *China's High-speed Rail Development* (Lawrence et al., 2019), pointing out the thing that other countries could learn from China's remarkable experience is the strong ecosystem, specifically, "the strong capacity development within and cooperation among China Railway Corporation, rail manufacturers, universities, research institutions, laboratories, and engineering centers that allowed for rapid technological advancement and localization of technology".

Another best practice example of a holistic ecosystem-driven FIS is from the China Xuzhou Construction Machinery Group (XCMG). The XCMG developed from a small local manufacturing factory to China's largest and the world's 4th largest construction machinery industry in 2020²). In response to the national innovation strategy and industrial upgrading trends, the XCMG developed a firm strategic vision to become a world-class innovative

1) For additional details, refer to: archpaper.com/2018/03/winners-mtas-first-genius-award-announced.

2) For additional details, refer to: news.lmjx.net/2020/202005/2020051820250828.shtml.

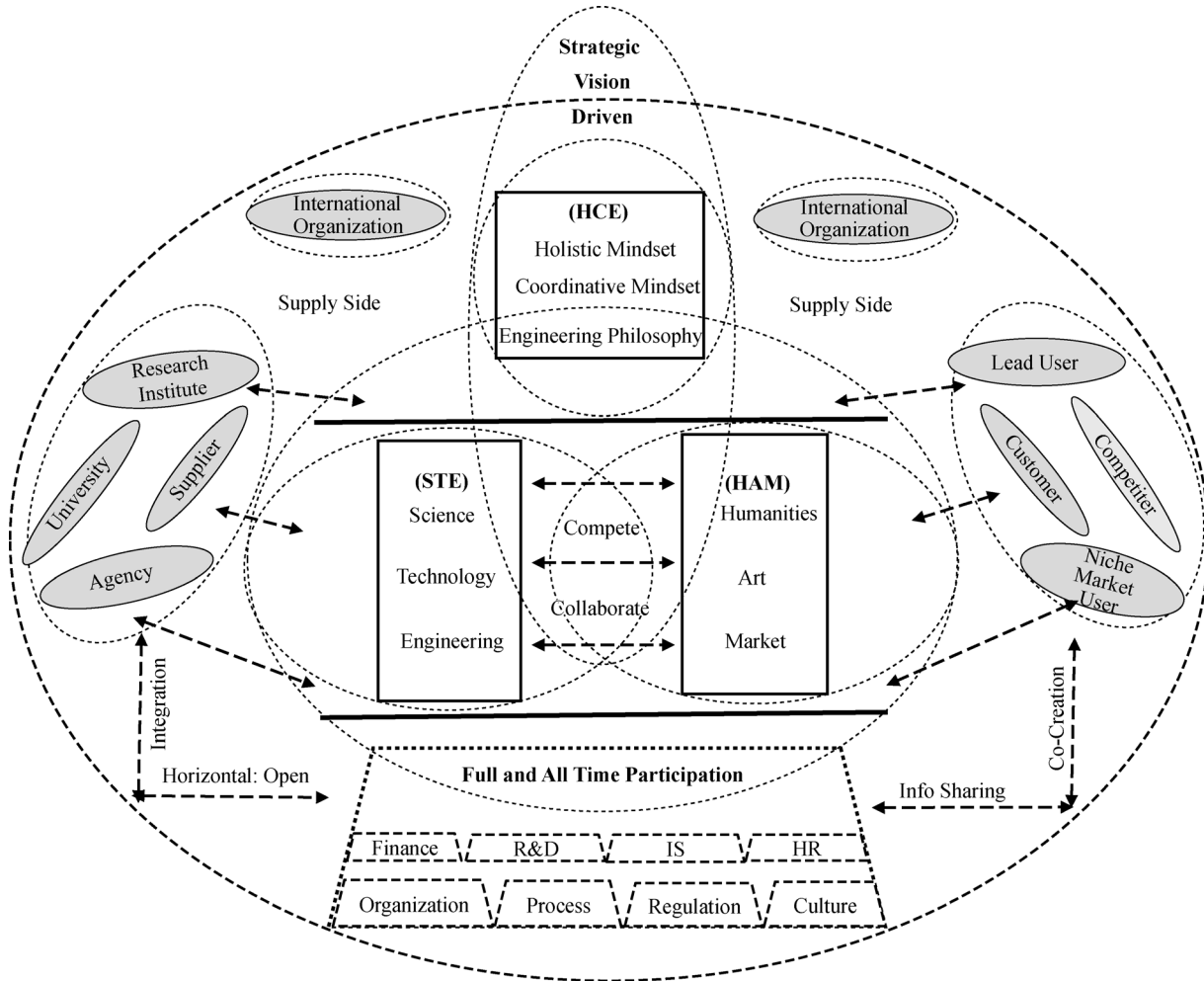


Fig. 5 FTIS 4.0: Holistic ecosystem-driven innovation (based on Chen et al. (2018)).

manufacturing company with core technologies that can contribute better infrastructures for people around the world. The XCMG has developed a strategic competence-based FIS consisting of technological and managerial core competence. Technological core competence is driven by the construction of a technological knowledge system, which consists of indigenous innovation, mergers and acquisitions, and collaborative innovation. Meanwhile, managerial core competence is driven by the construction of a managerial knowledge system, which consists of three main parts, namely, management of performance excellence, operation, and total budget. The XCMG also takes advantage of internationalization, informatization, and open innovation to utilize technical knowledge as well as management expertise in the overall process of product design, production, and after-sales service. Firms in emerging markets generally experience difficulties catching up with well-established firms. However, informatization and venturing beyond global and firm boundaries can provide new opportunities for acquiring and utilizing new

and global knowledge for sustainable innovation. Finally, the XCMG’s FIS yields substantial economic value and global competence. The XCMG’s high-value manufacturing FIS enabled the company to launch their XCMG 700 ton hydraulic excavator in 2018, which can lift more than 700 tons of goods at once. Moreover, the hydraulic excavator is China’s largest construction machinery and makes China the fourth country that has the ability for R&D and manufacture of hydraulic excavator of above 700 tons.

4 Conclusions and suggestions

In the context of the global knowledge economy era, China and other developing countries are experiencing rapid advancement as well as increasing severe international competition in the technological revolution. Several new challenges have emerged and critical questions on how world-class enterprises can be cultivated and an innovative

country can be built remain unanswered. Specifically, how can innovation-driven development strategy be implemented efficiently? How can cutting-edge technology innovation and knowledge management be applied to accelerate the core competence of enterprises? How can FISs be taken advantage of to strengthen firms' indigenous innovation to achieve high positions in the global value chain? Finally, how can the tension between indigenous innovation and open innovation be addressed?

Drawing on current innovation management theories and managerial practices, this study proposes four systematic paths for improving FISs, namely, the R&D-based internal collaborative FIS, the strategic vision-driven FIS, the open and user-driven FIS, and the holistic ecosystem-driven FIS. This study contributes a systematic approach for understanding and enhancing FISs. Moreover, this research provides practical insights for China and other emerging economies to cultivate world-class enterprises and build an innovative nation.

Although FISs are an important perspective, with theoretical and practical foundations for cultivating world-class innovative firms and countries, numerous other alternatives and complementary theoretical lenses exist for firms and nations to succeed via innovation (Tushman and O'Reilly, 2006). For example, the resource-based view (Barney et al., 2001), the knowledge-based view (Grant, 1996), and knowledge-creating companies follow a resources-based competitive advantage approach that provides critical knowledge to firms to manage resources and knowledge flows within and across FISs (Nonaka and Takeuchi, 1995). Economic-grounded perspectives, such as transaction cost economics (Williamson and Masten, 1995), provide insights into managing behavioral uncertainties and firm boundaries, whereas the structure–conduct–performance paradigm in economics (Porter, 1998) provides useful insights into bridging FISs with regional and sectoral/industrial innovation systems (Cooke et al., 1997; Malerba, 2002). Moreover, several emerging organizational practices and research, such as knowledge spillover theory of entrepreneurship (Acs et al., 2013) and hybrid organization embedded with multiple institutional logics (Battilana et al., 2015; Shepherd et al., 2019), provide new insights into innovation through FISs in the complex, dynamic, uncertain, and globalized world.

On the road to innovation, Chinese enterprises have experienced four different types of FISs in various contingencies and industries, ranging from R&D-based indigenous innovation to the holistic ecosystem innovation paradigm. In other words, to achieve global innovation leadership, Chinese firms must develop strong indigenous technological capabilities and sustained competence through the coevolution of strategy, organization, resources, and culture. To deal with open innovation risks in the process of becoming global, firms should adopt a mindset focusing on strengthening holistic capabilities by combing the strategic vision-driven with the open and

user-driven innovation system. This process is beyond the scope of open innovation theory but can shed light on its development.

Finally, an innovation policy for FISs should go beyond pure investment in science and technology and pay attention to an HI policy. An HI policy considers innovation as a nonlinear dynamic process involving science, technology, and philosophy to build an integrated system under the guidance of the national innovation-driven development strategy. Only in this way can the country apply national, industrial, and enterprise innovation strategies in every socioeconomic aspect, which will provide both the country and firms with powerful engines for indigenous innovation. In the long-term, an HI policy can help cultivate clusters of world-class innovative companies and strengthen China's global innovation impact. Most important, China's path and experience and Chinese firms' innovation can provide a meaningful perspective for other developing countries to observe innovation opportunities and catch up with this model.

References

- Acs Z J, Audretsch D B, Lehmann E E (2013). The knowledge spillover theory of entrepreneurship. *Small Business Economics*, 41(4): 757–774
- Adner R (2017). Ecosystem as structure: An actionable construct for strategy. *Journal of Management*, 43(1): 39–58
- Aguirre-Bastos C, Weber M K (2018). Foresight for shaping national innovation systems in developing economies. *Technological Forecasting and Social Change*, 128: 186–196
- Baldwin C, von Hippel E (2011). Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. *Organization Science*, 22(6): 1399–1417
- Barney J, Wright M, Ketchen Jr D J (2001). The resource-based view of the firm: Ten years after 1991. *Journal of Management*, 27(6): 625–641
- Battilana J, Sengul M, Pache A C, Model J (2015). Harnessing productive tensions in hybrid organizations: The case of work integration social enterprises. *Academy of Management Journal*, 58(6): 1658–1685
- Chandler A D (2009). *Shaping the Industrial Century: The Remarkable Story of the Evolution of the Modern Chemical and Pharmaceutical Industries* (vol. 46). London: Harvard University Press
- Chen J (2017a). *Theory of Firm Innovation System*. Beijing: Science Press (in Chinese)
- Chen J (2017b). Towards new and multiple perspectives on innovation. *International Journal of Innovation Studies*, 1(1): 1–4
- Chen J, Huang S, Xu Q (2015). Firm innovation systems: Perspectives of researches on state-owned key enterprises. *Frontiers of Engineering Management*, 2(1): 64–70
- Chen J, Lyu R W (2017). Innovation in China: The state of art and future perspectives. In: Brem A, Viardot E, eds. *Revolution of Innovation Management*. London: Palgrave Macmillan, 69–103
- Chen J, Yin X (2019a). Connotation and types of innovation. In: Chen J,

- Brem A, Viardot E, Wong P K, eds. *The Routledge Companion to Innovation Management*. Abingdon: Routledge, 26–54
- Chen J, Yin X (2019b). Operation and management models among the world-class enterprises. *Enterprise Management*, (07): 12–16 (in Chinese)
- Chen J, Yin X, Mei L (2018). Holistic innovation: An emerging innovation paradigm. *International Journal of Innovation Studies*, 2 (1): 1–13
- Chesbrough H W (2003). The era of open innovation. *MIT Sloan Management Review*, 44(3): 35–41
- Cooke P, Gomez Uranga M, Etxebarria G (1997). Regional innovation systems: Institutional and organisational dimensions. *Research Policy*, 26(4–5): 475–491
- Fleming L, Waguespack D M (2007). Brokerage, boundary spanning, and leadership in open innovation communities. *Organization Science*, 18(2): 165–180
- Grant R M (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17(S2): 109–122
- Kanter R M, Dai N H (2018). Haier: Incubating entrepreneurs in a Chinese giant. *Harvard Business School Case*, 318–104
- Krings-Klebe J, Heinz J, Schreiner J (2017). *Future Legends: Business in Hyper-Dynamic Markets*. Hamburg: Tredition
- Lawrence M, Bullock R, Liu Z (2019). *China's High-Speed Rail Development*. Washington DC: World Bank Group
- Lee K, Chen J, Li J, Kim J H (2017). Better innovation, better future: Working together for innovating Asia. *Asian Journal of Technology Innovation*, 25(1): 1–4
- Leviäkangas P, Ye Y B, Olatunji O A (2018). Sustainable public–private partnerships: Balancing the multi-actor ecosystem and societal requirements. *Frontiers of Engineering Management*, 5(3): 347–356
- Lundvall B Å (2010). National systems of innovation: Towards a theory of innovation and interactive learning. In: Lundvall B Å, ed. *The Learning Economy and the Economics of Hope* (Chapter 4). London: Anthem Press, 85–106
- Malerba F (2002). Sectoral systems of innovation and production. *Research Policy*, 31(2): 247–264
- Markard J, Truffer B (2008). Technological innovation systems and the multi-level perspective: Towards an integrated framework. *Research Policy*, 37(4): 596–615
- Martinkenaite I, Breunig K J (2016). The emergence of absorptive capacity through micro-macro level interactions. *Journal of Business Research*, 69(2): 700–708
- Ministry of Science and Technology (2016). *National Innovation-Driven Development Strategy Outline background briefing*. Beijing: Ministry of Science and Technology of China
- Nelson R R (1993). *National Innovation Systems: A Comparative Analysis*. Oxford: Oxford University Press
- Nonaka I, Takeuchi H (1995). *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford: Oxford University Press
- Porter M E (1998). *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York: Free Press
- Prahalad C K, Hamel G (2000). The core competence of the corporation. In: Hahn D, Taylor B, eds. *Strategische Unternehmensplanung—Strategische Unternehmensführung* (Chapter 2). Berlin, Heidelberg: Springer, 275–292
- Ringel M, Zablitz H, Grassl F, Manly J, Moeller C (2018). The most innovative companies 2018: Innovators go all in on digital. *The Boston Consulting Group*, 28
- Romer P M (1986). Increasing returns and long-run growth. *Journal of Political Economy*, 94(5): 1002–1037
- Rothwell R (1994). Towards the fifth-generation innovation process. *International Marketing Review*, 11(1): 7–31
- Russell M G, Smorodinskaya N V (2018). Leveraging complexity for ecosystemic innovation. *Technological Forecasting and Social Change*, 136: 114–131
- Schumpeter J A (1934). *Theory of Economic Development*. New ed. New Brunswick, NJ: Routledge
- Shepherd D A, Williams T A, Zhao E Y (2019). A framework for exploring the degree of hybridity in social entrepreneurship. *Academy of Management Perspectives*, 33(4): 491–512
- Simon H (1996). *Hidden Champions: Lessons from 500 of the World's Best Unknown Companies*. 4th ed. Boston, MA: Harvard Business School Press
- Su Y S, Chen J (2015). Introduction to regional innovation systems in East Asia. *Technological Forecasting and Social Change*, 100: 80–82
- Tushman M L, O'Reilly C A (2006). *Winning Through Innovation: A Practical Guide to Leading Organizational Change and Renewal*. Brighton, MA: Harvard Business Review Press
- von Hippel E (1986). Lead users: A source of novel product concepts. *Management Science*, 32(7): 791–805
- Williamson O E, Masten S E (1995). *Transaction Cost Economics*. Aldershot: Edward Elgar Publishing
- Xu Q, Chen J, Xie Z, Liu J, Zheng G, Wang Y (2007). Total innovation management: A novel paradigm of innovation management in the 21st century. *The Journal of Technology Transfer*, 32(1–2): 9–25
- Yin X, Chen J, Zhao C (2019). Double screen innovation: Building sustainable core competence through knowledge management. *Sustainability*, 11(16): 4266
- Zuraik A (2017). *A Strategic Model for Innovation Leadership: Ambidextrous and Transformational Leadership within a Supportive Climate to Foster Innovation Performance*. Dissertation for the Doctoral Degree. San Francisco: Alliant International University